

acsee

2
0
1
3

Official Conference Proceedings



i
a
f
o
r



ISSN: 2186-2311

The Asian Conference on Sustainability, Energy and the Environment

Osaka Japan 2013

The Asian Conference on Sustainability, Energy and the Environment

Conference Proceedings 2013

Dr Shamim Ali
Lecturer,
National University of Modern Languages, Pakistan

Professor David N Aspin
Professor Emeritus and Former Dean of the Faculty of
Education, Monash University, Australia
Visiting Fellow, St Edmund's College, Cambridge University,
UK

Dr William Baber
Associate Professor
Kyoto University Graduate School of Management, Japan

Professor Don Brash
Former Governor of the Reserve Bank, New Zealand
Former Leader of the New National Party, New Zealand
Adjunct Professor, AUT, New Zealand & La Trobe University,
Australia

Lord Charles Bruce of Elgin and Kincardine
Lord Lieutenant of Fife
Chairman of the Patrons of the National Galleries of Scotland
Trustee of the Historic Scotland Foundation, UK

Professor Judith Chapman
Professor of Education, Australian Catholic University,
Australia
Visiting Fellow, St Edmund's College, Cambridge University,
UK
Member of the Order of Australia

Professor Chung-Ying Cheng
Professor of Philosophy, University of Hawai'i at Manoa, USA
Editor-in-Chief, The Journal of Chinese Philosophy

Professor Tien-Hui Chiang
Professor and Chair, Department of Education
National University of Tainan, Taiwan/Chinese Taipei

Mr Marcus Chidgey
CEO, Captive Minds Communications Group, London, UK

Professor Kevin Cleary
President of the Japan Association of Language Teachers (JALT)

Professor Steve Cornwell
Professor of English and Interdisciplinary Studies
Osaka Jogakuin University, Osaka, Japan
Osaka Local Conference Chair

Professor Michael A. Cusumano
SMR Distinguished Professor of Management and
Engineering Systems, MIT Sloan School of Management
Massachusetts Institute of Technology, USA

Professor Dexter Da Silva
Professor of Educational Psychology
Keisen University, Tokyo, Japan

Professor Georges Depeyrot
Professor and Director of Research
French National Center for Scientific Research (CNRS)/Ecole
Normale Supérieure, Paris, France

Professor Sue Jackson
Professor of Lifelong Learning and Gender
Pro-Vice Master of Teaching and Learning
Birkbeck, University of London, UK

Professor June Henton
Dean
College of Human Sciences
Auburn University, USA

Professor Michael Hudson
President of The Institute for the Study of Long-Term Economic
Trends (ISLET)
Distinguished Research Professor of Economics at the
University of Missouri, Kansas City, USA

Vice-Consul Kathryn Kiser
Cultural Affairs Officer, Lahore, Pakistan
The United States Department of State, USA

Mr Shahzada Khalid
Deputy Director
SAARC Energy Center, Pakistan

Mrs Eri Kudo
Head Private Sector Fundraising
United Nations World Food Programme Japan, Tokyo, Japan

Professor Sing Kong Lee
Director
The National Institute of Education, Singapore

Dr Woon Chia Liu
Associate Dean, Practicum and School Partnerships, Teacher
Education, The National Institute of Education, Singapore

Professor Sir Geoffrey Lloyd
Senior Scholar in Residence, The Needham Research
Institute, Cambridge, UK
Fellow and Former Master, Darwin College, University of
Cambridge
Fellow of the British Academy
Honorary Foreign Member, The American Academy of Arts and
Sciences

Dr Robert Logie
Associate Professor of Computer Science
Osaka Gakuin University, Japan

Dr David McLoughlin
Associate Professor
Meiji University, Japan

Professor Vasile Meita
General Manager
The National Institute for Research and Development in
Construction, Urban Planning and Sustainable Spatial
Development (URBAN=INCERC), Romania

Professor Keith Miller
Louise Hartman Schewe and Karl Schewe Professor of
Computer Science
The University of Illinois Springfield, USA
Editor-in-Chief, IEEE Technology and Society

Professor Marjo Hannele Mitsutomi
Head of English Language Teaching Practices and the
Language Development Intercultural Studies Center
Akita International University, Japan

Professor Ka Ho Joshua Mok
Chair Professor of Comparative Policy, Associate Vice-
President (External Relations)
Dean of the Faculty of Arts and Sciences
The Hong Kong Institute of Education, Hong Kong SAR

Dr Jo Mynard
Associate Professor & Director of the SALC, Kanda University
of International Studies, Japan

Professor Michiko Nakano
Professor of English
Director of the Distance Learning Center
Waseda University, Tokyo, Japan

Ms Karen Newby
Director
Par les mots solidaires, Paris, France

Professor Jerry Platt
Professor of Business,
Akita International University, Japan,
Dean and Professor Emeritus, College of Business, San
Francisco State, USA

Professor Michael Pronko
Professor of American Literature and Culture
Meiji Gakuin University, Tokyo, Japan

Professor Richard Roth
Senior Associate Dean
Medill School of Journalism, Northwestern University, Qatar

Professor Monty P. Satiadarma
Clinical Psychologist and Lecturer in Psychology
Former Dean of the Department of Psychology and Rector of
Tarumanagara University, Indonesia

Mr Michael Sakamoto
Interdisciplinary Artist
UCLA, USA

Mr Mohamed Salaheen
Director
The United Nations World Food Programme, Japan & Korea

Mr Lowell Sheppard
Asia Pacific Director
HOPE International Development Agency, Canada/Japan

Professor Ken Kawan Soetanto
Professor and Director of CLEDSI
Waseda University, Japan

Dr Jeffrey Sommers
Associate Professor of Economics, University of Wisconsin-
Milwaukee, USA
Visiting Faculty, Stockholm School of Economics, Riga,
Latvia

His Excellency Dr Drago Stambuk
Croatian Ambassador to Brazil, Brazil

Professor Mary Stuart
Vice-Chancellor
The University of Lincoln, UK

Professor Gary Swanson
Distinguished Journalist-in-Residence & Mildred S. Hansen
Endowed Chair
The University of Northern Colorado, USA

Dr David Wilkinson
Associate Dean (International & External Programmes)
Faculty of Law and Management
La Trobe University, Australia

Professor Kensaku Yoshida
Professor of English
Director of the Center for the Teaching of Foreign Languages
in General Education
Sophia University, Tokyo, Japan

Mrs Elly Zaniewicka
Political Correspondent
BBC Political Programmes, London, UK

© The International Academic Forum 2013
The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
ISSN – 2186-2311
http://iafor.org/acsee_proceedings.html

- The Study and Research of Wind Energy for Electricity Generator in Chana District, Songkhla THAILAND*
 Thanat Nonthaputha
 Piya Prasongjan
 Jirapat Phookwantong pp. 1-8
- Status and Trends of Renewable Energy Development in Gaza*
 Anwar Abu-Zarifa pp. 9-21
- Reducing the budget deficit sustainably in Vietnam: Pathway to 2020*
 Quynh Tho Nguyen pp. 22-36
- Influence on the Combustion process of the type of fertilizer used on an energy crop (Populus nigra, L.)*
 Luis F Calvo
 Daniel Blanco
 Luis Escudero
 Sergio Paniagua pp. 37-41
- Cationic Contamination in Lake's Water Situated West Zone, Ahmedabad, Gujarat, India*
 Sanjay VEDIYA pp. 42-48
- The Real Cause for the U.S. Subprime, Financial, Economic Crises in 2007-2009*
 Peter Yang pp. 49-59
- DG Types Effect on the Optimal Location for Voltage Sag Mitigation*
 Ahmed Abdrabou
 Ayman Soliman
 Ahmed Safawi pp. 60-71
- Estimation of Nitrogen Dioxide Concentrations in the Inner Bangkok by Land Use Regression Model*
 Pannee Cheewinsiriwat
 Pongsri Chanhaw pp. 72-85
- Selecting Bio-Indicator Fish for Monitoring Organochlorine Pesticide Contamination in the River*
 Khobkul Nongnutch
 Jakkaphun Nanuam
 Chawanrat Somnuek pp. 86-91
- Future Prospects of Residential Solar Water Heating System in Oman*
 Abdullah Al-Badi
 Mohammed Albadi pp. 92-99

- Contamination of Marine Fish by Heavy Metals from Coastal Sewage Treated Effluent Runoff*
Salma K. Al-Musharafi
Ibrahim Y. Mahmoud
Saif N. Al-Bahry pp. 100-107
- A Lighting Controller for LED Lamp Cooperated with Daylighting in Thailand*
Phumiphat Kakham
Banchara Ounpanich pp.108-123
- Effect of Acidic Soil on Free Fatty Acid of Palm Oil in Thailand*
Pitchayasinee Ariyatanakatawong
Pannavich Ariyatanakatawong pp.124-134
- The Integrated Development of the Community Learning Center of Philosophy of Economic Sufficiency: A Case study at Dong Kra Tong Yam Sub-district, Si Maha Phot District, Prachin Buri Province*
Linda Nakpoi pp.135-140
- Rates of Sediment Deposition in Lam Phra Phloeng Dam , Nakorn Ratchasima Province, Thailand, Using ²¹⁰Pb as a Geochronometer*
Kanitha Srisuksawad
Sasimonton Moungrisun
Tuangrak Nantawisarakul
Kosit Lorsirirat pp.141-150
- Green Architecture and Environmental Design using Rapid-Prototyping Social-Networking Sandbox Tools, followed by Professional Architectural Software*
Joseph Thomas Wunderlich
Joseph John Wunderlich pp.151-166
- Sense of Place as Community Empowerment in Bioregional Planning Process: A Proposed Model*
Muhammad Farid Azizul
Stephen Knight-Lenihan
Marjorie van-Roon pp.167-181
- Implications of Spatial Sustainability on the Territorial Planning Framework in a Transition Country*
Alexandru-Ionuț Petrișor
Vasile Meîță pp.182-191
- Total Sulfur Deposition over Forest in Tropical Climates, Thailand*
Phuvasa Chanonmuang
Pojanie Khummongkol pp.192-200
- Ecological Study of Selected Lentic Water Bodies of Ahmadabad, Gujarat India*
Manisha Desai pp.201-205

- Applications of Sequential Power Flow Analysis for High and Low Voltage Distribution Systems to Energy Loss Evaluation for Dwelling Units or Buildings*
Nien-Che Yang
Rex Tsaihong pp.206-216
- Surveying Historic Buildings*
Valuing Sustainability in Places of Worship
Magdalini Makrodimitri
James Campbell pp.217-233
- Maintenance of Water Depth in Navigation Canals Versus Wetland System Loss- The Case of Canoly Canal, Calicut, Kerala, India*
Anjana Bhagyanathan
Kasthurba A.K pp.234-246
- Evaluation of Cadmium Concentrations in the Surface Sediments of Salt River Estuary, Taiwan*
Chiu-Wen Chen
Chih-Feng Chen
Cheng-Di Dong pp.247-252
- Sustainability through Subsistence: The Case for De-urbanization in Malaysia*
Nur Mohd Hussain
Hugh Byrd pp.253-266
- A Study of Feasibility of Pretreatment Process to Utilize Lignocellulosic Biomass as Materials for Biodiesel Production*
Malinee Sriariyanun
Patchanee Yasurin
Jirapa Phetsom
Kraipat Cheenkachorn pp.267-276
- The Consideration of Heat Reduction Hourly Schedule on Front Surface of Photovoltaic Module to Improve Efficiency*
Nuchida Suwapaet
Prapapit Boonla pp.277-285
- Key Issues on Designing and Implementing Emissions Trading System in China*
Ying Shen pp.286-299
- Modeling of a Single-chamber Microbial Fuel Cell Using Glycerin as an Energy Source*
Bunpot Sirinutsomboon
Napatsanun Wongsamajan
Katanyuta Sirikhum pp.300-313
- Adapting the Design Principles of Business Dashboards for Visualizing Status and Trends of River Water Quality - A Case Study of Yogyakarta Province, Indonesia*
Fahmi Machda
Firdan Machda pp.314-325

- The Effect of Accounting Information System Implementation on Accounting Information Quality and Its Impacts on Managerial Performance*
 Yaman Suryaman
 Sri Mulyani NS
 Sri Mulyani pp.326-339
- Bioenergy Potential Assessment of Wastewater Sludge and Forestry Waste in Taiwan: Financial Analysis and Life Cycle Assessment*
 Y. D. Huang
 H. H. Huang
 C. P. Chu
 Y. J. Chung
 K. T. Wu pp.340-352
- Power from the People: The Empowerment of Distributed Generation of Solar Electricity for Rural Communities in Malaysia*
 Nur Azfahani Ahmad
 Hugh Byrd pp.353-366
- Collecting Energy from a Planetary Entropic Stirling Engine*
 S. Kazadi, A. Schwartz
 J. Huang, R. Goy
 C. Koo, S. Choi
 J. Lim, A. Koh, J. Choi
 C. Koh, J. Wang pp.367-388
- An Impact Evaluation of Rural Electrification Projects in China*
 Xueting Wang pp.389-400
- The Sustainability of Cultural Heritage for Community-based Activity under Flood Disaster: A Case Study of Ayutthaya, Thailand*
 Wittaya Daungthima
 Kazunori Hokao pp.401-409
- Investigating Farm Land Ownership: Farm Land Owner's Response to Regional Growth and Sustainable Agriculture in Indonesia*
 Arrohman Taufiq Hidayat
 Satoshi Hoshino
 Shizuka Hashimoto pp.410-422
- A Simplified Mathematical Model to Predict the Thermal Physiological Responses of a Sleeping Person in Steady-state and Uniform Conditions*
 Pan Dong-mei
 Chan Ming-yin pp.423-434
- WEEE Recycling Network Design in China*
 Bibo Yang
 Renxia Chen pp.435-451

- Border Adjustments under Unilateral Carbon Pricing: The Case of Australian Carbon Tax*
 Mahinda Siriwardana
 Sam Meng
 Judith McNeill pp.452-469
- Energy Efficient Building Design: Revisiting Traditional Architecture*
 Naseer M A pp.470-482
- Environmental Impact Evaluation Using Cost Benefit Analysis and Multi Criterion Analysis: A Case Study of Rayong Province, Thailand*
 Nattanin Ueasin
 Suthin Wianwiwat pp.483-495
- The Potential of Tourist Attractions: A Case Study of 2 Rural Connecting Districts in the Western Part of Thailand*
 Areerut Patnukao
 Sirivilai Teerarojanarat pp.496-513
- Economic Effects of a Carbon Price on the Australian Economy: A Computable General Equilibrium Results*
 Disna Sajeewani
 Mahinda Siriwardana
 Judith McNeill pp.514-527
- Enhancing Coral Reef Resilience through Ecological Restoration: Concepts and Challenges*
 Tai Chong Toh
 Chin Soon Lionel Ng
 Loke Ming Chou pp.528-545
- Current Status of Coral Reef Restoration in Singapore*
 Chin Soon Lionel Ng
 Tai Chong Toh, Loke Ming Chou pp.546-558
- Drylands Agriculture and Prevention Strategy of Environmental Agroecosystem Damage in Kabupaten Musi Rawas, South Sumatra*
 Agustina Bidarti pp.559-565
- Introduction of Renewable Energy into City-Chino in Nagano*
 Tetsuya Takano
 Hiroshi Kawamura pp.566-573
- Conception of a New Water Collection System Using LiBr Solution for Dry Area*
 Lu Zhou
 Cyril Cassisa
 Xungang Diao pp.574-585

Assessment of Productive and Environmental Efficiencies of Japanese Industries
Mika Goto
Akihiro Otsuka
Toshiyuki Sueyoshi pp.586-599

Assessment of the Analgesic Activity of Musa Paradisiaca Linn Peels of the Family Musaceae
Rommel John Reyes
Ar-Raquib Abdulla
Jaime Jr Bisa
Henedina Maini
Judilynn Solidum pp.600-612

Evaluation of Diuretic Activity of Ethanolic Extracts of Plumeria Acuminata W.T. Aiton (Fam. Apocynaceae) Leaves In Rats
Omar A. Villalobos
Asmirah A. Solaiman
Paula Denise G. Jimenez
Joanna Marie V.
Franco, Nikka G. Mago
Danette Nica Nicdao
Mary Sol Apita, Kathrina Mae Dulva
Judilynn N. Solidum pp.613-620

How Does the Energy Industry Deal with Climate Change? - Perception and Actions of the Energy Industry on Climate Change.
Yeon Ji Kim
Ju Youn Kan pp.621-632

Emerging Issue in a Proper Recycling Technology for the Non-Metallic Portion Separated from Printed Circuit Board Scrap: A Pyrolysis Based Recycling Approach
Songpol Boonsawat
Sunil Heart
Premrudee Kanchanapiya
Erik L. J. Bohez
Yuttakan Makphan pp.633-636

Widening Access or Narrowing Student Choice? The Re-emergence of Elitism in the UK Higher Education System
Steve Talbot
James Johnston
Alan Reeves pp.637-647

- Parametric Study of Earth-to-Air Heat Exchanger in Malaysian Climate*
Md Najib Ibrahim
Aliyah Nur Zafirah Sanusi
Maisarah Ali
Sorani Hama Aziz Ahmed pp.648-656
- Promoting Sustainability In Selected African Fashion Design Institutions*
Anne Mastamet-Mason
Ruth J L Cheluget
Roselyn Kent-Onah pp.657-668
- Sustainable City Indicators for Greater Mekong Sub-Region: Cases from Thailand and Lao PDR*
Alice Sharp
Niparat Sritharet
Apinan Pongmethakul
Sirin Jaithieng pp.669-676
- A study of feasibility to utilize lignocellulosic biomass as materials for biodiesel production*
Patchanee Yasurin
Treuktongjai Saenghiruna
Jirapa Phetsomb
Malinee Sriariyanun pp.677-684
- Assessment for Sustainable Solid Waste Management in Nakhon Ratchasima City Municipality, Thailand*
Siriporn Boonpa
Alice Sharp pp.685-692
- A Study in Information Usage Behavior of Students in Rajabhat Rajanagarindra University*
Waraporn Sinthaworn pp.693-701
- Firm level motivations and barriers for initiating sustainability transitions in the Norwegian energy system*
Tyson Weaver pp.702-714
- Social Green as a Strategy to Design Sustainable City in Developing Countries A case study of Surabaya*
Citra Hennida pp.715-728
- Determination of Energy consumption in Pest Control Using pesticides in New Zealand*
Majeed safa pp.729-741
- Political Participation in Sport Development of Thailand*
Saowalee Kaewchuay
Sutus Sikaewkae
Eakrat Onnom
Patreeya Kitcharoen pp.742-748

"Sustainability, Environment and Tourism in Cape Coast: Searching for Synergies"
Monica Frimpong
Vida Commey
Akosua Afriyie Nkrumah pp. 749-767

Development of a Sustainability Indicators Framework
Yih Tng Chong
Kwong Meng Teo
Eng Seng Chia pp. 768-777

*The impact of energy transition on sustainable supply chain management of oil and gas:
A content analysis of corporate sustainability reports*
Wan Nurul Karimah Wan Ahmad
Marisa P. de Brito pp. 778-791

*The Preparation of a Strategy Plan at Community Level to Produce Diesel Fuel from
Biomass of Fast Growing Tree Species*
Kittapas Suppagornmongkol
Nikom Laemsak
Panapa Saksoong pp. 792-798

*The Study and Research of Wind Energy for Electricity Generator in Chana District,
Songkhla THAILAND*

Thanat Nonthaputha, Piya Prasongjan, Jirapat Phookwantong

Rajamangala University of Technology Srivijaya, Thailand

0007

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This article is aimed to study and research about the wind energy for the electricity generator around Chana District, Songkhla province (Southern of Thailand), Thailand. The experiment used three vertical wind turbines, 12 volts 200 watts electric current, charger control, 1,500 watts battery, and 525 watts inverter. This study revealed that the wind energy can generate the electricity for electric equipments at least 3 hours a day. It is concluded that the wind energy is an alternative power which can save the limited resources for the electricity generator.

Keywords: Wind, Electricity, Energy

1. Introduction

Environmental problems are national and global problems, mainly due to population increasing [1] and the kinds of new technology that destroy environment. While the basic needs of the population living, the resources are in a constant state, some are decreased and some are extinct or disappeared. In the past and also in a present time, human use of natural resources is very wasteful with the use of chemicals. This problem causes a crisis environment that affects human life [2]. In 2010, southern part of Thailand was affected by depression, there was flood, homes were damaged and no electricity [3]. And in 2011, [4] it was a torrent and flood that affected the people who live in many areas.

Moreover, the cause of environmental problems also is the growth of industrial cities that uses more electric power and many other kinds of power. So, the renewable energy such as wind energy and solar energy by clean technology or environmentally friendly technology is the interesting option to reduce the power using [2].

The wind energy for the primary energy to produce electricity research by using wind turbine is an environmentally friendly technology that is a worthwhile investment in lowering the cost of electricity in the household. Songkhla province has a high potential for wind energy [5] because it has a long coast and it is windy areas that appropriate to bring wind power into energy to produce electricity. So that, this paper studied the wind turbine to produce electricity at Chana Technical Collage, Chana district, Songkhla province in order to meet energy saving and environmentally friendly.

2. Types of Wind Turbine

A wind turbine is a device that converts the kinetic energy from the wind into the mechanical energy for the electricity production system [7]. A wind turbine for generating electricity has 2 types. It is considered from the rotation axis about either a vertical or horizontal axis shown in figure 1 and figure 2 respectively. Their difference is the end of the spindle rotor but they all have the same materials for electricity production such as the rotor blades, the nacelles, the generator sets, and the towers[6].



Figure 1. Vertical axis wind turbine



Figure 2. Horizontal axis wind turbine

3. The Components of the Wind Turbine for Electricity Generation

In [8], The wind turbine is composed of the main components that shown in Fig.3.

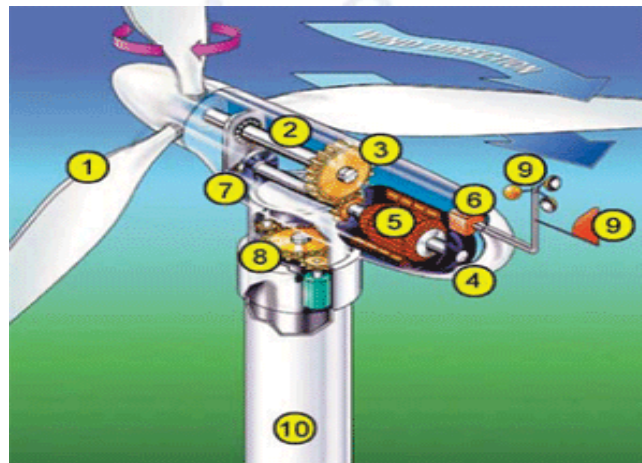


Figure 3. The wind turbine for electricity generator components

No.1 Blades: They are holed by a rotor hub, the power from the rotor hub is transmitted to a rotor blade and converts the wind energy into the mechanical energy.

No.2 Rotor blade: It gets the power from the rotor axis and transmitted by a system capacity to spin the generator.

No.3 Gearbox: It modifies and controls the speed of rotor blade and generator axle rotation.

No.4 Nacelle: It is a packaging system of the wind turbine that composed of gear system, generator, brake system, and controlling system.

No.5 Generator: It transmits the mechanical energy to the electricity energy.

No.6 Controlling System: It is an operation and power supply control system which is controlled by a computer system.

No.7 Brake system: It is used to control and stop the blades and rotor blade rotation during the maintenance when the wind speed is more than its carrying capacity.

No.8 Yaw drive: It is the nacelle rotation control to take the blades to the wind direction by electronic system.

No.9 Anemometer and wind vane: They connect a cable into a computer system. There are the wind speed and direction indicator that make the computer to control other mechanisms.

No.10 Tower: It bears all the components that are on its top.

4. The Wind Turbine for Electricity Generation Design

Figure 4 shows the wind turbine for electricity generator diagram that composed of 4 parts. The wind turbine generates the electricity for the wind turbine rotating when the wind is blowing and the dynamo that turns the mechanical energy into the electrical energy. The battery charger, its duty is to control the battery charging for a stable charging that generate the 12 volts 125 amps 1,500 watts DC voltage. And the 12 volts DC battery that is the source of energy which the DC voltage is transmitted to an inverter. The converter transmits the DC voltage to be 220 volts AC voltage and then supplies the power to the electrical equipments.

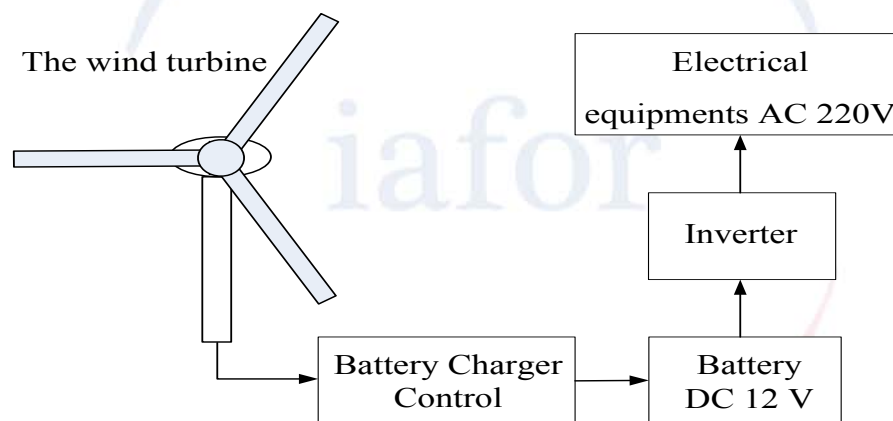


Figure 4. Block diagram of the wind turbine for electricity generator components



Figure 5. The Automatic wind generator charger controller (front side)



Figure 6. The Automatic wind generator charger controller (back side)



Figure 7. Battery



Figure 8. Inverter

Figure 9 shows the wind turbine installation at the 5th floor ceiling of an electronic department building, Chana Technical Collage, Songkhla Thailand. The wind turbine was connected with the battery charger control (shown in Fig.5 and Fig.6 respectively) and the battery (shown in Fig.7) in the operating room by the electric cord. And Fig.10 shows the functional testing that the battery charger control, the battery, the inverter and the electrical equipment were connected, respectively.

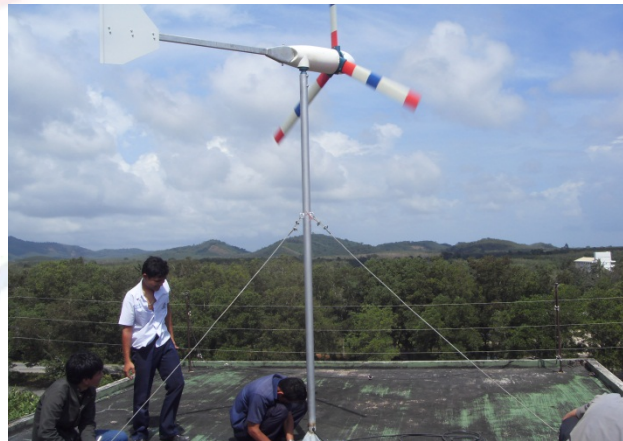


Figure 9. The wind turbine for electricity generator



Figure 10. Functional testing

5. The Results

The research of wind energy for electricity generation was studied at Chana Technical Collage, Chana, Songkhla, Thailand. The wind speeds were collected in the monsoon between November 2010 to October 2011) as shown in table 1. The study revealed that the highest average wind speed was in April at 6.35 meters per second and the lowest was in November at 3.87 meters per second.

Table 1. The averages of wind speed between November 2010 to October 2011

Years	Months	The averages of wind speed (meters/second)
2010	November	3.87
	December	5.97
2011	January	4.50
	February	5.60
	March	5.20
	April	6.35
	May	5.03
	June	4.95
	July	5.10
	August	4.90
	September	4.40
	October	4.25

Table 2 shows the electricity that generated by the wind energy. It was revealed that the battery charging in November, the lowest average wind speed month, was the longest charging which took 24 days to generate 1,500 watts (63 watts per day). On the other hand, the battery charging in April, the highest average wind speed month, was the shortest charging which took 9 days to generate 1,500 watts (167 watts per day).

Table 2. The averages battery charging per day

Years	Months	Period of 1,500 watts charging (days)	The averages of electricity per day (watts)
2010	November	24	63
	December	12	125
2011	January	20	75
	February	14	107
	March	16	94
	April	9	167
	May	17	88
	June	17	88
	July	17	88
	August	17	88
	September	18	83
	October	18	83

6. Conclusion

The study and research of wind energy for electricity generation at Chana Technical Collage, Chana, Songkhla that composed of 3 blades vertical axis wind turbines, 12 volts 200 watts dynamo, battery charger, and 1,500 watts battery concluded that it generated electricity the highest and the lowest in April, 2011 and November, 2010, respectively. It generated the electricity for the electrical equipments at least 2 hours per day. Therefore, the wind energy is an alternative energy that is not only save the limited resources but also be friendly to environment.

References

- [1] Kukiet Thungprakitthikhun. 2007. Environmental Problems in Thailand. Source. <http://www.lks.ac.th/kukiat/student/betterroyal/social/25.html>, May 12, 2010.
- [2] Prayong Wongpha Environmental situations and problems. Source http://www.dongjen.ac.th/webdongjen/sua/web_singvadlom/unit_4_2.html. May 30, 2010.
- [3] Khom chad luek online. 2010. Songkhla was hit by the storm-No electricity in Phatthalung. Source <http://www.komchadluek.net/detail/20101102/78121>.
- [4] Coordination Center for disaster victims. 2011. Nakhorn Si Thammarat. Source <http://nakornsriathammarat.thaiflood.com/>, April 17, 2011.
- [5] 2010. The biggest wind turbines in Thailand is at Huasai, Nakhorn Si Thammarat. Source : <http://www.oknation.net/blog/nn1234/2010/06/04/entry-1>, April 25, 2011.
- [6] 2008. Wind Turbine Technology. Source : <http://www.prapai.co.th/knowledgeview.php?nid=29>, May 5, 2011.
- [7] http://en.wikipedia.org/wiki/wind_turbine
- [8] Electricity Generating Authority of Thailand. Wind turbines technology. Source : http://www2.egat.co.th/re/egat_wind/wind_technology.htm, May 5, 2011.

Status and Trends of Renewable Energy Development in Gaza

Anwar Abu-Zarifa

Islamic University of Gaza, Palestine

0028

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org

1. Introduction

According to the Political situation on Gaza Strip and the mandatory siege since 2006 by the Israeli occupation after Palestinian election, Power Generation Sector faced several obstacles starting with destroying main generators of Gaza Power Plant in June 2006 through blocking fuel entry into Palestinian Territories in 2008 ending to unknown and horrible situation.

Total energy consumption in the Palestinian Territories is the lowest in the region and costs more than anywhere else in the Middle East [1]. The people in Gaza get only 0.17 kWh energy-shares per capita, in comparison to Israel 6356 kWh per capita [2].

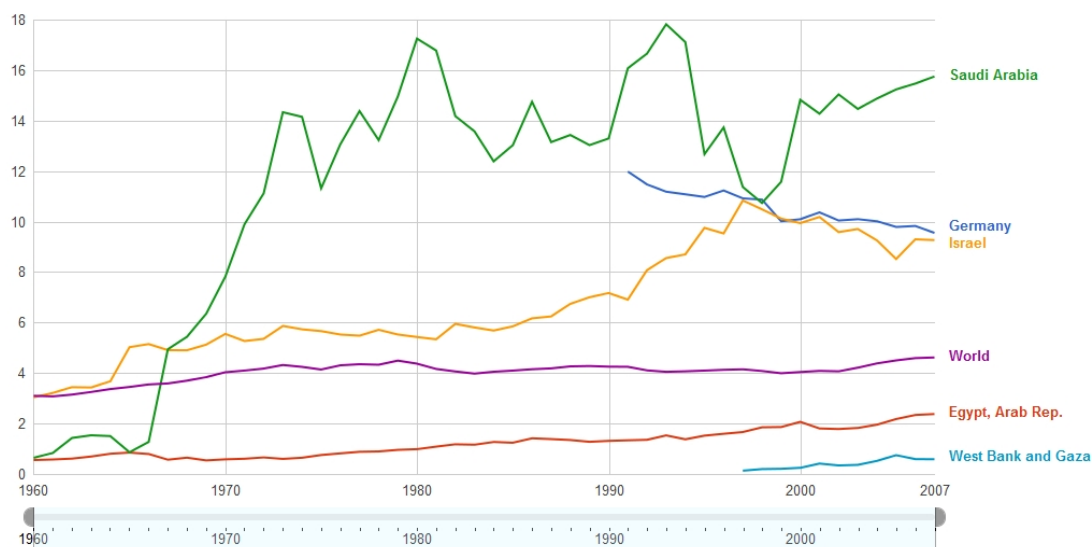


Fig.1 CO2 Emissions in West Bank and Gaza Strip (metric tons per capita)[3].

Therefore, the CO2 emission in Gaza Strip in comparison to other countries is minimal. Carbon dioxide emissions are those stemming from the burning of fossil fuels. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

2. Energy Situation in Gaza

The total amounts (100%) of fossil fuels consumed in the Gaza Strip are imported. Gaza is completely dependent on Israel for all its supplies of fuel. Fuel enters Gaza via underground pipelines which cross the Israel-Gaza border at Nahal Oz. The fuel comes in four types:

- Industrial gasoline - exclusively for Gaza's power plant for the production of electricity.
- Gasoline - for vehicles.
- Diesel - for vehicles and back-up generators which are vital during Gaza's frequent electricity cuts.
- Cooking gas

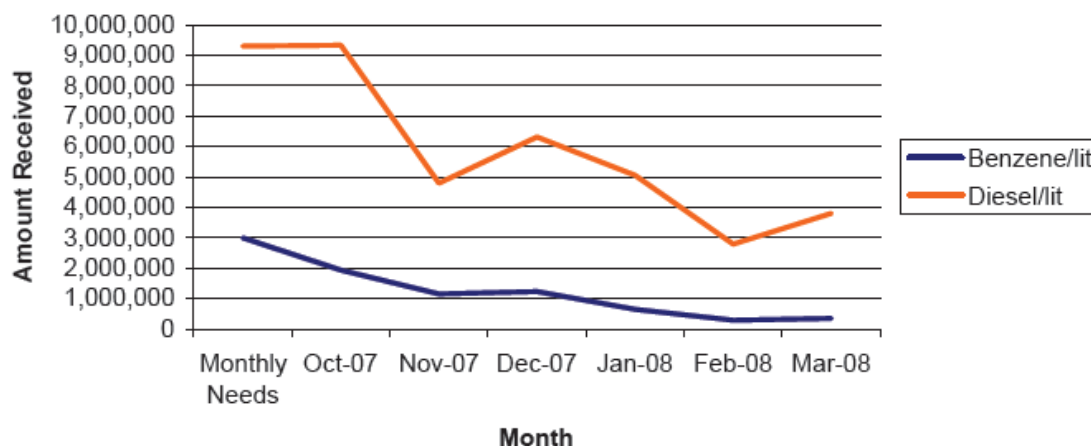


Fig. 2 Petrol and Diesel Supplies into Gaza

Before 28 October 2007, Gaza’s fuel supplies were dictated by market forces and supply was related to demand. On 28 October, following a decision of Israel Government to declare the Hamas government a ‘hostile entity’, Israel began reducing the supply of fuel to Gaza. In March 2007, 8.8 million liters of diesel and 1.7 million liters of gasoline were supplied to Gaza. In March 2008, the figures were reduced to 3.8 million liters of diesel and 340,000 liters of gasoline, representing a reduction of 57% and 80% respectively [4].

3. Electricity distribution in Gaza

The Gaza Strip’s needs range between 240 and 280 megawatts (MW), of which at least 42 percent is purchased from Israel. Gaza is connected from north to south by eleven connection points with Israeli power network, via transmission lines with 22 Kilovolt and total capacity of 115MW. In Gaza, the power supply comes from three sources, Israel, Egypt and generated by its own Gaza power plant (GPP). Currently, the Gaza Strip’s needs range 350 megawatts (MW), of which at least 42 % is purchased from Israel, distributed in separate feeder lines along the Gaza Strip, and 6-7 % is purchased from Egypt, distributed mainly to the Rafah area.

The remaining electricity need is supposed to be met by the GPP. Following the latest decline in production, however, the GPP is able to meet less than 13 % of the electricity needs. This is resulting in a deficit of up to 51 %, compared to 21% in 2009. Figure 3 shows the various electricity suppliers with its related shares in Gaza between 2005 and 2012 [5]. Figure 4 shows a Map of the Power Supply Deficit in the Gaza Strip, the following facts come from the United Nations Mai 2010 [6]. The Gaza Electricity Distribution Company copes with the electricity shortage by applying a load sharing system, through which it schedules electricity cuts in one area in order to feed another.

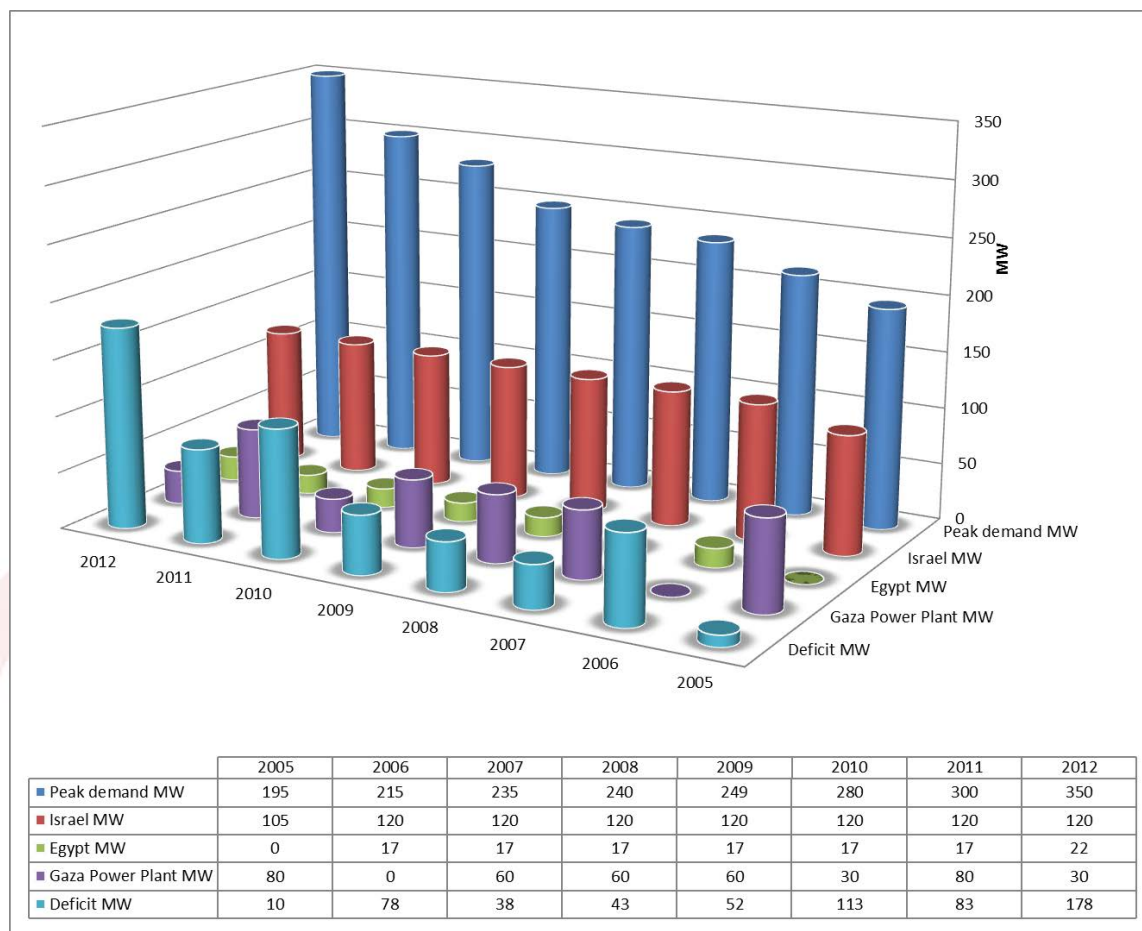


Fig.3 Electricity supply in Gaza Strip between 2005 and 2012

In June 2006, Gaza only power plant was destroyed. The plant was capable of producing up to 140 MW. Since the bombing, eight new transformers have been installed, with a maximum output of 80 MW. The power plant was fully dependent on fuel supplies from Israel. The plant needs 3,300,000 liters of fuel per week to produce 78MW but the Israeli occupation allow for just 2,200,000 liters as a minimum amount per week which sufficient to generate 55 MW only [7]. Palestinian engineers have made it possible to operate the power plant with cheap fuels coming currently official from Egypt through Israelis. That can always change according to political circumstances, and the Israelis can any time block the delivery of the necessary fuels.

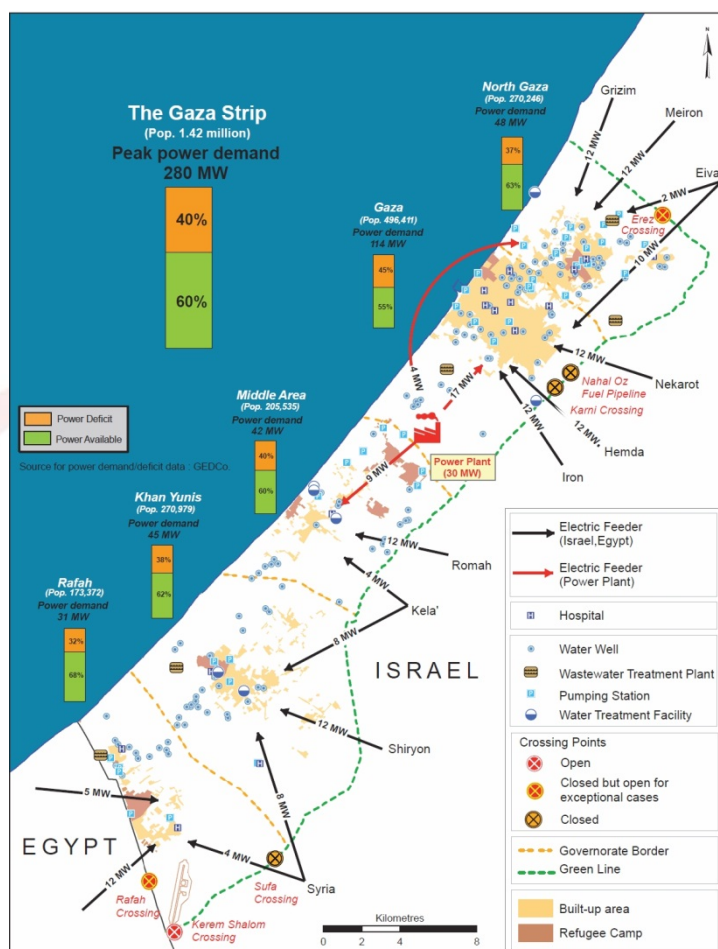


Fig.4 Power Supply Deficit in the Gaza Strip in Mai 2010

In June 2006, Gaza only power plant was destroyed. The plant was capable of producing up to 140 MW. Since the bombing, eight new transformers have been installed, with a maximum output of 80 MW. The power plant was fully dependent on fuel supplies from Israel. The plant needs 3,300,000 liters of fuel per week to produce 78MW but the Israeli occupation allow for just 2,200,000 liters as a minimum amount per week which sufficient to generate 55 MW only [7]. Palestinian engineers have made it possible to operate the power plant with cheap fuels coming currently official from Egypt through Israelis. That can always change according to political circumstances, and the Israelis can any time block the delivery of the necessary fuels.

4. Renewable Energy Trends

The potential threat of global climate change increasing energy demand of the developing world, and inevitably, although not rapidly, diminishing fossil fuel resources have made sustainable energy supply a planetary issue that has to be addressed by literally every sector of human life. At the same time buildings continue to play a significant role in the global energy balance. Typically they account for some 20-30% of the total primary energy requirements of industrialized countries. With increasing awareness of the ecological consequences of energy consumption, the

need for energy and environment conscious building design has become more and more pressing [8].

Using renewable energy has become a global trend. In 1997, the Kyoto Protocol was agreed upon; it is the world's only international agreement with binding targets to reduce greenhouse gas emissions. As such, it is the primary tool with which governments of the world can address climate change; so far, 129 countries have ratified or acceded to the protocol [9]. The effect of the Kyoto Protocol has no role in Gaza. Furthermore the energy authorities do not consider at the details of this Protocol, because the Gaza Strip counts of the few countries with minimal CO₂ emissions. In particular in Gaza gets the use of alternative energies more and more significant interests of the nation, increasing trend. Main reason for these increasing trends is the will of Gaza People to be independent on the Israeli fuel imports. The first step toward Palestinian energy independence and security would be the development of its renewable energy sources, both for large-scale energy production and smaller-scale, standalone systems [1]. "Also renewable energy promotes independence".

a. Solar energy

On the super-regional level, the continent Africa has a great photovoltaic solar electricity potential. Gaza Strip is in the average of overall potential of Africa [10]. According to the U.S. National Aeronautics and Space Administration NASA, Gaza Strip receives high radiation levels ca. 5.5 kWh/m² per day annually [11].

□

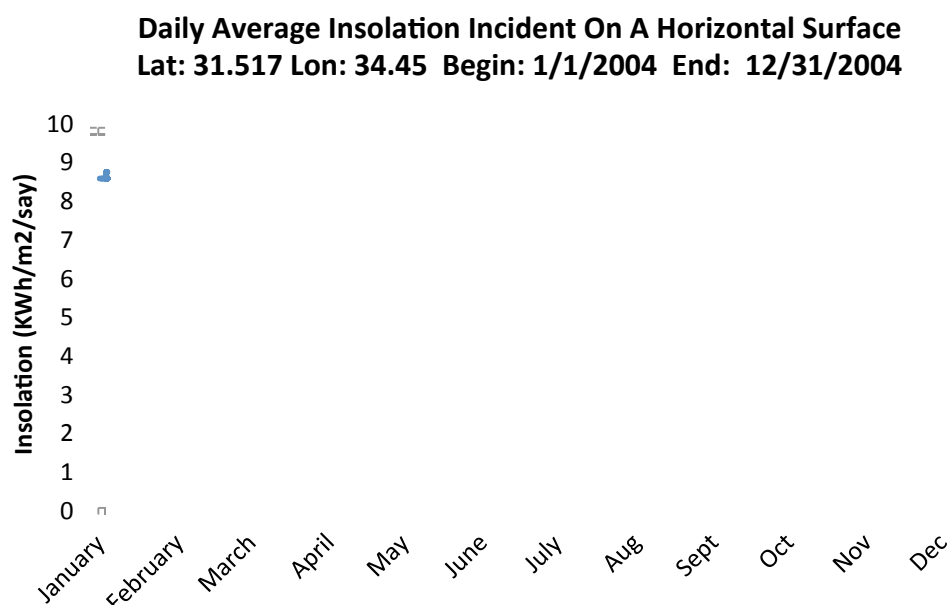


Fig.5 Solar Irradiance in Gaza, 2004

The total annual sunshine is approximately 3400 h. These are excellent conditions for harnessing solar energy for both large-scale and stand-alone applications.

Indigenous energy resources are quite limited to solar energy for photovoltaic and thermal applications, mainly for water heating. Utilization of solar energy for water

desalination is still the subject of research and investigation in Palestine, and also of course in Gaza Strip [12].

There are three major application of solar energy in Gaza; Solar dryers, Solar thermal panels (solar water heaters) and Photovoltaic Systems PVS. The Solar Dryers are used little in Gaza. Drying fruits and vegetables with this system is a cost-effective long-term food storage solution that requires no external electricity to operate, and eliminates the need for chemical preservatives. The aid organizations fund usually these devices to the farmers in villages.

Solar water heaters are extensively used in the residential sector in Palestine more than 70% of households use solar family systems. The existing installed capacity (up to year 2007, Source: Palestinian Central Bureau of Statistics PCBS) in all sectors is totaled 1,500,000 m². This can produce 940 GWh per year and saves 85 M€ yearly to the national economy. The corresponding avoided emissions of CO₂ are evaluated at 650,000 tons per year or avoided damage 2.3 M€ [12-13].

The max kilowatt PV system installed in Palestine is about 50kwp (The Palestinian Energy and Environment Research Center PEC), there are numbers of PV system projects are implemented in Palestine's villages in West Bank. The installation of PVS in Gaza is still comparable to the West Bank is very low. The Reasons for that are different, especially the height cost, the lack of experienced personnel and the difficulties of the imports PV-Modules. Unfortunately, the PV modules, Voltage Regulators and inverters which available in Gaza strip are limited [14]. Nevertheless, some projects have been implemented in Gaza; Gaza municipality lights some main streets using PVS, Fig. 6 shows an example of Street lighting by Wadi Gaza (Valley of Gaza). The system is currently does not work due to shortage of maintenance. In the Shifa hospital in Gaza City, a 5 KW PV-solar system was powered the intensive care unit ICU. On the roof of the kindergarten Umm al-Nasser in Khan Yunis, a city in the southern Gaza Strip, was installed a 10kW PV-solar system.



Fig.6 PV Street Lighting System at the Valley of Gaza

b. Wind energy

Wind, available in nature as a result of the different levels of earth surface heating, produces kinetic energy which can be converted into mechanical or electrical energy by means of two types of wind energy conversion technologies (WECT): horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). The amount of power extracted by this WECT is represented by the following Eqs. (1) and (2):

$$P_{WT} = C_p(\lambda, \omega) \frac{1}{2} \pi R^2 \rho v^3 \quad (1)$$

$$\lambda = \frac{\omega R}{v} \quad (2)$$

Where C_p is the wind power coefficient (function of pitch angle, ω and tip speed ratio, λ), R is the rotor blade radius (m), ρ is the air density (kg/m^3) and v is the wind speed (m/s). The first equation indicates that the generated wind power has a large dependency on wind speed (generated power is proportional to the cube of wind speed), hence a slight wind speed change can significantly affect the overall output of the wind turbine. As the wind speed is an important parameter, this study shows the wind speed measurement at 100 m hub height above ground level (AGL) [15].

Usually, Wind speed and direction are basic data required to identify wind resource in a site, however, these data need to be analyzed in a proper way to provide us better understanding of wind characteristics. Wind resource assessment studies have been conducted in the Israeli side and the Palestinian side before; however, the previous studies were restricted with the political border either Palestinian or Israeli except one of them that was based on measurements dated to 1940-1983 [16]. Moreover, the studies were performed years ago, with simple techniques and based on old data [1, 16].

The wind resource assessment ends up with identifying sites with higher potential that are situated in four selected sites, North of Palestine/Israel, North of West-bank, Jerusalem, and Eilat, the higher potential was in Eilat area bearing mean wind speed of 9.88m/s at 100 m hub height.

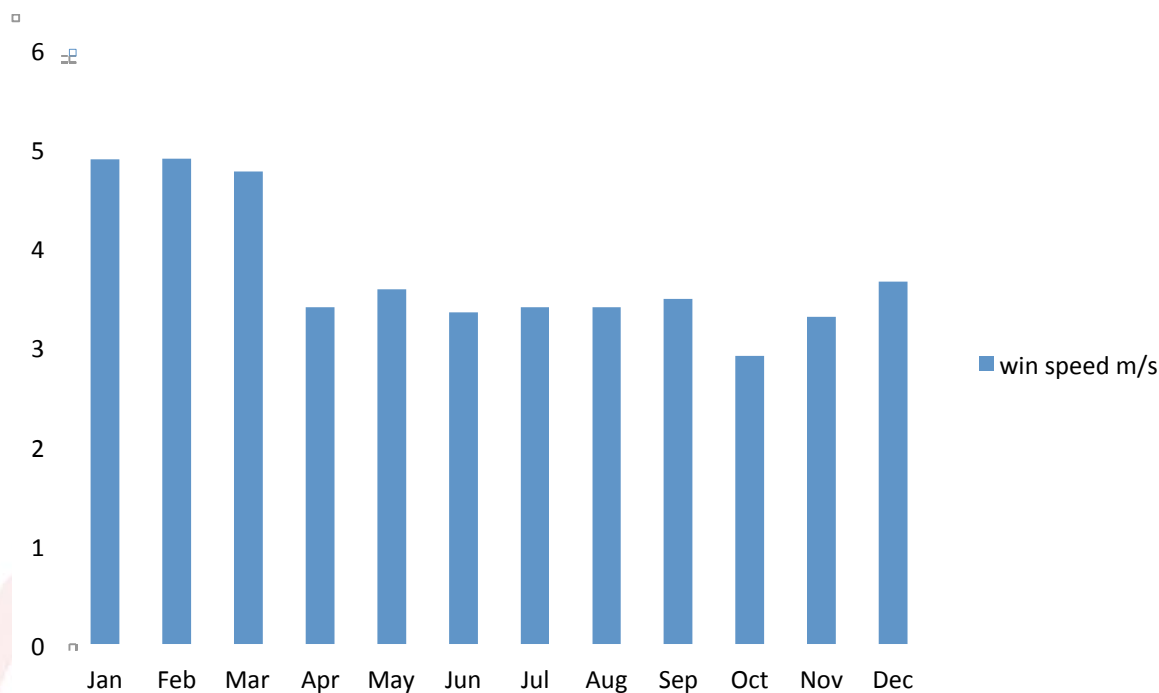


Fig.7 Average Wind Speed in Gaza Strip, 2012

Figures 7 show histograms of the observed wind speed in Gaza. Data has been collected in year 2012. The direct coastal location on the Gaza beach ensures passage-free wind and so the wind turbine harnesses most of the wind energy because of the absence of any obstacles. The average annual wind speed recorded in Gaza is 3.75 m/s , and the highest wind speed recorded is 18 m/s in winter . With such wind speeds it is feasible to construct a wind-energy system in this geographical location. The number of days-of-autonomy, where the wind speed will be less than the speed limit required for the turbine blades to rotate and turn with them the electric generator, is approximated to 6-days in July according to the wind speed records of Gaza.

Table 1 and Figure 8 provide an overview of wind directions that were measured during the year 2012 in Gaza. Wind Direction in Gaza Strip is between south-west and north-west, but the average could be determined to 247.5°, also WSW.

Tab. 1 Average Wind Direction of the Year in Gaza, 2012

M/D	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	SW	WSW	WSW	SE	WSW	WSW	NW	SW	NW	WNW	SW	ESE
2	WSW	W	W	W	WSW	WSW	NW	NW	NW	NW	ESE	N
3	NE	ENE	W	SW	W	WSW	WSW	NW	NW	NW	NNE	SSW
4	NE	E	WSW	S	NW	NW	NW	WNW	W	NW	SW	WSW
5	W	E	NNW	NW	SW	NW	NW	W	NNW	WNW	NNE	WNW
6	SW	ESE	NNW	NNW	WSW	NW	NNW	WNW	NNW	NW	S	SSW
7	SE	SSW	ESE	ESE	NW	NW	WNW	WNW	NNW	WNW	SSW	SW
8	SW	WSW	ENE	SSE	WSW	WSW	WNW	SW	WNW	WNW	NW	SW
9	SSW	WSW	NNE	W	NW	WSW	WNW	SW	W	NW	WSW	ENE

10	SW	W	NNE	WNW	WNW	NW	WSW	SW	NW	NNW	WSW	SW
11	SW	NE	E	WNW	NW	NW	NW	WNW	WNW	SW	W	WSW
12	SW	ESE	WSW	NW	SSE	NW	NNW	NW	WNW	E	WSW	SE
13	WSW	WSW	WSW	SW	W	NNW	NNW	NW	NW	NNW	NNW	W
14	SW	W	W	E	WNW	NW	WSW	NW	W	E	NW	NNW
15	SSW	W	W	S	WSW	WNW	WNW	WNW	WSW	ENE	NE	S
16	SW	W	W	WSW	S	NW	NW	WNW	NNW	S	ESE	NW
17	WSW	WSW	SW	SE	NW	NW	NW	NW	WSW	SSE	ESE	SSE
18	E	W	ENE	SSW	SSW	NW	NW	S	SSW	SW	WNW	S
19	NW	WNW	ENE	W	W	NW	NW	WSW	S	NW	NW	SSW
20	NW	NE	E	WSW	NW	W	WNW	NW	SSW	NW	S	SW
21	S	ENE	S	NW	NW	W	WNW	NW	NNW	NE	N	WSW
22	WSW	ENE	WSW	NNW	WSW	WNW	WNW	NW	NNW	NW	WNW	SSW
23	W	0	SE	NW	WSW	SW	SW	NW	NW	NNW	WSW	SE
24	S	NNW	ENE	WSW	NW	SW	NW	NW	NW	NNW	NW	
25	S	NW	WNW	NNW	SW	W	WNW	NW	NW	WNW	NW	SE
26	SW	WSW	WNW	NW	NNW	WNW	WNW	NW	WSW	W	NW	NNW
27	WSW	WSW	W	NW	SSW	WNW	WNW	WNW	SW	NNW	NE	NNE
28	WNW	SSW	WSW	NW	E	W	NW	WNW	NNW	ESE	ENE	NNW
29	0	WSW	WSW	SSW	WNW	WNW	WNW	WNW	WSW	NNW	ESE	NW
30	SE		W	SSE	WSW	WSW	WNW	NW	S	NNW	ESE	S
31	SW		SSW		NNW		WSW	WNW		NNW		N
Average	SSW	S	WSW	WSW	W	WNW	WNW	WNW	WNW	W	SSW	SSW

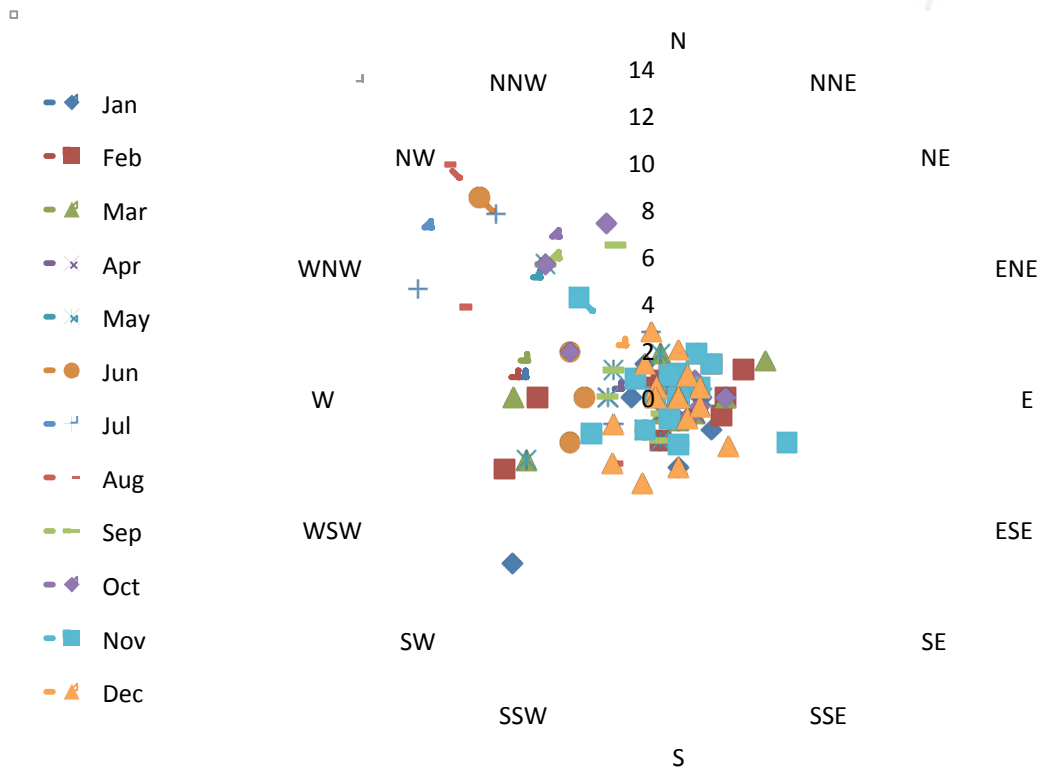


Fig.8 Wind Direction distribution in the Gaza strip, 2012

Running huge wind turbine (more as 1 MW) to generate electricity, which need wind speed not less than 10 m/s, is not recommended in Gaza Strip. However, this wind speed range can be used for small wind turbines' electricity generation. The high density of buildings and the scarcity of open and empty lands in the Gaza Strip obviate the possibility of building wind farms there. However, offshore wind farms could be installed in the Mediterranean Sea, were it not for present political obstacles. Today, the only large-scale wind turbine in the Palestinian Territories is at the Al-Ahli Hospital in Hebron. This turbine provides 40% of the hospital's energy needs [1]. The low speed winds in the Palestinian Territories may encourage using wind energy in stand-alone systems to provide small electricity loads, such as for water pumping, grain grinding and other purposes. Indeed, wind energy could make an important contribution to meeting the energy needs for development in rural areas, where 17% of the Palestinian population resides. Wind energy can be used to pump water that is stored in tanks and reservoirs or absorbed in the ground as well.

c. Waste-to-energy

Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of creating energy in the form of electricity or heat from the incineration of waste. WtE is a form of energy recovery. Most WtE processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels [17].

There are a large number of technologies on the market at the moment and the use of many terms and definitions, with often different meaning. This reduces the possibility of comparing the different options.

1. Energy from Waste (E
2. fW); is the process of creating energy in the form of electricity or heat from the thermal breakdown of waste through any thermal conversion technology or combination of conversion technologies. Any technology discussed in this paper is an EfW technology. With conventional EfW we mean grate fired or fluidized bed combustion of waste.
3. Combustion/incineration; is the thermal breakdown of waste supplying an excess of air, producing a flue gas (CO₂, O₂, N₂, water vapor) and heat.
4. Gasification; is the thermal breakdown of waste under oxygen starved conditions (oxygen content in the conversion gas stream is lower than needed for combustion), thus creating a syngas (e.g. the conversion of coal into city gas).
5. Plasma gasification; is the treatment of waste through a very high intensity electron arc, leading to temperatures of > 2,000°C. Within such a plasma, gasifying conditions break the waste down into a vitrified slag and syngas.
6. Pyrolysis; is the thermal breakdown of waste in the absence of air, to produce char, pyrolysis oil and syngas (e.g. the conversion of wood into charcoal) [18].

The daily solid waste generation across Gaza is more than 1450 tons (ca. 1.0 kg per capita). Nearly 65% of this waste is estimated to be organic, implying real opportunities for waste disposal schemes that emphasize recycling [19]. Scarcity of

waste disposal sites coupled with huge increase in waste generation is leading to serious environmental and human health impacts on the population.

The severity of the crisis is a direct consequence of continuing blockade by Israeli Occupation Forces and lack of financial assistance from international supporting helps organization. Most of the collected solid waste in the GS is disposed of in three main disposal sites; Johr al Deek Landfill east of Gaza City, Sofa Landfill east of Rafah City, and Deir El Balah Landfill in the Middle Area of GS. The three sites are reaching their maximum capacity, in addition to the fact that the expected amount of solid waste is expected to reach around 3700 tons/day in 2040. Accordingly there is a growing need for establishing an integrated Solid Waste Management (SWM) that to adequately handle the growing waste generation rates in GS with minimum impacts on public health and the environment. A sustainable solution with respect to social, environmental and economic impacts is therefore needed for the solid waste management in the GS [20].

Because a high proportion of the waste is organic, it may be environmentally preferable to incinerate solid waste. The Biogas potential in Palestine is over than 33 million m³. Biomass (wood and agricultural waste) is traditionally used for cooking and heating in rural areas. Being Palestine one of the many olive oil producing countries in the region, the interest now is directed to utilize the olive mill solid waste (OMSW) to be used as clean source of energy. The olive harvest season is all year round and so the OMSW as a raw material is also constantly available. The annual average amount of OMSW is around 76,000 tons. The municipal solid waste in Palestine could be used as a source of energy, a new developing proposal projects were released by PEC to generate electricity from burning the wastes (WtE). The proposal project is for constructing an 18 MW waste to energy (WtE) power plant in order to get rid of municipal solid waste (MSW) of the northern provinces of the west bank; this is done by a controlled combustion of the wastes which is exploited generate electricity. All technologies of WtE are in Gaza not available. The usage of waste to produce electricity was executed by a research project at the Islamic University of Gaza by students, but unfortunately remains in the theoretical phases, at least for short term. In addition, there is due to financial and political situations in Gaza Strip can probably wait a long time for released projects regarding WtE.

5. Conclusion

Gaza is a fossil energy-poor country. Alternative energy resources can play knight role in Gaza, if the financial support available is. By stretch of the imagination and enough research, a trend in Renewable Energy could be realized, so that the deficiency in electricity could be prevented.

Moreover, the use of solar energy plays an important role. The wind, geothermal and WtE Energies have no great potential in Gaza Strip. The best in this period of time and due to lack of financial resources, the research in solar energy should be concentrated.

In addition, Establishing of a center interested in renewable energy sources is very important which the primary purpose of this center is to promote, coordinate, facilitate and implement research and development projects in renewable energy sources,

conservation and sustainability practices, and to bridge the gap between the state-of-the-art and the state-of-practice in alternative energy utilization in Palestine.

References:

- [1] T. Abu Hamed, H. Flamm, M. Azraq, *Renewable and Sustainable Energy Reviews* 16 (2012) 1082-1088
- [2] World Development Indicators database, The World Bank, 2007
- [3] Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States. Sources World Development Indicators.
- [4] Gaza Humanitarian Situation Report Gaza Fuel Crisis, UN Office for the Coordination of Humanitarian Affairs, 2008
- [5] Data Source, Gaza Electricity Distribution Co. limited GEDCo
- [6] GAZA'S ELECTRICITY CRISIS, United Nations Office for the Coordination of Humanitarian Affairs occupied Palestinian territory, Fact Sheet, 17 MAY 2010
- [7] A. Naim, O. Al-Najjar, A. Kassem, Project Research, Building Electrification Using Photovoltaic System, Ministry of Energy and Natural Resources, Gaza Strip, 2003.
- [8] Photovoltaics in Buildings: A Handbook for Architects and Engineers, International Energy Agency, Paris, France. 1996
- [9] Sustainable water and energy in Gaza Strip, *Renewable Energy* 33 (2008) 1137–1146
- [10] P. Droege, Renewable peace and prosperity for Gaza and its greater region, Project S4G; Solar for Gaza, Hochschule Lichtenstein, 2009
- [11] Source Data; The Atmospheric Science Data Center (ASDC) at NASA Langley Research Center, 2004
- [12] B. Yasen, Renewable Energy Application in Palestine, 2nd International Conference on The Palestinian Environment, An-Najah Scholars, Nablus, Palestine 2009
- [13] M. Abu-Hafeetha, Planning for Solar Energy as an Energy Option for Palestine, Master's Thesis, An-Najah National University, Nablus, Palestine, 2009
- [14] M. T. Hussein , S. Albarqouni, Re-Evaluation and Re-Design Stand-Alone PV Solar Lighting Projects In Gaza Strip, Palestine, *Journal of the Islamic University of Gaza, Palestine*, Vol. 19, (1), 2010
- [15] M.J. Shawon, L. El Chaar, L.A. Lamont, Overview of wind energy and its cost in the Middle East, *Sustainable Energy Technologies and Assessments*, Volume 2, June 2013
- [16] Shabbaneh, R. and A. Hasan (1997). "Wind energy potential in Palestine." *Renewable Energy* 11(4): 479-483.
- [17] A. Bosmans, I. Vanderreydt, D. Geysen, L. Helsen, The crucial role of Waste-to-Energy technologies in enhanced landfill mining: a technology review, *Journal of Cleaner Production*, 2012
- [18] F. Lamers, E. Fleck, L. Pelloni, B. Kamuk, ISWA White Paper on Alternative Waste Conversion Technologies, ISWA – the International Solid Waste Association, 2013
- [19] Data Resources; The Applied Research Institute - Jerusalem (ARIJ)
- [20] Environmental and Social Impact Assessment for Gaza Solid Waste Management Project, Executive Summary, EcoConServ and Universal Group-Gaza, January 2012

Reducing the budget deficit sustainably in Vietnam: Pathway to 2020

Quynh Tho Nguyen

Banking Academy, Viet Nam

0029

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org

Budget deficit is one of the biggest concerns in economic world nowadays. Due to the fact that the government has to participate and implement its governmental functions in many aspects of socio-economy, expenses of the whole system is a huge amount that the government incomes cannot fully cover. Therefore, budget deficit appears as a consequence. In general, it is recognized as the phenomenon when the government spending exceed its incomes in a certain period of time. Budget deficit exists in most countries, but it is not always a bad thing. It will be good for the country when the government incomes are raised from stable channels, and the level of government spending, is expected to be covered in the near future. In contrast, when the incomes are from unstable funds or its spending is more than potential incomes, which the government plans to get in the near future, its budget deficit will influence negatively the country's socio-economy.

1. Budget deficit: definitions and classifications

There are various definitions of budget deficit, depending on the viewpoint and classification of budget management. Based on the classification of government expenses and incomes, international standard indicates that the government incomes include all revenues, which are not raised with any direct repayment responsibility. However, it is the fact that each country has different approach in recording government incomes, depending on political purpose and the objectives of financial policy, and it leads to various results of budget deficit. The loan via treasury bills and available aids is an illustration of this. In Japan, it is recorded as the annual government incomes, whereas in the US it is only used as a solution of budget deficit.

IMF (2009, 2010, 2012) recommends that when analyzing the budget, it is better to consider aids including grants as the recovery for the budget deficit, since the grants is not the frequent resource which is subject to the partner countries. Therefore, if the aids including grants are recorded in budget balance, the government would have to adjust the budget during the time, causing negative impacts on budget activities.

For these reasons, from international standard viewpoint, government incomes consist of taxes, fee collected by the government, and other incomes, excluding non-refundable aids, domestic and foreign loans (IMF, 2009, 2010, 2012). On the other hand, the government spending consist of expenses for development and investment, normal expenditures, interest expenses excluding principal payment, and the others. It is necessary to record interest expenses as the government spending because it is the results of budget management and from the borrowings, which is the component to balance the budget.

Various definitions of budget deficit's component affect on the classification of the spending and incomes. In general, budget deficit can be classified as follows:

Figure 1. Budget deficit content

Government Incomes	Government Expenditures
A. Regular incomes (taxes, fees)	D. Regular expenditures
B. Incomes from capital investment (selling government properties)	E. Expenditures for investment
C. Deficit Covering	F. Net lendings
- Grants	(= New lendings – Principal collected)
- Reserves	
- Borrowings (= New borrowings – Principal repayment)	

So, *Budget deficit = Total Government Expenditures – Government Incomes*

However, from different viewpoint, these components of budget deficit can be defined in either governmental level or local level. According to World Bank, public area consists of governmental area, local government, Central Bank, and other state owned institutions which more than 50% capital is invested by the government. Thereby, when public institutions have low level of liquidity or they need a high level of liquidity for restructuring, the government has to take responsibility of all payments. If all these payments are in the fiscal year, they will be recorded as government expenditure of the year. That means budget deficit cover entirely public area. This is the largest measurement of budget deficit.

On the other hand, IMF indicates that in order to distinguish the government's fiscal policy from its monetary policy, budget deficit should include only governmental area. According to Government Financial Statistics (GFS) by IMF (2009), the term *government* consists of all public authorities and their agencies which are established through political processes, however, it do not include activities of central bank regardless it belongs to the government or not.

Although can be defined in different ways, from the viewpoint of modern public finance, budget deficit, by nature, can be divided into two types including structural deficit and cyclically deficit. In specific, structural budget deficit is the deficit controlled by the government's policies such as tax regulations, social insurance, expenditures for education and national defense, etc... Cyclically budget deficit is the one caused by the economic cycle, e.g. it depends on the level of production output and national income, for example, in economic recession, the increasing unemployment rate leads to the reduction of tax payment and consequently results in the decrease in government income, meanwhile the government expenditure for unemployment compensation may rise.

2. Impacts of budget deficit

In despite of the approaches and classifications of budget deficit mentioned above, the deficit has a comprehensive influence on every sectors and socio-economic activities, such as GDP, inflation, trade balance, interest rate, economic structure, living standards, and so on. Derived from researches of Boariu A. & I. Bilan (2007), Government Financial Statistics (IMF, 2001), William G. & R. Orszag (2003), Doménech R *et al* (1997), budget deficit can affect in number ways:

Budget deficit affect society and standards of living. High level of deficit pushes the government to earn more incomes by setting higher taxes, fees. It directly influence on the life of citizens. Meanwhile, it leads to the shortage of the banks' financial resources; the interest rate will rise, reducing the opportunities of investors to access capital. In a long term, the investment will decrease seriously; number of bankrupted enterprises will increase because they are not able to get relevant source of capital; manufacturing will decline; as a consequence, trade deficit raises, real incomes of citizens decrease and so on.

Budget deficit can influence on inflation. Once the budget deficit is high, one of the most powerful solutions that the government can use is printing cash. This respond can immediately increase the amount of cash in circulation. In economic recession, the increase in money supply can stimulate the whole economy, promote the investments and boost the production output to the potential. In this case, the negative impact of inflation is at minimum. However, issuing cash is dangerous to the growth economy in the long run because it may increase inflation.

Budget deficit can also affect the future of whole economy. If the deficit is allowed to finance profitable projects in long term, the profits from these projects will contribute to the government incomes and cover the borrowings for the past deficit. When the government expenditures are used for instant demand, it influences total demand in short term. However, it will not create any potential income in long term but cause worse public debt in the future.

Finally, budget deficit may control foreign direct investments of the country. The more serious deficit indicates the poor budget management, losing the faith of domestic and foreign investors. Therefore, less capital will be invested into the country. As a consequence, the objectives of the country cannot be achieved.

3. Approaches to evaluate the level of budget deficit sustainability

a. Budget constraint approach

Most researches on budget deficit sustainability came up with a general model, in which the government has to set up a budget constraint. In each period, the budget constraint is static. With the assumption of a close and simple economy and there is no foreign loan, static budget constraint is determined by the following formula:

$$B_{t+1} = R_t B_t + D_t \quad (1)$$

In which:

B_t is the original value of government debt

$R_t = 1 + r$, is the discounted rate between period t and $t + 1$

D_t is the original deficit (excluding interest).

The fluctuating budget constraint can be derived from formula (1):

$$B_t = - \sum R(t,t+1)^{-1} D_{t+j} + \lim R(t, t+T)^{-1} B_{t+T+1}$$

(2)

In which

$R(t, t+j)$, is the discounted rate between period t and $t + j$

Formula (2) shows that the sustainability of government requires the present value of future budget excess to exceed the future budget deficit in order to cover the difference between the original government debt and the present value of

debts at the end of the period.

If the present value of the debts at the end of period is positive, formula (2) is satisfied even when the government refunds by borrowing more money to pay principals and interest. However, O'Connell và Zeldes (1988) proved that this is impossible. For instance, if the government only allows citizens to hold government bonds at some certain periods, the demand of holding bonds will raise due to the fear of losing the right to buy bonds in the future. Conversely, the demand will reduce at least once if people can buy the bonds at any time. Therefore, that means there is not every time the government can borrow money to refinance.

This idea implies that the budget is stable when $\lim R(t, t+T)^{-1} B_{t+T+1} \leq 0$. In fact, $\lim R(t, t+T)^{-1} B_{t+T+1} = 0$, because there is always government debt in the private sector. Thereby, a relevant policy for sustainable budget deficit needs to meet the requirement of present value budget constraint (PVBC) as follows:

$$B_t = - \sum R(t, t+1)^{-1} D_{t+j}$$

So, reducing budget deficit sustainably is to keep the present government debt at relevant level, which is equal to the difference between the present value of the future budget excess and deficit.

The biggest advantages of this approach are simple and no assumption of stable economy. Also, it does not require growth rate, interest rate and income to be stable at any certain level. However, its disadvantage is that it is based on historical data and only examines the past.

b. VaR Approach

Barnhill and Kopits (B & K, 2003), considers the government as a corporation, so their objective is to estimate the net value of the government's assets and assess the possibility of a negative value. Therefore, the approach expands the analysis with the assumption that the government always satisfies the constraint of budget.

VaR is applied to assess the government debt compared to net cash flow of borrowings using present value. Thereby, the net value of government's assets is always zero.

According to B&K (2003), expenditures, tax of printing money, other taxes and incomes, which do not happen infrequently are not accounted into net cash flow in order to eliminate the stability of government budget. For this reason, the net value of government's assets cannot be 0. Assume that the net budget X_t consists of planning budget X_t^p and the rest X_t^r , the net value of government's asset is calculated on the difference between the present value of planning budget and the original government debt.

Assume W_t is the net value of government's assets at the end of year t , so:

$$W_t = E_t (\sum_{i=1}^{\infty} X_{t+1}^p / N_t^{t+1}) - B_t$$

In which: B_t is the market value of government debt at the end of year t .

Based on all available historical data until time t , W_t is unique. On the other hand, W_{t+1} is the variable and estimated based on the similar set of information. If W^* stands for 5% probabilities of W_{t+1} , it is considered as net value of government's asset with the risk affect. Then, VaR is $W_t - W^*$.

This is a modern approach; however, it has not shown the relation between budget deficit reduction and expenditures, GDP, interest, etc... in different periods of time.

c. Evaluate budget deficit reduction with assumption of long-term stable economy

According to IMF (2002, 2003), Chalk N. & R. Hemming (2000), in order to assess the sustainability level of budget deficit reduction, firstly the latest information about macro economy needs to be collected (normally within 5 years). The assumption is the policies are unchanged during the time. A set of core variables should be created, including production growth, investment, inflation, imports, exports, savings, interest, etc... Based on the above data, stability on public debt reduction shows that the government reduces budget deficit sustainability.

With the main assumption of stable economic policies in long-term, budget deficit can be determined as follows:

$$B_{t+1} - B_t = I_{t+1} - X_{t+1}$$

In which: B_{t+1} , is the value of public debt until the end of year $t+1$

I_{t+1} , is the interest of loans

X_t , is the original public debt

Other assumptions are: loan maturity is at the end of each period, debt is fixed on the nominal, nominal interest of the debt is n_{t+k} . Then, the value of public debt until the end of year $t+i+1$ is:

$$B_{t+i+1} = \sum_{k=1}^{i+1} p(t+k, t+i) d_{t+k-i} + p(t, t+i) b_t$$

In which:

$p(t+i, t+j) = \prod_{k=i}^j \frac{R_{t+k}}{1+n_{t+k}}$, is the discounted rate adjusted on the growth rate of the economy between year $t+k$ and $t+i$

$(d_{t+j})_{j=0}^i$, stands for the debt coefficient at the original balance

So: $\Delta \overline{d_{t+j}} = \theta_{t+j} \Delta \overline{d_{t+j-1}}$

In which:

$$\overline{\Delta d_{t+j}} = \overline{d_{t+j}} - \overline{d_{t+j-1}}$$

$$\theta_{t+j} < \theta_{t+j-1} < 1$$

$$j = 1 \dots i$$

θ_{t+j} is the political parameter showing the influence of financial policies in previous years. The smaller and decreasing θ_{t+j} over years presents positive adjustment of the policy. This also implies strong financial policies that can effectively reduce budget deficit sustainably. This approach allows evaluating budget reduction in both long-term and short-term.

4. Reducing budget deficit sustainably

Most economic theories indicated that reducing budget deficit creates negative effects to the economy in the short term; even the government increases the incomes via taxes or decreases the expenditures. When the economy is strong, this effect can be

accepted and the government can keep a stable level of deficit reduction. In contrast, if the unemployment rate of the economy is high, reducing budget deficit may boost the rate higher or slow down the speed of unemployment declining rate. According to the Congressional Research Service – US (2012), in order to reduce the budget deficit sustainably, it is important to determine a relevant declining rate of budget deficit. In particular, the health of the economy is the most important determinant. Also, the government needs to decide the relevant time to implement methods to reduce deficit. In another word, the approaches of reducing budget deficit should be postponed until the economy improved. This concept is also mentioned in many researches of the Romanian Center for Economic Policies (RCEP), Public Governance and Territorial Development Public Management Committee for OECD countries, Institution for Spanish Economic Research, etc...

What is the relevant level of a sustainable budget deficit?

When the deficit is too large due to the demand of economy growth, the government often borrows money to cover the spending for infrastructure and core projects which benefit the whole economy. Public debt is normally the most important channel of raising funds. For this reason, it is very necessary to set up an optimal proportion of public debt in order to have a relevant level of budget deficit. Deficit is not really a bad thing to a country. However, the more important thing is whether the deficit level is relevant to the capacity of the economy, and creates an overloaded public debt.

Based on the research of Buiter (1993), the public debt to GDP ratio is determined by the following formula:

$$d_t - d_{t-1} = - \left[\frac{\psi_t}{1 + \psi_t} \right] d_t + def_t$$

Where: d_t , the public debt to GDP ratio at the end of period t
 ψ_t , the growth rate of nominal GDP in period t
 def_t , is deficit to GDP ratio in period t

The formula shows that on one hand the growth rate of nominal GDP can reduce the debt to GDP ratio; on the other hand, the deficit to GDP may raise the debt to GDP ratio up. Assume that the debt to GDP ratio is constant, so:

$$d_t = \left[\frac{1 + \psi_t}{\psi_t} \right] def_t$$

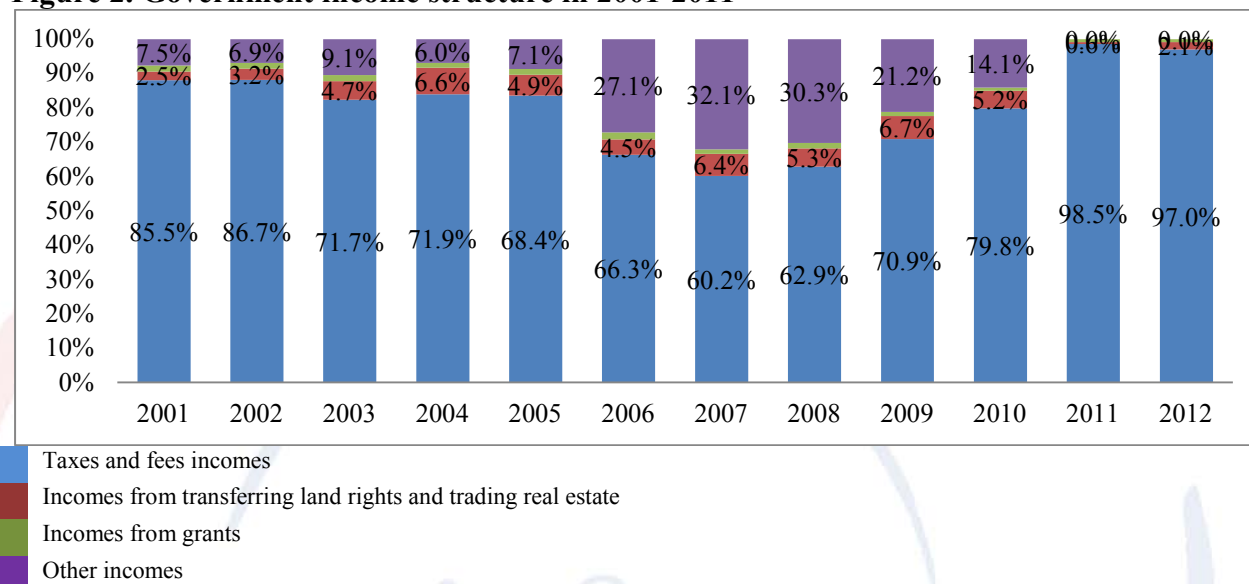
The above formula implies that the deficit guideline def^* and debt guideline d^* , in the long term, can be consistent only when the growth rate of nominal GDP is constant. In the case of European Commission, Buiter (1993) indicated that the real GDP of 3% and inflation of approximate 2% state an annual growth of nominal GDP of 5%. Also, it will be a sustainable budget deficit when the deficit to GDP ratio is 3% and debt – GDP ratio is 60%.

5. The actual performance of budget deficit in Vietnam

Regarding the government income during the 10 years, the main incomes of the government are from taxes and fees, incomes from transferring land rights and trading houses, grants, and other incomes. In particular, from 2001 – 2005, tax policy was usually reduced for manufacturing and commercial sectors, while income from land rights and selling raw mineral oil increased. In overall period from 2001 – 2005, government incomes in Vietnam account for approximate 23,9% GDP. Domestic incomes had grown and been the main income of the budget. The growth rate of

domestic incomes was averagely 18% per year in 5 years. The biggest contribution was from raw mineral oil, increasing 20% per year in average.

Figure 2. Government income structure in 2001-2011



Source: Finance Ministry of Vietnam (2001-2012)

From 2006 – 2010, total government incomes had increased dramatically, 2,5 times larger than those of period 2001-2005. It was equal to 24,5% GDP, including approximately 22,5% GDP from taxes and fees). The percentage of domestic incomes to the total government incomes increased from around 52% in 2005 to about 63% in 2010. Incomes from several core and stable taxes such as corporate tax, value-added tax, personal tax rapidly increased and played more and more important role. The percentage of these 3 main taxes to the total incomes increased from 55% in 2005 to 60% in 2010. Although income from raw mineral oil was still very important but reduced. This period was influenced by the global economic crisis. It resulted in the reduction in government incomes. However, the total incomes is basically likely to increase and sustainable.

In the whole period 2001-2012, it can be seen that most government incomes were from the increase in taxes and fees; foreign grants. Incomes from transferring land rights were quite small; however, it is likely to increase over the time.

Regarding the government spending, from 2001-2005, several new policies relating to state budget activities were changed and improved. Edited Budget Law 2002 valid from 1/1/2004 was one of them. Growth rate of government spending and the ratio of spending to GDP had been changed a lot. In particular, the growth rate of government spending used to be more than 100% during the period; however the spending to GDP ratio increased only from 17% in 2001 to 28,2% in 2005. Government spending were mostly based on regular spending and tend to reduce.

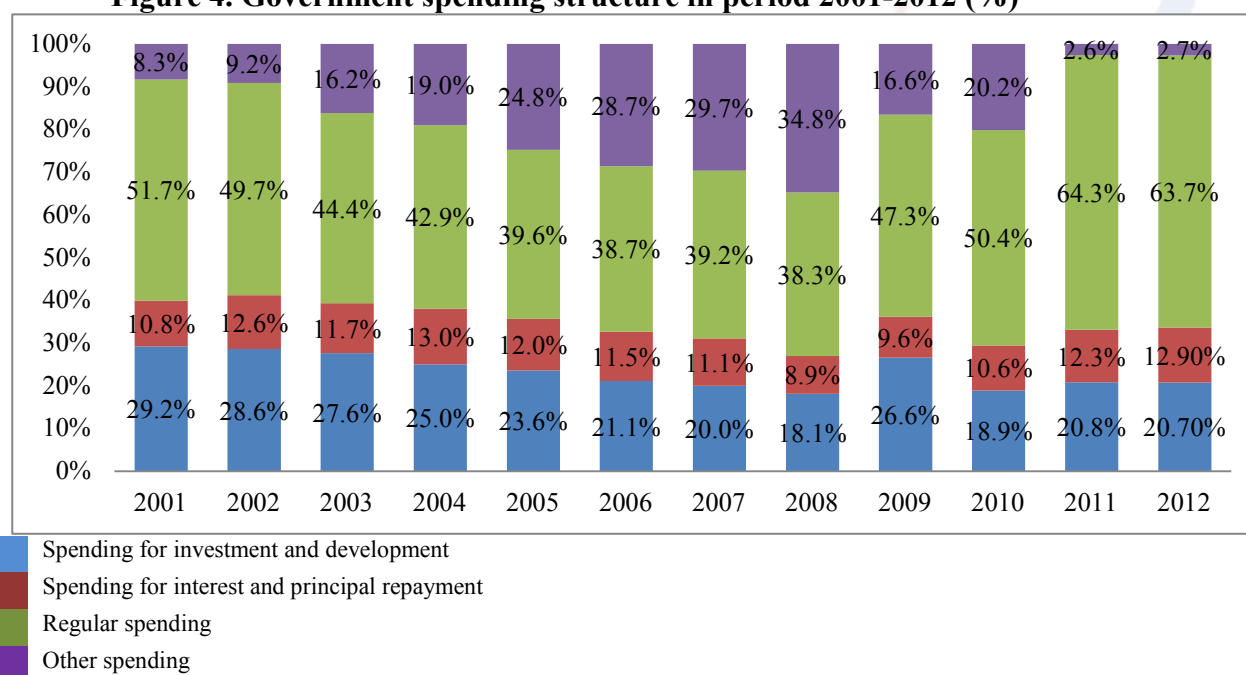
Figure 3. Growth rate of government spending and the government spending – GDP ratio in 2001-2005

	2001	2002	2003	2004	2005
1. Growth rate of government spending (%)	119,1	112,4	119,2	116,7	111,5
Include: - Investment and Development	135,8	114,2	112,8	115,7	111,8
- Repayment	112,6	132,7	124,9	118,7	118,3
- Regular spending	115,8	109,0	122,4	103,1	102,9
2. The government spending to GDP ratio (%)	17,0	27,7	28,8	28,9	28,2
Include: - Investment and Development	8,4	8,4	8,3	8,3	8,1
- Repayment	3,1	3,7	4,0	4,1	4,3
- Regular spending	14,9	14,6	15,6	13,8	12,4

Source: Restructuring budget for poverty reduction

Nevertheless, government spending in the next period from 2006 to 2012 dramatically increased. The figure in 2010 was 2.6 times more than this of 2005. Especially in 2011, in the rough economy condition, the total income was 25%-26% GDP, but the spending was bigger at approximately 30% GDP. Spending for investment accounted for a large proportion – 21%, although it decreased by 1.8% compared to period 2001-2005 (Finance Ministry of Vietnam, 2001-2012). This implied that the role of the government in investment was still very big. Therefore, it is necessary to restructure government spending. During 2001-2012, it was mostly subject to regular spending. In 2001, regular spending accounted for 50% of total spending. The figure was about 38% in 2008 and around 64% in 2012. This implied that in any economic condition, regular spending was required. On the other hand, spending for development and investment was stable at around 20%-30%. In 2008, it was special low (referred to Figure 4)

Figure 4. Government spending structure in period 2001-2012 (%)

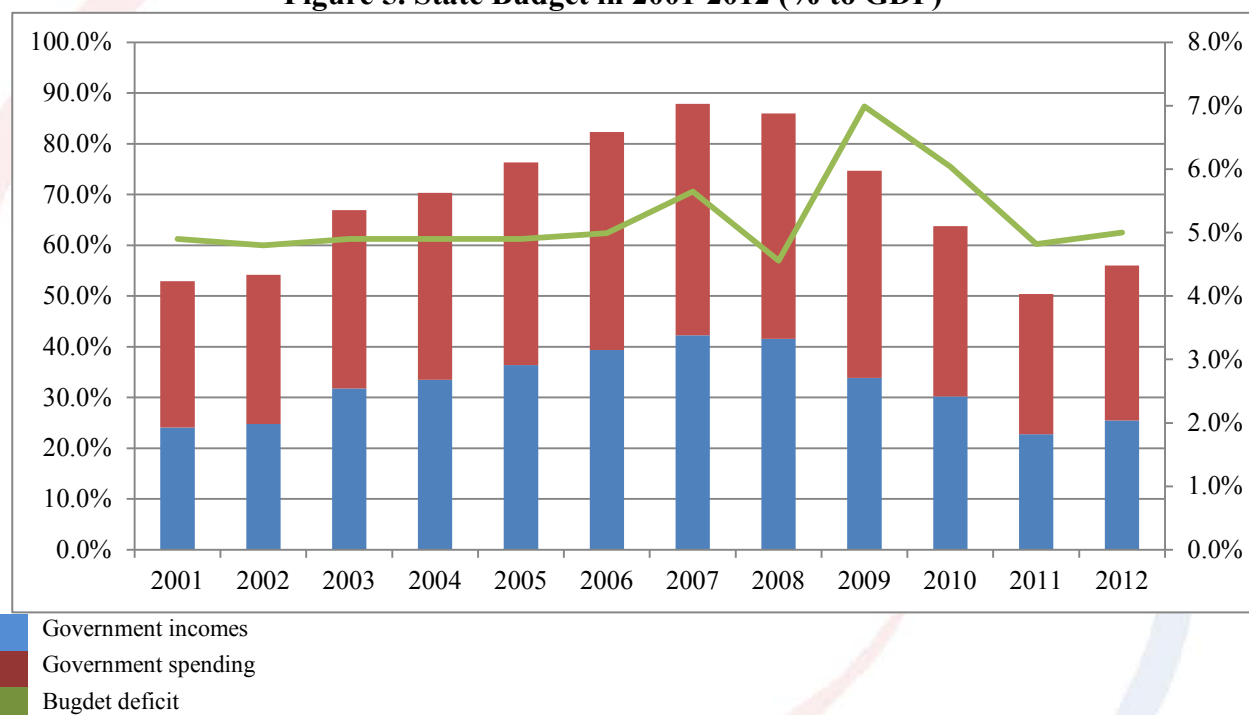


Source: Finance Ministry of Vietnam (2001-2012)

Regarding the budget deficit in Vietnam, there is a difference in determining budget deficit in Vietnam compared with the others. Vietnam accounts all spending for loan principals and interests into government spending. This approach results in the bigger number of budget deficit, however, it can easily show that the budget deficit is equal to the borrowings used to cover the deficit in a certain year.

Most years in period from 2001 to 2012, budget deficit was always under the edge of 5% GDP. Only in 2009, this number was high at 6.9% (referred to Figure 5). The main reason was the global economic crisis, which requires a lot of aids from the government to stimulate investment. The high level of government spending during the past 10 years is the main reason pushing public debt up rapidly.

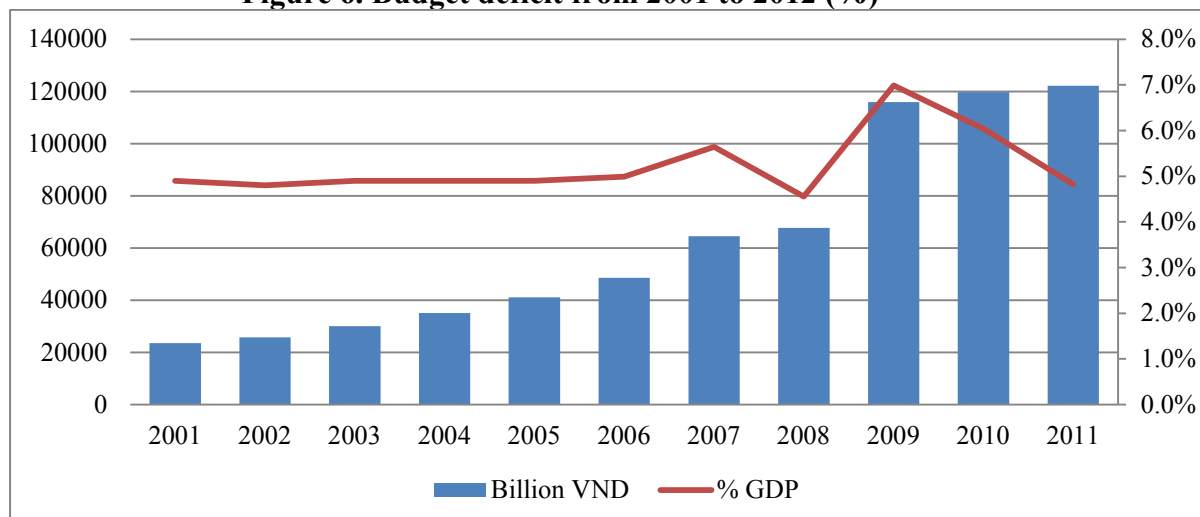
Figure 5. State Budget in 2001-2012 (% to GDP)



Source: Finance Ministry of Vietnam (2001-2012)

Although deficit – GDP ratio was still at the safe level of around 5% GDP, the number of deficit tended to sharply increase. In 2001, it was only about 20,000 billion VND, the figure became double within 5 years. In 2010, it was 6 times more than the number in 2001. The deficit of consequent year is always more than the previous one.

Figure 6. Budget deficit from 2001 to 2012 (%)



Source: Vietnam Ministry of Finance (2001-2011)

The approach in which the level of budget deficit reduction is examined by only the deficit/GDP ratio does not mention the sustainability of budget deficit and budget deficit reduction. Therefore, even the deficit was reported at allowable level but still had had big influence on the economy. For these reason, it is necessary to examine the real number of deficit and deficit/GDP ratio when evaluating the level of budget deficit reduction.

6. Relevant level of budget deficit for Vietnam and pathway to 2020

The relevant level of budget deficit needs to be compatible to the economy capacity. According to the public debt and foreign debt strategy from 2011-2020 (2012), the Prime Minister of Vietnam suggested that the public debt to GDP ratio in the period should not more than 65%. In order to keep the public debt at 65% and to avoid the risk when using debts, it is very important to figure out the relevant level of budget deficit which is compatible with the public debt.

If b is the public debt to GDP in year t ; d is the budget deficit to GDP in year t ; g_y is the growth rate of GDP; and i is the average interest rate, we get:

$$b = \frac{d}{g_y - i}$$

Assume that the public debt to GDP (b) is constant over the years at 65%; the growth rate of GDP in Vietnam (g_y) is 8%; and average interest rate in Vietnam (i) is 2.1% annually. So, the maximum level of budget deficit is:

$$d = b * (g_y - i) = 65\% * (8\% - 2.1\%) = 3.84\% \text{ GDP.}$$

This result implies that the optimal budget deficit level is 3.84%. However, it is based on the assumptions of 8% growth rate of GDP and average interest rate is 2.1%. These factors are flexible and unpredictable. Therefore, it is necessary to evaluate the macro economy at first.

In 1991, the governments from EC agreed at Maastricht to join into the full monetary union by 1999. One of the most important term in the Treaty of Maastricht is financial term in which EC government had to promise to keep the budget deficit under 3% GDP and public debt under 60% GDP. Based on Buiters's research (1993) on the relation between real growth rate and inflation to determine the relevant level of

budget deficit and public debt, we run a model with variables including economic growth rate (GDP), public debt to GDP ratio (DEBT), inflation rate (CPI), budget deficit to GDP ratio (DEFICIT). Applying the above formula, the historical data from 2005 to 2012 and IMF prediction for 2013-2020 period, a level of budget deficit in Vietnam is predicted. It can be concluded that the level of public debt to GDP and budget deficit to GDP in Vietnam had been quite compatible from 2005 – 2012. Therefore, we used the IMF prediction to estimate the relevant level of budget deficit in Vietnam until 2021. The prediction is shown in the following figure:



Figure 7. Public debt to GDP ratio and prediction until 2021 (%)

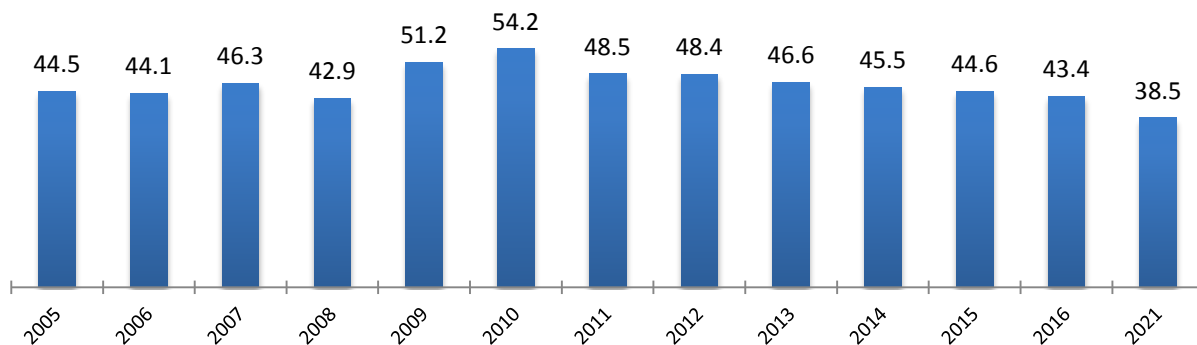


Figure 8. Growth rate of GDP in Vietnam and prediction until 2021 (%)

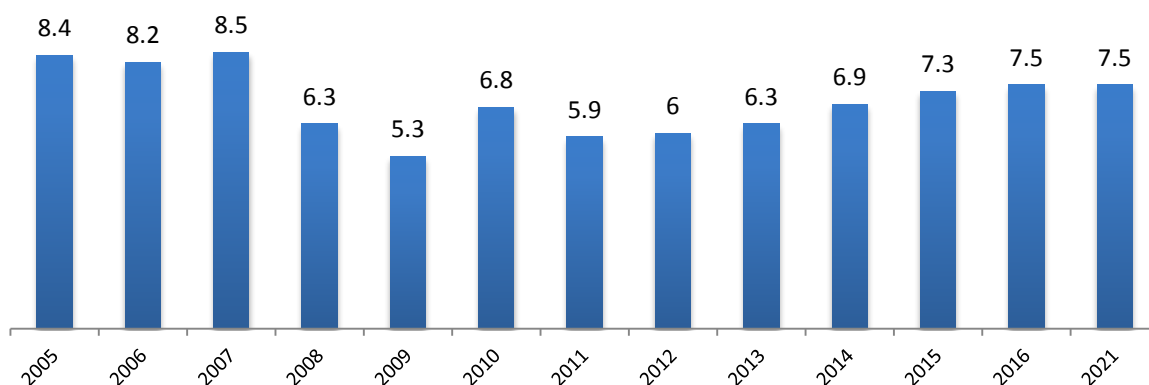
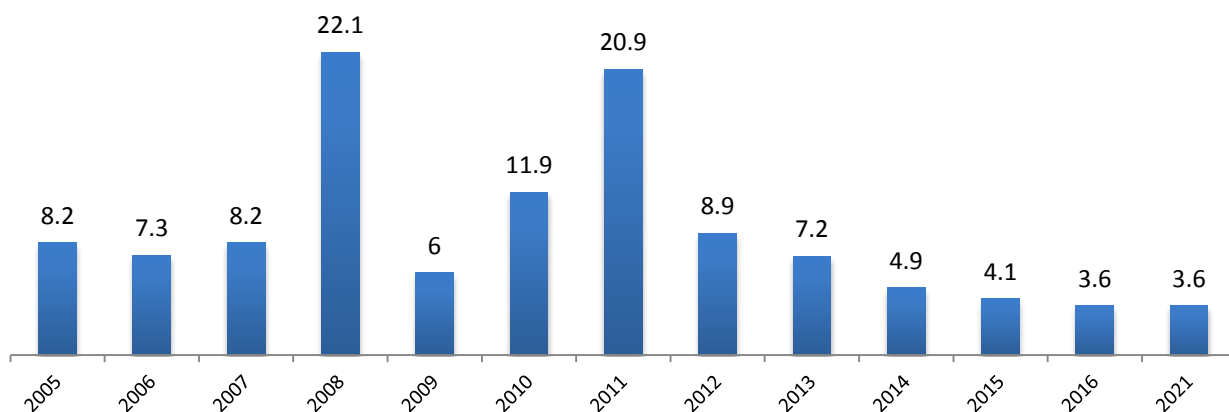
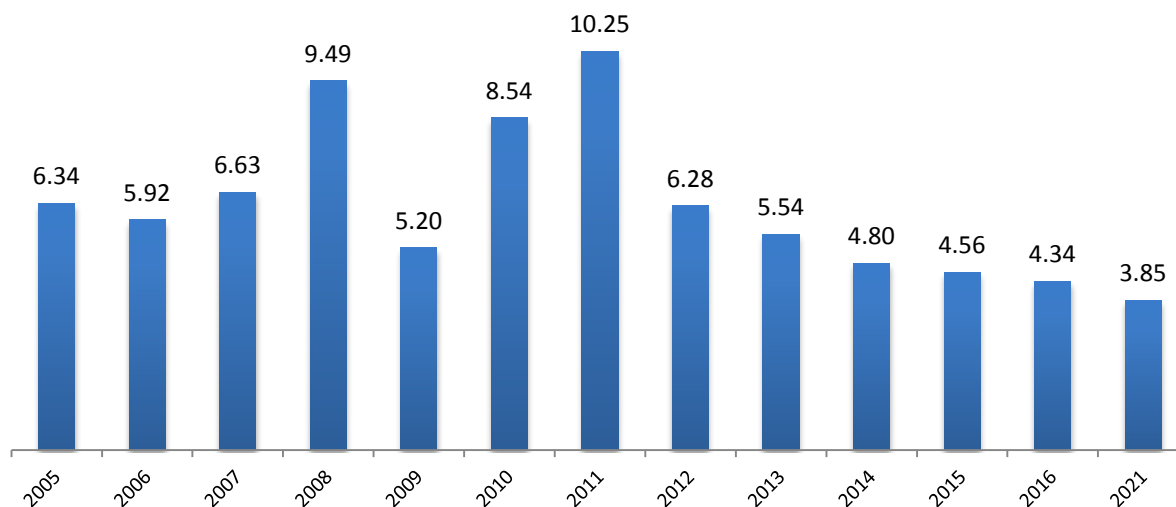


Figure 9. Inflation in Vietnam and prediction until 2021 (%)



Based on the predictions, in order to keep the balance between budget deficit and public debt, we followed the research of Buiter (1993) to forecast the level of budget deficit from 2013 to 2021 as the below:

Figure 10. Prediction of budget deficit from 2013 to 2021 (%)



It can be seen that with prediction of stable public debt ratio, inflation, growth rate; the level of budget deficit tends to reduce. Budget deficit is considered at sustainable level of 4.56% in 2015 and around 3.85% in 2021. Moreover, the level of budget deficit has been is compatible with the growth rate of public debt. That also means using loans to cover the deficit can create a balance in the state budget.

Procedure for reducing budget deficit in long term in Vietnam

There have been many solutions to reduce budget deficit. However, the most important thing is to reduce budget deficit sustainable. For that reason, reducing budget deficit is the long term process:

Firstly, it is necessary to improve and diversify the government incomes as to avoid the dependence on unsustainable incomes such as incomes from raw mineral oil, import tax, etc... which are currently accounting for more than 40%. Restructuring government incomes also refers to consider the taxes structure. Sustainable taxes such as income tax, especially individual income tax, should be more focused. However, it is not easy for the government to increase the tax rate due to its negative effects on the economy, income per capita, and then investments. It needs a long-run for the government to increase the income via taxes gradually and slowly.

In addition, government spending should be controlled more effectively. It is necessary to control regular spending effectively and focus more on investment and development. To do so, the salary system for the management ought to consider. In fact, there are more and more official staff in the office and it raises the salary spending higher and higher.

Moverover, the government should also well-allocate the funds to different sectors in the economy. The main sectors of Vietnam such as energy, agriculture, mining, education and national defense should be preferred. Also some ineffective sectors should be eliminated.

REFERENCE

- Albu L. & E. Pelinescu, 2000, *The sustainability of the Public debt and Budget Deficit*, RCEP/WP no.4/October 2000, Romania
- Angela Boariu & Irina Bilan, 2007, *Inflationary effects of budget deficit financing in contemporary economies*
- Buiter, W.; Corsetti, G. và Roubini, N. (1993) "Excessive deficits: sense and nonsense in the Treaty of Maastricht", on <http://www.willembuiter.com/sense.pdf>
- Castro F. & P. Cos, 2002, *On the sustainability of the Spanish public budget performance*, Revista de Economia Publica, 160-(1/2002), pp 9-27, **Instituto de Estudios Fiscales**
- Christopher Towe, Danny Leipziger, and Kenneth Lay, 2009, "Managing Public Debt: Formulating Strategies and Strengthening Institutional Capacity", IMF and World Bank
- Finance Ministry of Vietnam, 2010, *Budget report*, Vietnam
- Hirai T. & M. Nomura, 2001, *The sustainability of Budget Deficits of central and local government for Japan*, **University of Kagawa, Japan**
- International Monetary Fund & World Bank, 2003, *Guidelines for Public Debt Management*
- Kibritcioglu A. et al., 2002, *Inflation and Disinflation in Turkey*, Ashgate Publishing Company, **UK**
- Labonte M., 2011, *The sustainability of the Federal Budget Deficit: Market Confidence and Economic Effects*, **Congressional Research Service – CRS**
- Labonte M., 2012, *Reducing the Budget deficit: Policy issues*, **Congressional Research Service - CRS**
- Levit M., 2011, *Reducing the Budget deficit: The president's fiscal commission*, **Congressional Research Service - CRS**
- Martin Rama, 2008, "Making difficult choices: Vietnam in transition", **World Bank**
- National Institute for Finance, 2012, "Relation between public investment, public debt, and sustainable state budget in Vietnam"
- Nina Budina & Sweder van Wijnbergen, 2007, "Quantitative Approaches to Fiscal Sustainability Analysis: A New World Bank Tool Applied to Turkey", **World Bank Policy Research Working Paper**
- PhD. Le Thi Dieu Huyen, 2012, "Improve debt management system in Vietnam", **Banking Academy of Vietnam, Vietnam.**
- PhD. To Kim Ngoc, PhD Le Thi Dieu Huyen, MSc. Nguyen Quynh Tho, MSc. Nguyen Thi Lam Anh, 2013, "The sustainability on budget deficit reduction: Pathway to 2020", **Banking Academy of Vietnam, Vietnam**
- Schick A., 2005, *Sustainable Budget Policy: Concepts and Approaches*, **Public government and territorial development public government committee - OECD**
- Schick, A. (2005) "Sustainable budget policy: Concepts and Approaches", on www.oecd.org/gov/budgeting/43481125.pdf
- Shigeyuki H. & H. Naoko, 2009, *On the sustainability of budget deficits in the Euro area*, Economics Bulletin 29(1), pp56-66, Kobe University
- Sustainable Budget Commission, 2009, *Sustainable Budgets: Principles and Processes*, **Government of Southern Australia**
- Taiji H., 2006, *The sustainability of Budget Deficits in an inflationary economy*, **University of Tsukuba**
- Tapchithue (2013) "The performance of investment, government incomes and spending in the first 5 moths of 2013", on <http://www.tapchithue.com/c14t16978-tinh-hinh-dau-tu-thu-chi-ngan-sach-nha-nuoc-5-thang-dau-nam-2013.html>
- Tran Van Giao, 2008, "Budget deficit management to restrain inflation", Ho Chi Minh National Academy of Politics and Public Administration, Vietnam

*Influence on the Combustion process of the type of fertilizer used on an energy crop
(Populus nigra, L.)*

Luis F Calvo, Daniel Blanco, Luis Escudero, Sergio Paniagua

University of Leon, Spain

0032

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org

Introduction.

Hence, black poplar was used as a lignocellulosic biomass crop. We used *four different clones of poplar*, two of them associated with native Spanish varieties (UNAL and I214) and two varieties of specific clones for biomass (AF-2 and AF-8). *Three different treatments* were applied to fertilize our energy crop: digestate from the anaerobic digestion of manure, sewage sludge from the food industry and a control treatment

The overall objective of this work was to investigate the differences in thermal behavior in relation to the plant variety and the material used to fertilize an energy crop.

A *thermogravimetric technique* was utilized to attain the objective of the study. Thermogravimetric analysis (TGA) is a method widely used for investigating the thermal properties of materials. Non - isothermal, or dynamic, TGA is more commonly used than isothermal TGA, as fewer data are needed to determine the reaction kinetics. One would expect that the thermal behavior would be different for each particular case; however, in view of the results obtained, *no clear trends are evident*

Experimental procedure.

An energy crop with different black poplar clones being grown for biomass (three years of cultivation) was subjected to three different fertilizing treatments. The batch termed CB (*control batch*) was a control sample that was given no form of fertilizer. Batch DB (*digestate batch*) was fertilized during cultivation with digestate derived from an anaerobic digestion process. Finally, batch SB (*sludge batch*) was fertilized during growth with sludge from a sewage treatment works. The material was subjected to a grinding process by using a ball mill (Fig.1A). We selected a sample size of between 6-9 mg. Previously samples were placed in a *thermobalance* (Fig. 1B) and subjected to a heating rate 10°C/min from ambient to 1000°C. This heating is done under a 100 mL/min air flow to obtain, in this way, the oxidative process of combustion. At all times we work with a 1atm. pressure.



Figure 1.A



Figure 1.B

Figure 1 - Material used in samples' pre-treatment. - Retsch MM200 ball mill (Fig. 1A) and TA Instruments SDT2960 thermobalance (Fig. 1B) -

Results.

Figures 2, 3 and 4 show the relationships between variations over time in the percentage (%/min) of weight (deriv. weight) of the samples for which we want to analyze the thermal behavior.

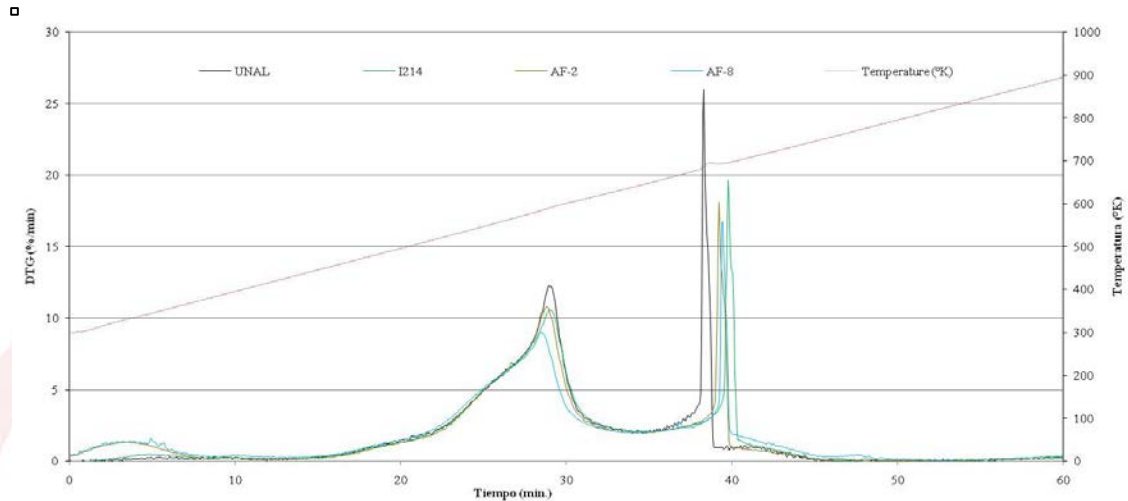


Figure 2 - Changes in the Percentage Variation of Weight of different poplar clones on control batch (CB) -

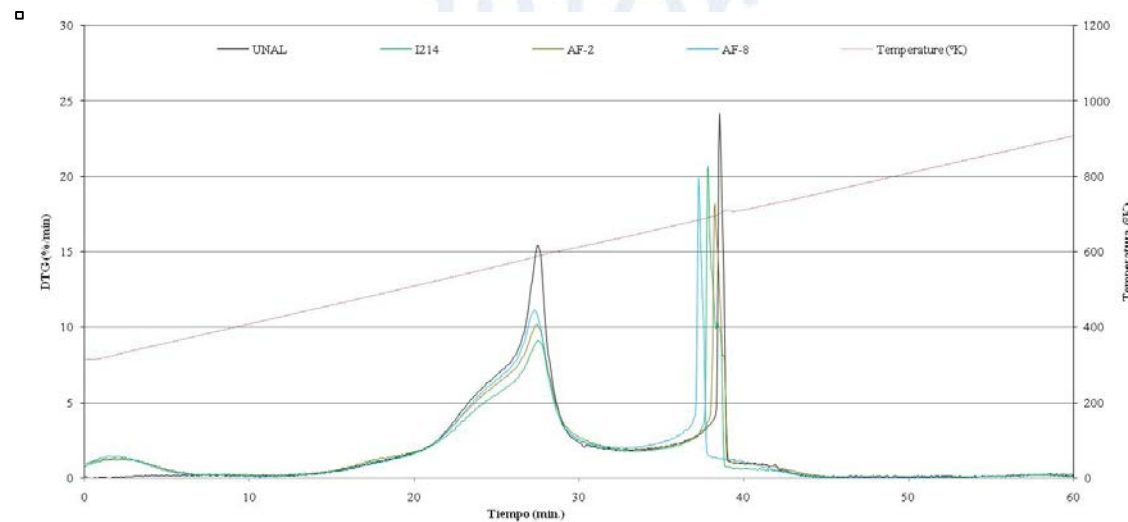


Figure 3 - Changes in the Percentage Variation of Weight of different poplar clones on digestate batch (DB) -

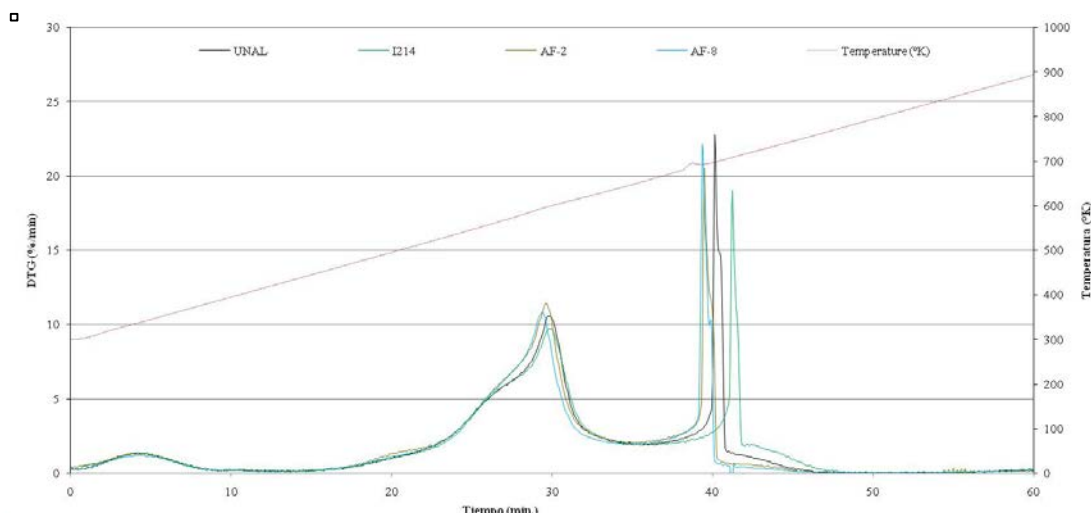


Figure 4 - Changes in the Percentage Variation of Weight of different poplar clones on sludge batch (SB) -

Conclusions.

Although the way in which we fertilize a crop does influence on the growth of plants (work published thereafter) thermal characteristics aren't influenced by this kind of fertilized. Something that can be reaffirmed in the table 1 information.

Table I - Thermogravimetric study results -

	CONTROL				DIGESTATE				SLUDGE			
	UNAL	I214	AF-2	AF-8	UNAL	I214	AF-2	AF-8	UNAL	I214	AF-2	AF-8
Peak I - Desvolatilization												
T ₀ (K)	470,43	451,03	471,58	470,80	483,90	484,82	465,72	462,67	479,68	481,52	485,44	476,98
T _r (K)	525,43	528,03	531,08	541,80	560,40	523,32	540,22	510,17	558,68	544,02	543,94	507,98
DTG _{máx} (%/min)	1,257	1,228	1,148	1,279	1,652	1,301	1,338	0,728	1,496	1,185	1,558	1,014
T _{DTGmáx} (K)	490,93	497,53	492,58	495,80	513,40	500,82	494,72	480,17	508,68	501,02	502,44	485,98
Peak II - Desvolatilization												
T ₀ (K)	543,93	541,03	554,58	550,30	562,40	545,32	546,72	545,67	550,68	547,02	551,94	546,48
T _r (K)	644,43	646,53	609,08	615,80	599,90	641,82	612,72	641,67	608,68	609,52	631,44	599,48
DTG _{máx} (%/min)	12,250	10,570	10,760	8,589	15,450	9,079	10,170	11,140	10,550	9,708	11,410	10,830
T _{DTGmáx} (K)	589,93	590,53	588,58	590,80	584,90	589,82	588,72	587,67	589,18	589,52	587,94	584,48
Peak I - Combustion												
T ₀ (K)	653,93	665,53	664,08	657,30	652,40	658,32	657,72	657,67	653,68	668,52	647,94	648,48
T _r (K)	681,93	688,03	703,58	700,30	726,90	696,32	715,75	691,67	698,68	713,52	687,44	690,98
DTG _{máx} (%/min)	2,629	2,604	2,739	2,482	2,754	2,159	2,627	2,638	2,372	2,513	2,415	2,397
T _{DTGmáx} (K)	665,93	680,03	681,08	686,30	684,90	673,82	683,22	617,17	674,18	687,02	664,44	666,48
Peak II - Combustion												
T ₀ (K)	682,43	697,53	691,58	696,30	698,90	691,82	696,22	686,67	692,18	702,02	685,44	683,43
T _r (K)	684,43	683,53	693,08	717,80	700,40	693,82	698,22	687,67	693,18	704,02	687,44	684,48
DTG _{máx} (%/min)	25,960	18,720	18,090	3,636	24,150	20,690	18,200	19,900	22,780	19,040	20,510	22,140
T _{DTGmáx} (K)	683,43	698,53	692,58	710,30	699,90	692,82	697,22	687,17	692,68	703,02	686,44	683,98
Peak III - Combustion												
T ₀ (K)	690,43	698,53	699,08	689,30	731,40	710,82	697,72	719,67	699,18	736,02	708,94	711,98
T _r (K)	753,93	759,53	731,58	758,30	757,40	761,82	765,72	755,17	755,68	741,52	728,94	750,98
DTG _{máx} (%/min)	0,980	0,894	0,739	3,683	0,917	0,541	0,986	0,848	1,228	1,111	0,526	0,646
T _{DTGmáx} (K)	715,43	721,03	719,58	707,30	733,40	728,32	717,72	723,67	706,68	738,02	721,94	719,98

Acknowledgements.

This work (REF.Le129A11-2) would not have been possible without the cooperation of *Directorate General Of Universities And Research Ministry Of Education* of the “Junta de Castilla y León” (Spain)

References.

Chang H.Y., Park Y.H., Park C.R., *Effects of pre-carbonization on porosity development of activated carbons from rice straw*, Carbon 39 (2001) 559–567.

Conesa J.A., Marcilla A. , Caballero J.A., Font R., *Comments on the validity and utility of the different methods for kinetic analysis of thermogravimetric data*, Journal of Analytical and Applied Pyrolysis 58– 59 (2001) 617– 633.

Singh, A.B.(1996).Ph.D.: *A study of reaction kinetics for thermochemical conversion of rice straw*. University of California. Davis

Tia, S., S.C. Bhattacharya, et P. Wibulswas. *Thermogravimetric analysis of Thai lignite-I: pyrolysis kinetics*. Energy convers. Mgnt . 31 (3) (1991) pp. 265 – 276.

List of figures and tables.

Figure 1 - Material used in samples' pre-treatment. -	1
Figure 2 - Changes in the Percentage Variation of Weight of different poplar on CB - . .	2
Figure 3 - Changes in the Percentage Variation of Weight of different poplar on DB - ..	2
Figure 4 - Changes in the Percentage Variation of Weight of different poplar on SB - ...	3
<hr/>	
Table I - Thermogravimetric study results -	3

Cationic Contamination in Lake's Water Situated West Zone, Ahmedabad, Gujarat, India

Sanjay Vediya

Sir P.T.Science College, India

0046

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Ahmedabad is unique in the whole of India in matter of environmental neatness and flourishing conditions and it is superior to other cities in the excellence of its monuments. Ahmedabad Urban Development Authority (AUDA) proposes to undertake work for revival, development of catchments areas and beatification of few lakes under the present project .of these Ramol, Vastral, Singarva and Nikol lake's waters were analysed for cationic contaminations. The results values of the metals estimated through 4 lakes during monthly Analysis of the January-2010 to December -2010. Their ranges of concentration were comparing to permissible limit of BIS. Calcium content of water samples from all localities were within the permissible limit of BIS except locality no.2 November-2010. Magnesium content of water samples from all localities were within the permissible limit of BIS except locality no.3 in March-2010. Sulphate contents of water samples from locality no.2 December-2009. Ammonia Content of water samples from locality no.4 July-2010, Phosphate content of water samples from all localities were within the permissible limit of BIS except locality no.1 and 2 in April-2010. The results suggested that water was suitable for drinking purpose. Nitrite content of water samples from all localities were within the permissible limit of BIS except locality no, 1 in November-2010. The results suggested that water was suitable for drinking purpose.

Key Words: Cation, Calcium, magnesium, Sulphate, Ammonia, Phosphate, Nitrite, lake.

Introduction:

Limnology is a discipline that concerns the study of inland waters (both saline and Fresh) specifically lakes, ponds and river (both natural and man made) including their biological, physical, chemical and hydrological aspects. The term 'limnology' stem from Greek 'limne (lake)' and 'logos'(study)'. In ecology the environment of a lake is referred to as *lacustrine*. The lakes are quiet large bodies of fresh water usually deep enough that their beds lie much beyond the photosynthetic zone (Agrawal, 1999) fluctuations in the lake level are because of climate conditions and human requirements of water. The rate of water replacement of a lake also depends upon the season. A lake may be occasionally created by digging a basin that intercepts the water table. Such a lake is in a sense nothing but a wide shallow well. Most man made lakes are created by damming a stream at a strategic point, so that the the water backed up the dam can be contained in a natural valley or basin. Many lakes are artificial and constructed for hydro-electric power supply, recreational purposes, industrial, agricultural use and domestic water supply. Ahmedabad is unique in the whole of India in matter of environmental neatness and flourishing conditions and it is superior to other cities in the excellence of its monuments. Ahmedabad Urban development Authority (AUDA) carried out a survey of 645 lakes and identified 22 lakes which have been severely degraded. AUDA proposes to undertake works for revival, development of catchments area and beautification of lakes under the present project. Of these, 4 lakes were studied which are located at Ramol ,Vastral , Singarva and Nikol villages , Ramol lake is located at near vatva back side Ramol village , Ahmedabad . Its total storage capacity is 77.0 Carore liters. Lake Desilting area is 6535 m³ and peripheral development Works including landscaping; Vastral Lake is located at Vastral Village its total storage capacity is 77.0 Carore liters. Lake Desilting Area is 5400 m³ and peripheral development works including landscaping: recreation facilities are such as Amphi theatre, children park and Boating facilities and percolation wells to recharge ground water table. Singarva Lake is located at Kathwada Village one of side GIDC Area And Atached to National Highway no.8 Ghodhra and Kapadvanj road Singarva village a Ahmedabad. Its total storage capacity is 13.6 Carore liters. Lake Desilting area is 5675m³ and peripheral development work including landscaping: recreation facilities are such as Amphi theatre, children park And Boating Facilities and percolation wells to recharge ground water Table; Nikol Lake is located at Nikol village. Its total storage capacity is 10.5 Carore liters. Lake Desilting area is 2498 m³ and peripheral development Works including landscaping ; AUDA has commenced work on this lake also through own resources.

Methodology:

Water samples were collected from four lakes (Ramol, Vastral, Singarva, Nikol). Samples were collected in these month January-2010 to December -2010. following cations were analysed using standard methods given by APHA , 1998 Ca⁺⁺ and Mg⁺⁺ were determined By complexometric titration methods:SO₄²⁻, NH₃ N, PO₄ P and NO₂ N was determind by spectrophotometric method: Distilled water was used as control for comparison and their results were compared with the desirable limit and permissible limit of WHO, 1992: BIS, 1991 and ICMR,1975.

Result and Discussion:

Major Cationic concentration (Ca⁺⁺, Mg⁺⁺, SO₄²⁻, NH₃ N, PO₄ P , NO₂ N) are naturally variable from season to other in water according to changes in Environment

Conditions similar study was Latif , A.F.A and A.A Elewa *et al.*,(1998) as well as increases in the decay organic matter. Sabre, S.Z and A.M Abdel-Satar *et al.* (2001) which cause the release of cations to overlying water. Also ,the adsorption of cation on the surface of fine suspended particles plays an in\mportant role on the distribution of cation in the aquatic Environment; Badr,M.H., A.A Elewa, M.B.Shehata, L.F.Mohamed and G.Abdelaziz *et al.*(2006)the study included measuring the concentrations of calcium, magnesium, Ammonia, sulphate, phosphate and nitrogen in surface and bottom water layers in different seasons with emphasis on the effect of flood water on the distribution of major cations in fresh water ; Elewa ,A.A., *et al.* (1980).

Calcium content of water samples from all localities were within the permissible limit of BIS Except locality No. 1,2,3,4 in January-2010 to December -2010. The highest concentration of calcium in water was record at locality no.2 in November-2010 (150mg/l). The lowest concentration of calcium in water was recorded at locality no.3 July -2010(30 mg/l), (Table -1).

Magnesium content of water samples from all localities were within the permissible limit of BIS except locality no1, 2, 3, 4 in January-2010 to December-2010. The highest concentration of magnesium in water was recorded at locality no.3 in March-2010(180 mg/l). The lowest concentration in water was recorded at locality no.4. November-2010 (30 mg/l) of Table -2 .similar studies was conducted by Agarkar (1998) and Kapaly *et al.* (1998) in Maharashtra.

Sulphate (SO₄²⁻) Content of water samples from all localities were within the permissible limit of BIS except locality no.1, 2, 3,4 in January-2010 to Decmber-2010. The highest concentration of Sulphate in water was recorded at locality no.2 December-2010 (6.2 mg/l) of 2009. The lowest concentration in water was recorded at locality no.2 March-2010 (0.001 mg/l) of 2010 (Table-3).

Ammonia(NH₃-N) Content of water samples from all localities were within the permissible limit of BIS except locality no.1, 2, 3, 4 in January-2010 to December-2010. The highest concentration of Ammonia in water was recorded at locality no.4 July -2010 (14.25 mg/l) of 2009. The lowest concentration in water was recorded at locality no.1 and 4 February -2009 (0.01 mg/l) of 2009 The January -2010 To December-2010, Shown in Table-4 clearly depicts that Ammonia Decreased .The progressive increase in water quality to Ammonia could be due to Heavy Growth of Aquatic weeds which efficiently utilize the Ammonia in the lake (Kaloo *et al.*, 1995).

Phosphate (PO₄-P) Content of water samples from all localities were within the permissible limit of BIS except locality no.1, 2, 3, 4 in January-2010 to December-2010. The highest concentration of Phosphate in water was recorded at locality no.1 And 2 April-2010 (4.0 mg/l) of 2010. The lowest concentration in water was recorded at locality no.3 November -2010 (0.11 mg/l), (Table-5).

Nitrite (NO₂-N) Content of water samples from all localities were within the permissible limit of BIS except locality no.1, 2, 3 ,4 in January-2010 to December-2010. The highest concentration of Nitrate in water was recorded at locality no.1 November-2010 (77.11 mg/l) of 2009. The lowest concentration in water was recorded at locality no.2 November -2010 (0.58 mg/l) of 2010 (Table-6)

Nitrite is more toxic and nitrogen indicates the recent pollution from lake water. Maximum permissible limit of WHO for both is 1.0 mg/l (Anon., 1984). The nitrite nitrogen was also observed within the permissible limits of WHO (Table-6).

Table -1

Analysis of Ca^{++} (mg/l) in water of various lakes during the year 2010 for comparative study of pollution.

No	Locality name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01	Ramol	100	100	90	100	50	60	50	80	70	110	110	110
02	Vastral	120	80	60	50	40	50	40	80	100	110	150	120
03	Singarva	60	50	40	40	60	40	30	60	60	100	90	60
04	Nikol	80	60	60	50	80	70	40	90	80	70	100	100

Table -2

Analysis of Mg^{++} (mg/l) in water of various lakes during the year 2010 for comparative study of pollution.

No	Localit y name	Ja n	Fe b	Ma r	Ap r	Ma y	Ju n	Jul	Au g	Se p	Oc t	No v	De c
01	Ramol	110	150	160	160	160	160	160	120	160	130	150	130
02	Vastral	60	130	170	160	110	60	120	70	120	120	100	130
03	Singarva	90	110	180	170	100	110	120	60	90	100	110	90
04	Nikol	70	100	90	50	90	80	80	110	80	80	30	110

Table -3

Analysis of SO_4^{2-} (mg/l) in water of various lakes during the year 2010 for comparative study of pollution.

No	Localit y name	Ja n	Fe b	Mar	Ap r	Ma y	Ju n	Jul	Au g	Se p	Oc t	No v	De c
01	Ramol	0	0	0	1.0	2.0	3.5	3.8	5.2	2.2	2.1	2.1	5.4
02	Vastral	0	0	0.00	2.0	0.9	2.1	4.8	6.1	4.5	4.0	5.1	6.2
03	Singarva	0	0	1.0	2.0	0.7	2.1	5.1	4.1	1.3	1.5	1.7	5.7
04	Nikol	0	0	0	1.0	0.5	1.2	3.3	5.1	2.5	2.1	3.5	6.1

Table -4

Analysis of NH₃ N (mg/l)in water of various lakes during the year 2010 for comparative study of pollution.

N o	Localit y name	Ja n	Fe b	Ma r	Ap r	May	Ju n	Jul	Au g	Se p	Oc t	No v	De c
01	Ramol	0	0.0 1	0	0	1.3	0.2 4	3.51	0.1 4	1.2	1.0	0.1 1	3.7
02	Vastral	0	3.0	0	0	2.22	0.2 3	1.41	0	0.5	1.1	1.2 2	0.9
03	Singar va	0	0.1	0	0.0 5	3.44	0.9 8	1.23	0.1 1	1.4	1.2	0.9 1	0.9
04	Nikol	0	0.0 1	0	0.0 3	11.2 1	7.2	14.2 5	0.3 2	4.9	4.1 2	2.3 1	3.7

Table -5

Analysis of PO₄ ⁻P (mg/l)in water of various lakes during the year 2010 for comparative study of pollution.

N o	Localit y name	Ja n	Fe b	Ma r	Ap r	Ma y	Ju n	Ju l	Au g	Se p	Oct	No v	De c
01	Ramol	0	0	0	4.0	2.1	2.5 5	3. 8	2.5	1.6	2.1	3.5 1	3.2
02	Vastral	0	0	0	4.0	1.7	1.8 2	2. 8	1.6	0.4	1.1	1.4 2	2.7
03	Singarv a	0	0	0	2.0	1.0	0.5	1. 7	1.1	1.2	0.8 8	0.1 1	0.6
04	Nikol	0	0	0	3.0	1.2	1.7 5	2. 3	3.6	0.8	0.5 5	0.3 2	0.4

Table -6

Analysis of NO₂ ⁻ (mg/l)in water of various lakes during the year 2010 for comparative study of pollution.

N o	Localit y name	Ja n	Fe b	Ma r	Ap r	Ma y	Ju n	Jul	Au g	Se p	Oct	Nov	De c
01	Ramol	0	0	0	0	0	0	1.2 2	0	8.5	25.2 2	77.1 1	1.4
02	Vastral	0	0	0	0	0	0	1.1	0	5.3	2.22	0.58	1.6
03	Singar va	0	0	0	0	0	0	1.5 5	0	1.5	0.91	0.8	1.1
04	Nikol	0	0	0	0	0	0	1.1 1	0	3.3	1.9	0.9	2.5

Summary and Conclusion:

Ahmedabad city is situated on the river bank of Sabarmati at Gujarat. The Water samples were collected from Different lakes. The Cationic Contamination like Calcium, Magnesium, Ammonia, Sulphate, Phosphate and Nitrite were studied comparatively during January-2010 to December-2010. The results suggested that water was not suitable for Drinking Purpose.

Reference:

Agarkar, S.V (1998): Physico-chemical aspects of ground water quality in Chikhli town of Buldan District. *Poll. Res.*, 17(3):291-292

Agrwal, S.C. (1999): *limnology*, A.P.H. Pub. Corporation, New Delhi

American Public Health Association (APHA) (1998): Standard methods for the examination of water and waste water, 20th edition, Clesceri, L.S., Arnold, E, Greenberg, Eaton, A.D. (eds.), American Public Health Association Washington

Anonymous. (1984): Guidelines for drinking water quality. (Health criteria and other supporting Information). Geneva, World Health Organization

Badr, M.H., A.A Elewa, M.B Shehata, L.F Mohamed and G.Abdelaziz, 2006: Studies on the effect of Rahway on the River Nile water pollution by trace of metals and major cations at El-Kanater El-Khyria area under the effect of Seasonal variation Assuit, University Bulletin, 9: 35-53

Elewa, A.A., 1980: Studies on the distribution of some chemical elements of Lake Nasser .Ph.D Thesis, Faculty of Science AI-Azher University, Egypt, pp: 274

Kaloo,Z.A. Pandit .A.K And Zutsh, D.P (1995):Nutrient Status and Phytoplankton dynamites of Dal Lake under salvainia natans and obnoxious weed Growth *Original science* 1, 74-85

Kaplay, R.D., H.S Patode and D.B. Panaskar (1998): Ground water quality in an industrial area of Tупpa, Nanded. Maharashtra. *Poll.Res.* 17(3):251-254

Latif, A.F.A and A.A Elewa, 1988: Effect of physicochemical conditions of Aswan High Dam reservoir Water on the disposition of some elements. *Egypt. J.of aquat Resear.* (NIOF) Bulletin of Institute Of Oceanography and Fisheries, 14; 189-212

Mhamed A.F. Toufeek and Mostafa A. Korium (2009): Factors Controlling the Distribution of The Major Metals in Lake Nasser Water, National Institute of Oceanography and Fishier, Egypt;

American-Eurasian J. Agric. & Environ.Sci., 5(6): 804-812

M.Y. Khuhawar, M. Aslam Mirza (2004): Limnological Study Of Baghsar Lake District himber Azad

Kashmir, *Pak j. Bot.*, 41(4): 1903-1915,2009

National Environmental Engineering Research Institute (NEERI) (1998): Manual on water and

Wastewater analysis, Nagpur, pp.31-80

Tebbutt, T.H.Y. (1998): Principles of water quality control, Butterworth, Heinemann, and Oxford

S.Murtaza. (2008): Impact of Pollutants on Physicochemical Characteristics of Dal Lake under

Temperate Conditions of Kashmir, www.forestrynepal.org Published: August06,2010

Sabre, S. Z. and A.M. Abdel-Star, 2001: Chemical and bacteriological studies on El-salam Canal, *Egypt J. of Egyptian Academy of Science Environmental Development*, 2;173-179

S.D. Vediya ,Anil Kumar Shrivastava(2004):Cationic Contamination In Like's Water situated At

Ahmedabad, Gujarat. *J. of Plant. Archives* vol. 8 no.2,pp 1011-1014 ,ISSN 0972-5210

World Health Organisation (WHO)(1968): Technical series no 404, Water pollution control in

Developing countries

World Health Organisation (WHO) (1992): World health Organisation, International Standards for

Drinking water, Geneva, Switzerland

The Real Cause for the U.S. Subprime, Financial, Economic Crises in 2007-2009

Peter Yang

Case Western Reserve University, USA

0109

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This paper is devoted to investigate the real cause of the U.S. subprime, financial, economic crises. It will first review related literature, and then examine a number of key economic factors related to oil production and consumption. The resulting insight will help answer the question on the impacts of ARRA because the knowledge of the fundamental cause of these crises will help determine what the most effective solutions to the economic recovery should be and examine if ARRA succeeded to deliver these solutions.

Keywords

rising oil price, short supply of oil, suburban housing market, oil dependence, crisis, sustainability

1 Introduction

Since the 2008 global economic crisis, economic and financial theorists and practitioners have widely discussed and acknowledged the lax economic and financial regulations and legislations as structural problems of the existing US and global economy that allowed mounting economic and financial risks to be overlooked and to have directly triggered the global financial and economic crisis. However, studies on some of more fundamental issues, such as rising energy prices and climate change, their relationship to the carbon-based global economy's consumption of fossil fuels, especially of oil, and their relationship to the global financial and economic crisis, were scarce and largely ignored.

This study will examine the U.S. economy's dependence on the consumption of carbon-based energy sources, especially oil. It will also investigate several related key indicators, including energy consumption per unit of GDP for selected economies, world GDP, world energy consumption, world oil price, and U.S. delinquency rate.

2 Literature Review

There was a consensus that the collapse of the housing market triggered the 2007 U.S. financial crisis. Major factors identified as leading to the boom and bust of the housing market included subprime lending, government regulation in expanding home ownership through mortgage subsidies for impoverished borrowers, monetary policy in the United States and Europe, corporate pay structures, credit-default swaps, banks' leverage, lax financial deregulation, etc. (Acharya, Philippon, Richardson, and Roubini 2009; Bordo 2009; Caballero and Krishnamurthy 2009; Reinhart and Rogoff 2008; Acharya and Richardson 2010; Caballero, 2010; Mian and Sufi 2010; Mayer 2011).

However, studies exploring the relationships between the rising oil prices and the housing and financial crisis in 2008 were scarce and largely ignored. These studies explored the issue from two main perspectives, with one focusing on the causes of the housing boom and the other focusing on what caused the collapse of the housing market.

One of the popular explanations of the housing boom between 1996 and 2006, in which real housing prices rose by 53 percent, was easy credit in the form of low real interest rates, high loan-to-value levels and permissive mortgage approvals. If this explanation were valid, then the financial crisis could be considered less a systemic or structural problem of the U.S. and world economy. Improved monetary and financial mechanisms would be capable of preventing this kind of irrational housing bubble in the future. However, if easy credit was not the primary culprit of the housing bubble, then more research is necessary to investigate what actually caused housing first to boom and bubble and then to collapse and burst to trigger the financial crisis.

Glaeser et al. disputed the low interest rate and easy credit explanations. Their study reexamined the housing prices and found that the predicted impact of interest rates on housing prices is much lower once the standard user cost model of housing prices is generalized to include mean-reverting interest rates, mobility, prepayment, elastic housing supply, and credit-constrained home buyers. This theoretical impact of interest rates on prices was found in line with their empirical estimates. Based on this study, the

authors concluded that low real interest rate can explain only 20 percent of the price increase of the housing boom. The study did neither find convincing evidence that changes in approval rates or loan-to-value levels could explain the bulk of the housing boom. The authors pointed out the need of “better corrections for the endogeneity of borrowers’ decisions to apply for mortgages” (Glaeser, et al., 2010).

Other studies focus on what caused the housing bubble to burst. Carr and Beese (2008) found a moderate correlation between the rise in interest rates and the rise in oil prices between 2004 and 2007, which led to home foreclosures between 2005 and 2008. Theramus (2009) found that volatility in the oil prices caused the financial crisis in 2008. Hamilton (2009) reviewed several approaches (Blanchard and Gali, 2007; Edelstein and Kilian, 2007; Blinder and Rudd, 2009) to estimating the impact of oil price shocks on the economy, including some methods that had previously shown an economic decline following previous oil price shocks.

Hamilton further explored similarities and differences between the run-up of oil prices in 2007–08 and the earlier oil price shocks. He found that different from previous oil price shocks, which had been primarily caused by physical disruptions of supply, the price run-up of 2007–08 was caused by “strong demand confronting stagnating world production” (Hamilton, 2009). His observation seemed to concur with the view of a growing number of studies that world oil production has reached its peak (Campbell and Laherrère, 1998; Almeida and Silva, 2009; Höök et al., 2009; Shafiee and Topal, 2009; Zhao et al., 2009).

At the same time, he observed that despite the different causes of soaring oil prices, the 2007–08 oil shock had the same economic depressing consequences as the previous oil shocks, for the economy in general and for consumption spending and purchases of domestic automobiles in particular, which caused home market crash, severe financial and economic crises, and economic recession. He concluded that the increase in oil prices in the period of 2007 through 2008 had made a “material contribution” to the subsequent U.S. financial crisis (Hamilton, 2009).

Sexton et al. also found in their recent empirical study that high gas prices caused the U.S. housing bubble to burst (2012). Their study went beyond the mainstream economists’ view that blamed the U.S. housing collapse in 2007 for inducing a financial crisis that spread to the entire economy and causing a severe and prolonged economic downturn.

The authors investigated the role of skyrocketing gas prices and a dramatic gas price shock in triggering the housing market collapse. They did this by developing a model of housing demand that integrates the Alonso-Muth urban model and the Poterba model of housing investment. The Alonso-Muth urban model showed that, in equilibrium, suburban residents are compensated for increased commuting costs by lower land prices. The Poterba model was used to simulate the likely effects of gas prices on house prices.

The authors showed how low gas prices had first fueled the housing boom along with low interest rate, easy access to credit, and new mortgage products, which made suburban housing affordable to high leveraged and long work commuting homebuyers who were otherwise low credit worthy because of low incomes.

The study showed how the persistently rising and subsequently skyrocketing gas prices, which doubled between 2005 and 2008, then increased the costs of commuting between suburban homes and workplaces in city centers and the costs of distant, commuting-based suburban living, and forced the vulnerable homeowners to abandon their commuting lifestyle. The authors concluded that suddenly rising commuting costs lowered the values of distant homes away from the city centers and made them undesirable, and caused rising foreclosure rates.

This view was echoed by Anderson (2009) who argued that the recent financial crisis was largely caused by the long-term problem of the current world economy lacking a sustainable path of development. He based his findings on the theory of “limits to growth” – expressed principally through rises in the price of oil and other commodities – created a crisis for the global financial system, which essentially assumes an indefinite economic growth. These findings supported an increasing public recognition of and increased calls for the need for sustainable development (Strange and Bayley, 2008), a development pattern that “meets the needs of the present without compromising the ability of future generations to meet their own needs” or meets “the needs of the present while contributing to the future generations’ needs” (Needham, 2011).

3 Examinations and Results

Drawing on the existing studies that link the recent financial crisis to the conflict between the U.S.-led world economy’s oil dependence and the recent changes in the world oil market, this study will examine the relationship between the recent economic and financial crises and the problems of the U.S. economy.

To pin point more exactly the impact of oil price surges on the United States and other developed economies, the study investigated these economies’ respective oil dependence (**Fig. 1**) from two perspectives—the one concerning the oil consumption as a share of the respective economy’s total primary consumption and the other concerning the correlations of the growth of the world economy and the growth of the world oil consumption.

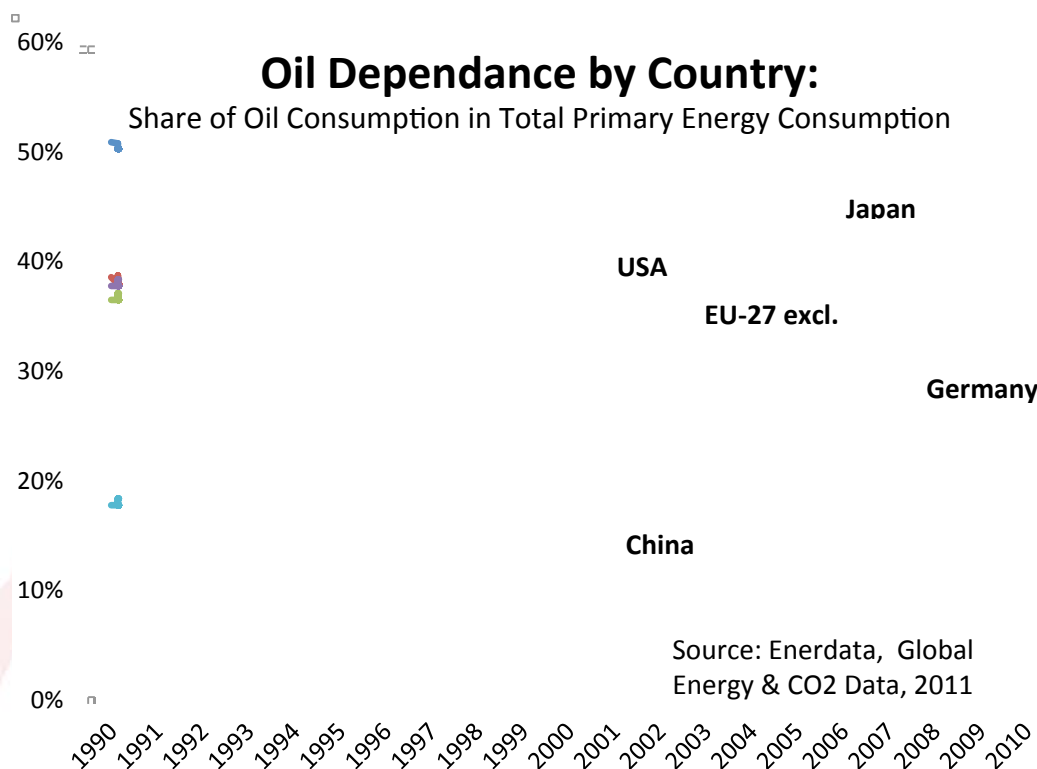


Fig. 1 Oil Dependence of Major Economies (Data Source: Enerdata, 2011)

The results of the investigation showed both a promising trend of reduced oil dependence and a concerning reality of high oil dependence of the major developed economies. On the one hand, the major developed economies' oil dependence experienced a notable reduction, with a 14 percent decrease from 51 percent in 1990 to 37 percent in 2010 in Japan, and a three percent decreased respectively in the United States, Germany and other EU-27 countries in the same period. On the other hand, the developed economies still displayed significant oil dependence between 31-37 percent. While the reduced oil dependence was induced by high oil prices and the gradual advancement of renewable energy, the persistently high oil dependence of the United States and other major developed economies made them particularly vulnerable in the face of volatile oil markets and rising oil prices.

A sectorial analysis of the U.S. oil dependence revealed an even depressing picture. While the economy-wide oil dependence in the United States was only around 35 percent in 2010, the oil dependence in manufacturing and transportation were much higher: 43 percent and 96 percent respectively. While the overall high oil dependence explained well why U.S. economy was especially vulnerable to soaring oil prices, the extremely high oil dependences of the key economic sectors manufacturing and transportation in the United States made it self-explanatory why the oil price hikes in 2007-2008 damaged, as Train and Winston (2008) observed, these economic sectors most severely.

The examination of the long-term oil production and oil consumption relation revealed an interesting two-factor trend. On the one hand, the world oil demand has been steadily increased from approx. 1500 megatons in 1965 to approx. 4000 megatons in 2011, a 167 percent increase. On the other hand, while the oil production was able to offer a sustained supply surplus over the oil consumption in the long period from 1965 to 2000, this

surplus turned into a frequent supply shortfall since then. This two-factor trend indicated the difficulty the world oil production had to meet the increasing world oil consumption, which explained well the continuously rising oil prices (Fig. 2).

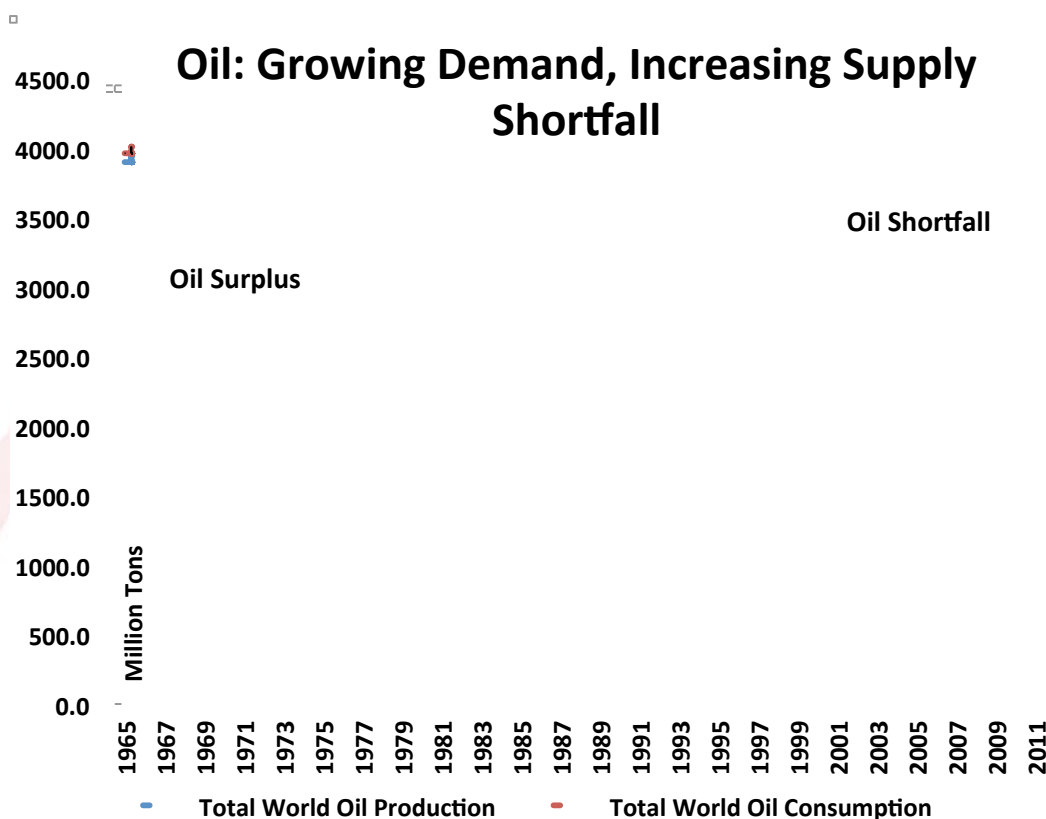


Fig. 2 Rising Oil Demand: From Supply Surplus to Supply Shortfall (Data Source: BP, 2012)

The composition examination of the world oil consumption showed two interesting observations. First, the oil consumption of the major developed economies such as the United States, the EU, and Japan still constitutes a major share of the world oil consumption. Second, the increase of the oil demand did not come from these major developed economies, but came rather from other countries, especially from the rapidly developing countries such as China and India (Fig. 3).

Considering the size of population and the further developing needs in these developing economies, their demand for oil represented On the one hand a strategic approach to energy consumption because of oil's less environmental and ecological impact than that of the major energy source in these countries—coal. However, this increased oil demand called for an inevitable oil supply shortfall and rising oil prices in the face of insufficient oil production since the turn of the new millennium. The correlation coefficient of .46 between the oil supply shortfall and the rising oil prices in the period between 2002 and 2011 showed that the rising oil prices in this period were closely related to the short supply in the world oil markets.

□

Oil Consumption by Country

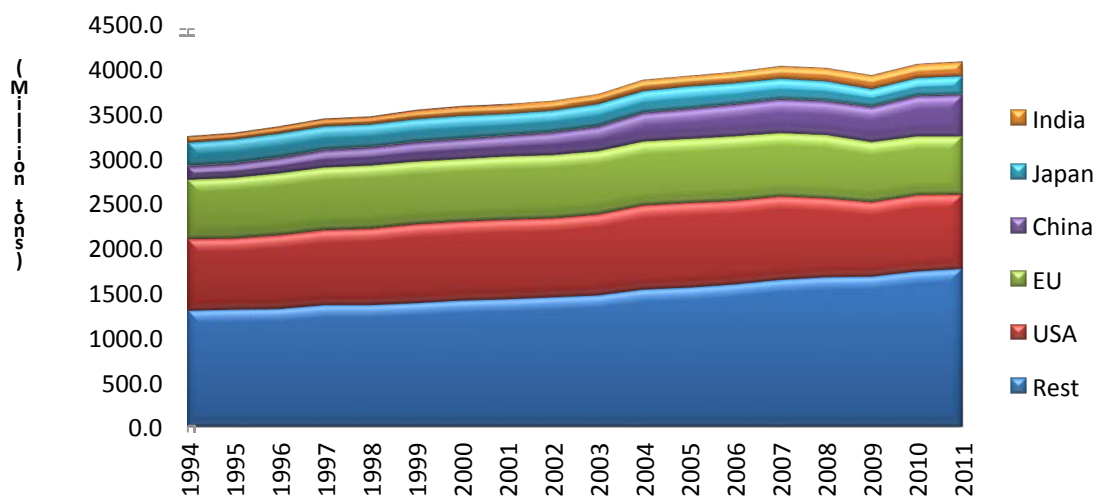


Fig. 3 Oil Consumption of Major Economies (Data Source: BP, BP Statistical Review of World Energy 2012)

The investigation of the correlations of the growth of the world economy and the growth of the world oil consumption revealed that the current world economy was highly oil dependent. The growth in the world GDP and the change in the world oil consumption showed a high correlation (.79). The world economy’s high oil dependence informed us that, in the absence of other significant alternative energy sources, the any GDP growth would further intensify the world economy’s oil demand and oil consumption. However, the U.S. economy had an even higher oil dependence of .85, much higher than other major economies, which indicated that the world biggest economy was also the world’s most oil dependent major economy in the last 20 years (Fig. 4).

□

Oil Dependence: Correlation Coefficient between GDP and Oil Consumption (1991-2011)

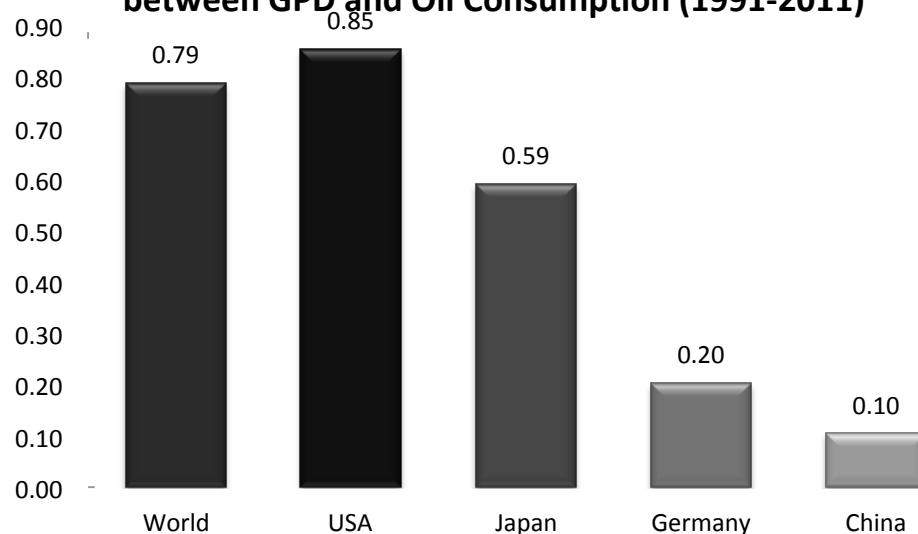


Fig. 4 Oil Dependence Measured by Correlation between GDP and Oil Consumption in 1991-2011 (Data Sources: World Bank, 2012; IMF, 2012; BP, 2012)

Based on this basic investigation of the oil production and oil consumption in recent years, this study compiled and analyzed data related to the growth in the world GDP, the world oil consumption, the increase in world oil price index, first mortgage default index; and decline in the U.S. auto sales.

Fig. 5 shows the dynamic impact of skyrocketing oil price since 2002 the U.S. economy in general and on the U.S. first mortgage delinquency rates and the U.S. auto sales in particular before, during, and after the U.S. economic crisis. As a long term trend, rising oil prices already caused the mortgage default rate to rise sharply before the 2007 U.S. financial crisis. In this period, the U.S. auto sales also felt the strong downward pressure caused by the oil price rises and kept a gradual downward trend from 2004, several years before the economic crisis.

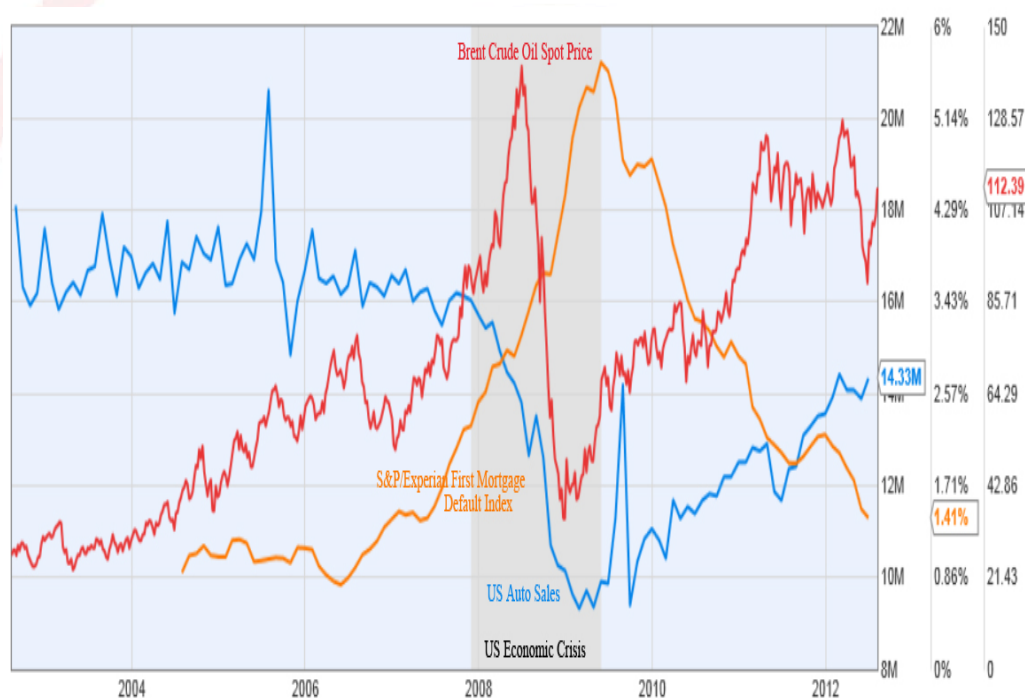


Fig. 5 Oil Price, U.S. Mortgage Default, U.S. Auto Sales, and U.S. Economic Crisis (Data Sources: BP, 2012; S&P/Experian, 2012; Autodata, 2012)

During the U.S. economic crisis, both the surge in the U.S. mortgage delinquency rates and the drop in the U.S. auto sales were intensified, which constituted a sharp contrast to the rigid oil price hike. The continued skyrocketing oil price lasted for a month, despite the strong market signal of a dramatic economic downturn, until it reached its record high and plunged into a free fall to the 2004 price level.

The rigid oil price hike at the beginning of the economic crisis contributed to forcing the mortgage default rate to surge to a record high and the U.S. auto sales to drop to a record low during the economic crisis. This insensitive upward movement in the oil prices can be read as its “overreaction” to the oil supply shortfall caused by the growing oil-dependent world economy. The continued surge in oil prices even during the early months of the economic crisis was paralleled, with a delay, by the continued surge in U.S. delinquency rate. This observation confirms the findings of Carr and Beese (2008) and

the assumption made by Anderson (2009) and Hamilton (2009) that there is a positive relationship between the rises in the oil price and the financial crisis.

Although the mortgage delinquency flood did not reverse its rising trend and the U.S. auto sales did not reverse its plunge until the economic crisis was over, the oil price started already to rise again before the economic crisis was over.

4 **Conclusions**

This study investigated the relationship between the rising oil prices and the economic crisis in the United States. The investigation found a substantial relationship of the U.S. economy's high oil dependence as its structural weakness and economic and financial vulnerability and the rising oil prices since 2004 and skyrocketing oil price hikes in 2007 as the primary culprit of the 2007 U.S. financial crisis and the subsequent U.S. and global economic crisis and the long-term financial constraint of the oil-dependent U.S. and global economy.

The findings of this study suggest the need of the transition from the carbon-based economy to a greener and more sustainable economy and the need to develop and implement a comprehensive green economic transformative strategy. Such a transformation can play a significant role in proactively dealing with the financial constraint of the future economic growth, and allow the U.S. and global economy to grow in an economically and financially more sustainable and healthy manner.

Certainly, the recent financial crisis was immediately triggered by the mortgage crunch as a result of the subprime lending and related "shoddy" subprime lending practices. However, one should not ignore the economic factors that caused the housing bubble and subsequently the housing bust on the one hand, and the fatal impact of oil price surge on housing market in particular and on the overly oil dependent U.S. economy in general. In other words, we must see what caused the mortgage crunch to trigger the financial crisis. As the expansion of the world GDP and the increase in oil demand and oil supply shortfall fueled oil price hikes, the skyrocketing oil prices, in turn, put significant strain on U.S. living, manufacturing, and transportation in terms of rising costs (World Bank, 2012), related job markets (rising unemployment rate), and financial markets (subprime market bust).

To be sure, the drastic drop in oil prices during the financial and economic crisis was only a temporary phenomenon as a result of substantially reduced energy demand in response to the contracted size of the wasteful and inefficient carbon economy. Now that the existing carbon-based economy returns to "business as usual," the hard financial constraint, as we now are witnessing, has started haunting the economy again and causing the economic recovery to take place at a painfully slow pace. As matter of the fact, the resurged high gas prices are constraining the U.S. economic recovery in general and the recovery of the U.S. oil-dependent sectors such as manufacturing and transportation, as well as housing markets in particular. The latter is especially true for distant houses that are associated with high commuting costs.

If the current still relatively "low" oil prices were mistaken as a turning point from the long-term oil constraint and rising oil prices, the U.S. economy could sadly miss the

opportunity of switching over to a greener sustainable economy based on increased renewable energy generation and reduced oil dependence. To sum up, in addition to the U.S. mortgage crunch as the direct trigger of the 2008 global economic crisis, this study found the rising oil prices as the main culprit of the U.S. mortgage, financial, and economic crises in 2007-2008. In addition, the study found the carbon-based, oil-dependent energy structure of the U.S. economy, especially its key economic sectors manufacturing and transportation, as the one of the main reasons for the severity of the U.S. mortgage, financial, and economic crises caused by the skyrocketing oil prices and the difficulty of the U.S. economic recovery.

Based on these findings, this study concludes that without a green transformation that significantly improves the efficiency of fuel consumption and the carbon-based, oil-dependent energy structure of the U.S. economy and the other major economies, the U.S. led global economy will not be able to avoid the fundamental contributing factors of the recent economic crisis and frequent future economic crises it will be facing: soaring energy prices, pollution and climate change, and the global financial mess. As Pavan Sukdhev pointed out, the carbon-based “economic models of the 20th century are now hitting the limits of what is possible” (UNEP, 2008).

References

- Acharya, Philippon, Richardson, and N. Roubini (2009): “The Financial Crisis of 2007-2009: Causes and Remedies,” *Financial Markets, Institutions & Instruments*, 18(2), 89–137.
- Acharya, V., and Richardson, M. (2010): *What Caused the Financial Crisis? How Securitization Concentrated Risk in the Financial Sector*. University of Pennsylvania Press: Philadelphia.
- Almeida, P.; Silva, P. (2009) “The peak of oil production Timings and market recognition,” *Energy Policy* 37(4):1267–1276.
- American Recovery and Reinvestment Act of 2009 (ARRA, 2009), *Public Law* 111-5, H.R. 1, S. 1.
- Anderson, Victor (2009) “Economic growth and economic crisis,” *International Journal of Green Economics* 3(1):19–27.
- BBC. (2008) “Oil price hits yet another record,” BBC News, 3 July. news.bbc.co.uk/2/hi/business/7486764.stm
- Blanchard, Olivier J. and Gali, Jordi (2007) “The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so Different from the 1970s?” *MIT Department of Economics Working Study* 07–21. August 18.
- Blinder, Alan and Jeremy Rudd (2009) “Oil shocks redux,” *VoxEU.org*, 13 January 2009.
- Bordo, M. (2009): “The Crisis of 2007: The Same Old Story Only the Players have Changed,” *Globalization and Systemic Risk*, 6, 39.
- Caballero, R. (2010): “The ‘Other’ Imbalance and the Financial Crisis,” *Working Paper* 15636, National Bureau of Economic Research, Cambridge, MA.
- Caballero, R. and Krishnamurthy, A. (2009) “Global Imbalances and Financial Fragility,” *NBER Working Paper* 14688, January.
- Campbell, C. and Laherrère, J. (1998) “The end of cheap oil,” *Scientific American* 278(3):78–83.

- Carr, F.M. and Beese, J.A. (2008) "How rising oil prices caused home foreclosures from 2005–2008," *Proceedings of the Allied Academies* 15(2):70–73.
- Edelstein, Paul and Kilian, Lutz. (2007) "Retail Energy Prices and Consumer Expenditures," *CEPR Discussion Study* 6255, April.
- Glaeser, Edward L.; Gottlieb, Joshua D.; and Gyourko, Joseph. "Can Cheap Credit Explain The Housing Boom?" National Bureau of Economic Research (NBER) Working Paper Series, July 2010.
- Hamilton, James D. (2009) "Causes and Consequences of the Oil Shock of 2007–08," *NBER Working Study* 15002, May.
- Höök, M.; Hirsch, R. and Aleklett, K. (2009) "Giant oil field decline rates and their influence on world oil production," *Energy Policy* 37(6):2262–2272.
- International Monetary Fund (IMF). (2012) *International Financial Statistics*, 2011.
- Mayer, C. (2011): "Housing Bubbles: A Survey," *Annual Review of Economics*, 3(1), 559–577.
- Mian, A., and A. Sufi (2010): "The Great Recession: Lessons from Microeconomic Data," *American Economic Review*, 100(2), 1–10.
- Autodata. (2012). *Motor Intelligence*, <http://www.motorintelligence.com/>
- Reinhart, C., and K. Rogoff (2008): "Is the 2007 U.S. Sub-Prime Financial Crisis So Different? An International Historical Comparison," *The American Economic Review*, 98(2), 339–344.
- S&P/Experian. (2012) *First Mortgage Default Index*. In: S&P/Experian Consumer Credit Default Composite Indexes.
- Sexton, Steven; Wu, JunJie; and Zilberman, David. "How High Gas Prices Triggered the Housing Crisis: Theory and Empirical Evidence." UC Center for Energy and Environmental Economics Working Paper Series, February 2012.
- Shafiee, S. and Topal, E. (2009) "When will fossil fuel reserves be diminished?" *Energy Policy* 37(1):181–189.
- Theramus. (2009) "Was Volatility in the Price of Oil a Cause of the 2008 Financial Crisis?" *The Oil Drum*, December 8.
- Train, K.E. and Winston, C. (2008) "Vehicle choice behavior and the declining market share of U.S. automakers," *International Economic Review* 48(4):1469–1496.
- United Nation Environment Programme (UNEP). (2008) "Global green new deal – environmentally-focused investment historic opportunity for 21st century prosperity and job generation," London/Nairobi, October 22.
- World Bank. (2012) *World Development Indicators*, 2011.
- Zhao, L.; Feng, L. and Hall, C. (2009) "Is peakoilism coming?" *Energy Policy* 37(6):2136–2138.

DG Types Effect on the Optimal Location for Voltage Sag Mitigation

Ahmed Abdrabou*¹, Ayman Soliman*², Ahmed Safawi*¹

*¹University Technology Malaysia, Malaysia, *² Electronics Research Institute, Egypt

0139

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Voltage sag is considered to be the most serious hazard of power quality and can produce a harmful effect in electrical power system stability. Distributed Generation which used in this paper is playing an important role in power system to improve the grid performance. Grid performance and avoiding degradation the power system networks depend probably on the locations of DGs, hence, optimizing the DGs locations are necessary. In this paper Genetic algorithm is used for DGs locations optimization. The type of DG will directly influence the penetration level “size” and the locations of DGs. Three different DGs “synchronous generator, wind turbine and photo voltaic” will be penetrated individually to find their optimum location and compare their performances on the power system grid and investigate their impact in mitigation voltage sag. This approach will be applied on IEEE 13 bus system which is simulated using PSCAD software. Genetic Algorithm is used to find the optimum solution of multi-objective function; the objective function combines the overall number of buses experience voltage sag, the number of buses experience voltage drop, the number of buses experience voltage less than 10% and the overall number of buses experience voltage swell which Matlab software is used for simulation. Finally, Results are analyzed and discussed which show that the optimum locations of each DG will vary according to the type of DG but all of them will be around the load center.

Keywords—Voltage Sag Mitigation, Power Quality, Optimal DG Locations, Genetic Algorithm.

I. INTRODUCTION

Voltage sag is a momentary drop in voltage magnitude and is considered the most serious problem in power system and could produce a harmful effect [1, 2]. As the voltage sag and short duration power outage are accounted 92% of the power quality problems reported by industrial consumers [1], and this is due to spreading the sensitive devices in industry and commercial loads then this phenomenon will be highly considered to find the best solution to mitigate the voltage sag. This phenomenon is produced due to starting large motors or due to short circuit balanced or unbalanced and can lead to malfunction and stacking or freezing sensitive devices specially electronics and power electronics equipments such as PCs, PLCs and variable speed drives. To improve the power system network performance and reduce the effect of the voltage sag phenomenon, distributed generations are proposed to provide a lot of benefits to the electrical network. Also, sag mitigation is implemented using VSC (Voltage Source Converter) [2] but to mitigate the voltage sag at a specific location which the authors focus on the controlling the power electronic converter to compensate the voltage at this location. Improving the voltage profile and reducing the power loss without considering the voltage sag improvement are widely considered in [5-9] using DGs. Improving the reliability and stability of power system without finding the optimal location of DG are considered in [4, 14, 15]. DGs are used also to mitigate the voltage sag phenomenon and to reduce the effect of this phenomena as much as possible [1, 2, 3, 4, 12, 16] but with many limitations and without optimizing their locations except in [1]. The researcher in [1] applied only 3ph fault to ground, which used general type of single phase DG with high power at medium voltage which is not realistic. While in [2, 3, 16] concentrated on the power electronic technology to optimize the control scheme, series or shunt DVR (Dynamic Voltage Restorer). Different types of distributed generation are widely inserted through the power system network while the renewable energy types are the most commonly used due to their environmentally friendly features and protect the earth from the emission of worm gasses [12, 15, 16]. In this paper Generation from photo voltaic, wind turbine and diesel generator are used to improve the performance of unbalanced radial system used for medium voltage distribution. IEEE 13 bus approach is used to represent the unbalanced radial network.

The proposed solution is to insert three individuals DGs resources, these resources are photovoltaic, wind turbine and diesel generator. The optimum location will be defined using genetic algorithm, the genetic algorithm, will be implemented by constructing an objective function, this function will combine four factors. The first factor is the overall number of 1ph buses experience voltage sag all over the whole process, the sag will be produced by executing short circuit (1ph and 3ph) at all the buses for a specific period of time 0.3-0.5 sec for each DG location. 2nd factor is the overall number of 1ph buses experience voltage drop 0.9 over the whole process. The 3rd factor is the overall number of 1ph buses experiences zero voltage. The 4th one is the overall number of 1ph buses experience voltage swell 1.1. To minimize the search space some assumptions are considered such as, the inserted DGs are two identical types and size each three-phase 500 KW. An important assumption is that the load is considered fixed with time to avoid

the necessity of increasing or decreasing the DG sizes. This paper is organized as follows, section II describes DG features for used three types and a brief description about GA technique, in section III the problem formulation and optimization technique are introduced. Analysis, simulation results and discussion are presented in section IV. Finally, conclusion is presented in section V.

II. DISTRIBUTED GENERATION AND GENETIC ALGORITHM (GA)

Distributed Generation is a power source ranges from tens of KW up to tens of MW and normally provided in medium voltage and sub-transmission. DGs are inserted in the electrical network grid to improve the grid performance. Different types of DGs are considered to play an important role due to the great development in the electronic and power electronics technology to control most of the new types of DGs such as photovoltaic which needs sun tracking system and needs for DC to DC converters for MPPT (maximum power point tracking) in-addition to frequency converter to change to AC, the photovoltaic actually relies on two parameters which will be considered as constant in this work , they are the temperature and the irradiance and will be taken 70 oC and 650 W/M2 respectively. Another type of used DGs in this work is wind turbine, it can be connected directly to the grid or it can include converter and inverter to control the turbine to avoid the frequency disturbance due to the variation of the wind speed which changes frequently. The wind turbine also needs control scheme to control the pitch angle of the tail according to the direction of wind. The last type of used DGs in this paper is the synchronous generator and will be connected directly to the grid network. Other types of DGs are used also but not included in our scope are Concentrated Solar Power, Tidal Wave Power and Biomass Electricity Generation and some DGs use CHP (Combined Heat and Power). Genetic Algorithms are family of computational model that rely on the concept of the revolutionary process [1]. It is well known in the law of natural in the course of several generations that the individuals that better adapted to the environment will manage to survive and pass their gens to the succeeding generation.

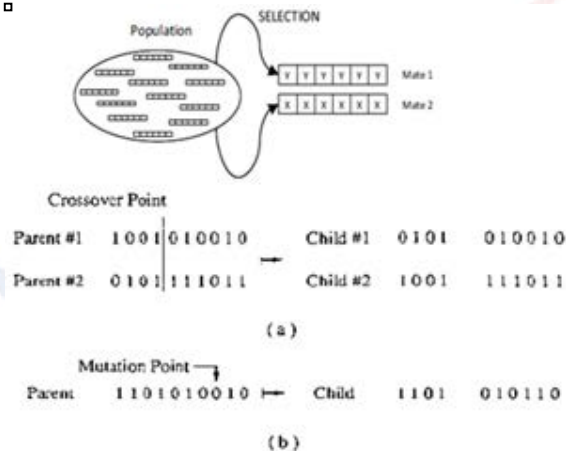


Fig. 1 Selection, Crossover and Mutation of GA

The encoding of the system to a string or a vector of binary (1 or 0), the encoding can be also numbers or letters, the length of the string depends on the number of nodes in the grid. Suppose that we have 7 nodes grid network and 2 DGs with same size, then number

of possible solutions are $27 = 128$ because if there is a DG the status will be 1 while no DG the status will be 0 but if we assume two different DGs, so we will have 3 status (DG1=1, DG2=2 and noDG=0) then the number of possible iterations or solutions will be $37 = 2187$, this assumption will be considered in this work. Cross over and mutation are used here with the genetic algorithm, the cross over will be used up to 80% while the mutation will be around 1-5%. Fig.1 shows the three Genetic Algorithm operators, selection, crossover and mutation to generate the new generation. The flow chart in Fig. 4 shows all the optimization procedures.

III. PROBLEM FORMULATION AND OPTIMIZING TECHNIQUE

The main target in this paper is to find the optimum location of each DG type individually to mitigate the sag. Procedures which proposed to obtain this target are as following:-

Firstly, Make Simulation without penetrating any DG type and coding the IEEE 13 bus using Matlab Software as a start of GA technique so that the bus with DG is 1 while the bus without DG is 0.

Secondly, The IEEE13 bus system which shown in Fig. 2 is simulated using PSCAD software. Power System Computer Aided Design is software which used to process electrical network in transient and steady state condition in-addition to many control processes and mathematical operations.

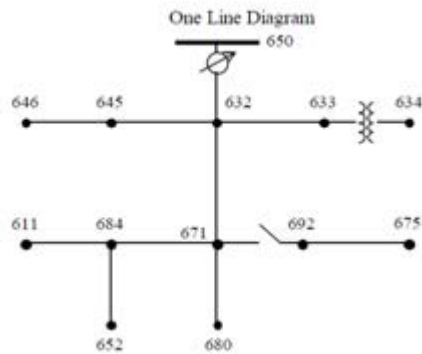


Fig. 2 Single line diagram of IEEE 13 bus system, the buses 611, 684,652, 645 and 646 are 1ph

Thirdly, Simulating GA for each DG type individually by selecting a random solution (two identical DG types as initial solution), each DG model will be inserted to the 13 bus system then 1ph short circuit which is 80% probably occurs and 3ph short circuit which is the most severe fault will be applied at all possible locations in the grid which all voltage measurements are considered. Fig. 3 shows the PSCAD simulated grid for IEEE 13 bus grid which includes main generator 5MVA 115KV, transformer 5MVA 115/4.16 KV, all the DG types synchronous, wind and PV in-addition to all the measuring meters at all buses and the fault modules for 1ph and 3ph. The synchronous generator is connected to the grid while both wind turbine and PV sources are ready to be connected.

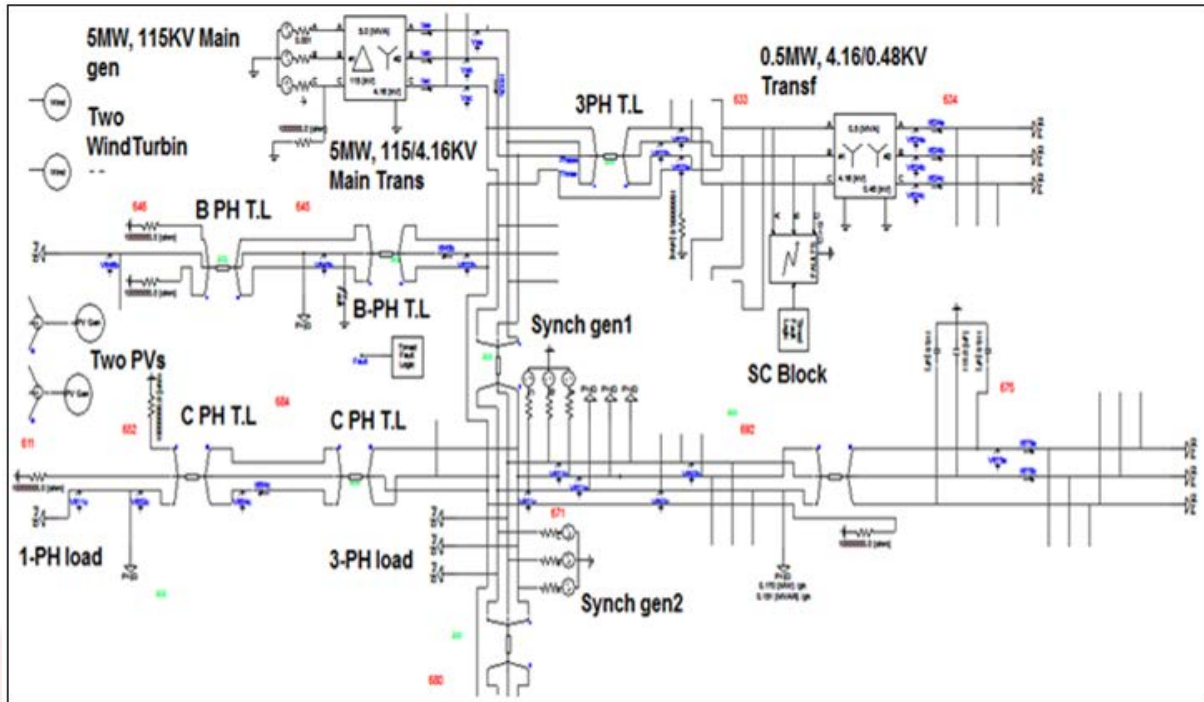


Fig. 3 PSCAD simulated grid for IEEE 13 bus grid

Fourthly, Objective function is applied to specify if the solution is fit or not using Matlab Software. The objective function combines four variables, the overall number of buses experience sag, the overall number of buses experience voltage drop, the overall number of buses experience zero voltage (less than 10%) and the number of buses experience swell voltage. All these variables are calculated over the whole short circuit process. The measured buses in this work are considered as single phase buses because the applied short circuit is 1ph and 3ph so it is suitable to deal with single phase bus than three phase bus and the SC is approximately occurs 80% while the 3ph SC is 10%. These variables are denoted as N_{sag} , N_{drop} , N_{zero} and N_{swell} . The objective function is defined as, $F_{obj} = a * N_{sag} + b * N_{drop} + c * N_{zero} + d * N_{swell}$ Where $a = 0.7$, $b = 0.1$, $c = 0.1$ and $d = 0.1$ are factors can be changed according to importance of the 4 variables and the paper target.

Fifthly, The selection, crossover and mutation are applied to reproduce the next generation, each solution which violates the constraints are ignored, the constraints are that the DGs penetration will be 25% and the DGs will be three phase. This means that the solutions which include 1ph bus locations will be ignored.

Finally, The new solution will be added to the network as a new location until reaching to the optimum location, after that all these steps are repeated to all different DG types to obtain the optimization locations for all types. Flow chart that indicates Optimization procedure technique is shown in Fig.4.

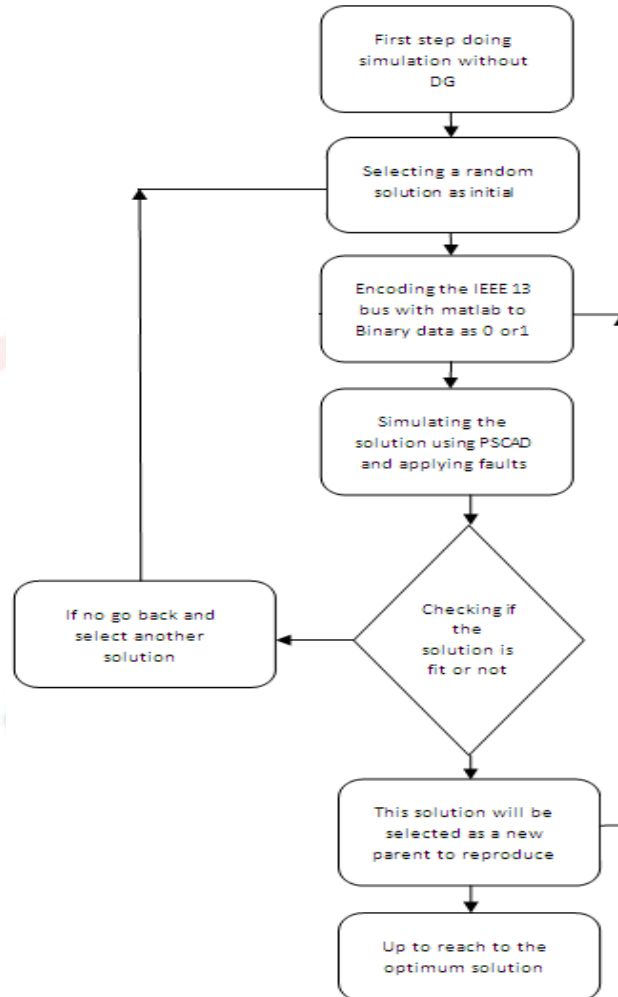


Fig. 4 Optimization procedure technique of GA

IV. ANALYSIS, SIMULATION RESULTS AND DISCUSSION

A. Synchronous Generator as a DG Type

In general, DGs penetration provides boosting to the bus voltage. Hence, Simulation is done for IEEE 13 bus grid without and with DG penetration at the buses 633 and 692 which results is shown in Figure 5. It is clear when looking to Fig. 5 below, the voltage sag “in another buses” in case of no-DG (Fig.5 a) is deeper than the case while the DGs penetrated (Fig.5b). This means that it is not only important to insert DG to the grid but the important is to find the optimum location to have better performance.

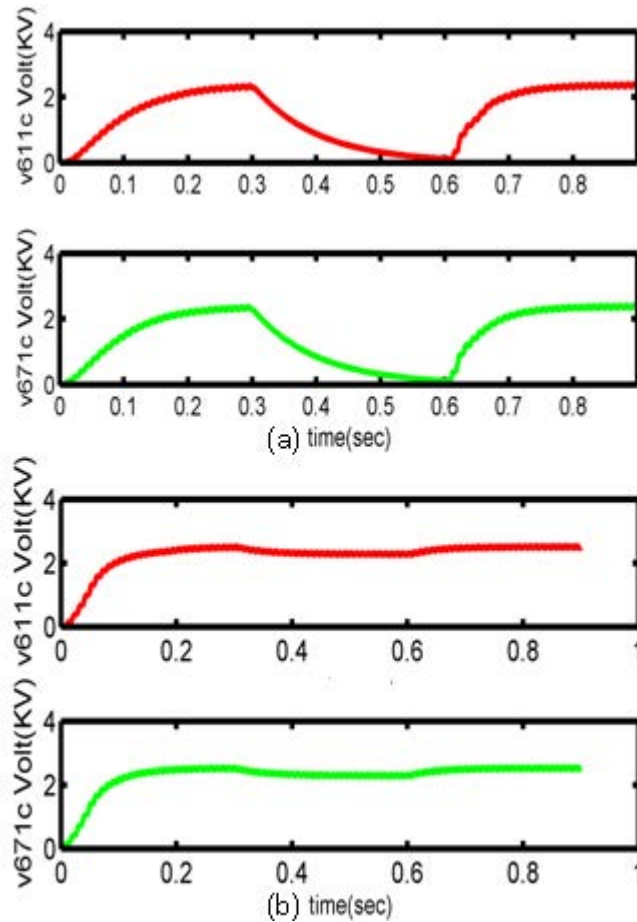


Fig.5 the buses voltages without (a) and with (b) DGs of IEEE13 bus

The simulation results shown in Table I prove that not all the synchronous generator locations as a DG produce an improvement on the grid better than no DG case. The location like 632-671 produces Fobj value 225.6 which is higher than 117.8 for no DG but the location 633-692 is 54.8 which more is better than no-DG and this location produces the minimum objective function value. Then, optimization of DG penetration is highly important. Fig. 6 shows that the locations 671-675 are local optima and the most optima are 633-692.

TABLE I
 DG SYNCH GENERATOR LOCATIONS AND PERFORMANCES

DG locations	N_{sag}	N_{drop}	N_{zero}	N_{swell}	F_{obj} Objective Function
No-DG	310	40	31	77	231.8
DG633-675	69	38	43	292	85.6
DG633-680	73	21	34	278	84.4
DG633-692	51	20	12	159	54.8
DG633-671	52	20	12	158	55.4
DG632-671	313	47	8	10	225.6
DG632-692	305	47	14	12	220.8
DG632-645b	360	8	35	0	256.3
DG671-675	77	30	5	128	70.2
DG671-675	77	32	5	140	71.6

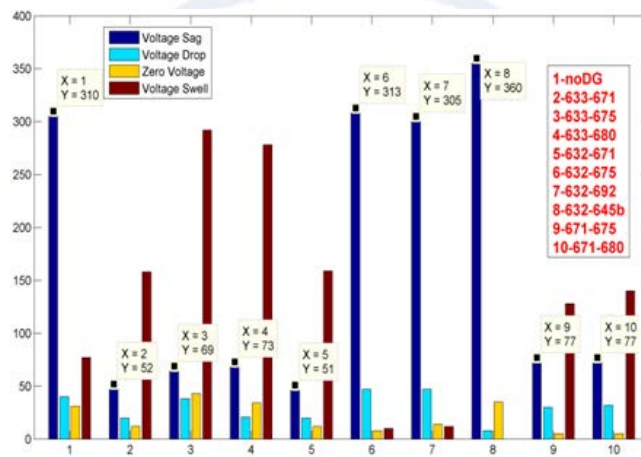


Fig.6. N_{sag} , N_{drop} , N_{zero} and N_{swell} for synch generator as a DG

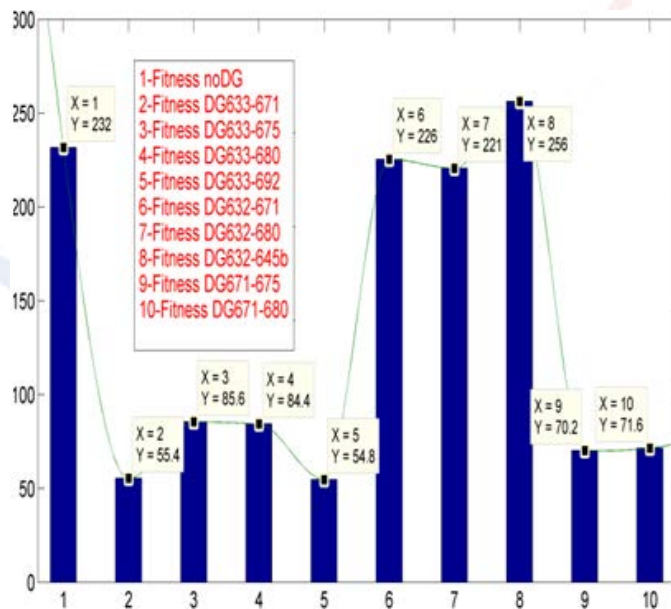


Fig.7 Fitness values for synchronous generator as a DG

Figure 7 shows the DG location which produces minimum objective function value (fitness value) is at the location 633-692. The results shown in figures 5,6,7 and Table I provides the improvements in the grid performance by mitigating the voltage sag and reducing the overall number of buses experience sag in-addition to the overall number of buses experience voltage drop, the overall number of buses with zero voltage and finally the overall number of buses experience voltage swell but attention should be taken because not all the location improve the grid performance, some of them could lead to degradation of the performance as shown in the locations DG632-671 and DG632-680 in figure6. Finally the best location provides the better performance is at the buses 633-692 and produce the lower objective function value as found in figure 7 and Table I in which is 54.8.

B. Wind Turbine as a DG Type

In this case, all variables, N_{sag} , N_{drop} , N_{zero} and N_{swell} shown in Table II clarify how the presence of DG produces better performance than the case without DG except roughly the location 633-692 while the best location was 632-671. In this best location N_{sag} is minimum, N_{zero} and N_{swell} are low too except N_{drop} but this do not affect the objective function value (fitness value) in which is 225.2. If this produced value is compared with the produced value in synchronous DG type which is 54.8 at the solution (location) 633-692, we can find that the synchronous generator mitigates the voltage sag better than the wind turbine and in a different location too. So, this is a proof that each DG type provides different effect on the grid.

TABLE II
 DG WIND TURBINE LOCATIONS AND PERFORMANCES

DG locations	N_{sag}	N_{drop}	N_{zero}	N_{swell}	F_{obj} Objective Function
No-DG	310	40	31	77	231.8
DG633-671	305	16	29	83	226.3
DG633-675	302	8	32	131	228.5
DG633-680	308	3	35	91	228.5
DG633-692	302	6	34	161	231.5
DG632-671	300	60	29	63	225.2
DG632-692	309	3	32	92	229
DG632-675	309	3	32	92	229
DG-671	21	1	81	242	331

C. Photo Voltaic as a DG Type

Table III shows N_{sag} , N_{drop} , N_{zero} , N_{swell} and the objective function (fitness) values for PV source as a DG. It shows also that all the DG solutions (locations) produce a worse performance than the case without DG where all PV locations fitness ranges from 241.5 up to 251.6 while the case without PV is 231.8 but anyway PV is considered an important DG and the penetration of it to avoid severe degradation and to better

compensate the voltage in case of SC or starting of large motors. So, it is recommended to select the location that provides better performance on the grid than the others and this location is can be 633-692 or 632-633.

TABLE III
 DG PHOTOVOLTAIC LOCATIONS AND PERFORMANCES

DG locations	N_{sag}	N_{drop}	N_{zero}	N_{swell}	F_{obj} Objective Function
No-DG	310	40	31	77	231.8
DG633_675	339	18	3	122	251.6
DG633_680	336	12	2	81	244.7
DG633_692	331	12	2	84	241.5
DG633_671	336	12	2	84	245
DG632_671	336	12	2	79	244.5
DG632_692	336	12	2	79	244.5
DG632_675	336	12	2	79	244.5
DG632-633	330	23	2	80	241.5
DG633	341	32	3	77	249.9

TABLE IV
 THE OPTIMAL LOCATIONS OF THREE DG TYPES

DG Type	Synchronous Generator	Wind Turbine	PV Source
Location	DG633-692	DG632-671	DG632-633 or DG633-692
Min F_{obj} (Fitness)	54.8	225.2	241.5

Table IV shows the comparing results of PV with the both synchronous and wind turbine, it is found that the synchronous has better performance than wind and PV while wind is better than PV.

V. CONCLUSION

In This paper Genetic Algorithm is used to optimize the location of three types of DG with a modified reference to the random solution and the next generations and the target is to minimize the objective function, which evaluates each DG location individually. Each model of DG type is inserted separately to investigate its behaviors on the grid precisely, which results shows that each type provide different features and behaviors on the IEEE 13 bus. In the mean time, results prove that the optimum locations differs by each DG type in which, synchronous generator mitigates the sag better than wind turbine and photovoltaic while wind turbine is better than photovoltaic.

REFERENCES

- [1] M. J. Jahromi, E. Farajah, M. Zolghardi, "Mitigation Voltage Sag by Optimal Allocation of Distributed Generation Using Genetic Algorithm", 9th International Conference, Electrical Power Quality and Utilization, Barcelona 9-11 Oct. 2007, pp. 1-6.
- [2] WANG Song-cen, YU Kun-shan, and TANG Guang-fu, "Mitigation of Voltage Sags by Grid-Connected Distributed Generation System in Series and Shunt Configuration", December 1-3, 2008, Johor Baharu, Malaysia conf, pp. 463-476.
- [3] G. Justin Sunil Dhas, Dr. T. Ruben Deva Prakash, "A Novel approach for Voltage Sag Mitigation Using FACTS Device Interline Dynamic Voltage Restorer", 2011 IEEE, pp. 37-41.
- [4] Juan A. Martinez-Velasco, "Distributed Generation Impact on Voltage Sags in Distribution Networks", August 7, 9th international conference, Electrical Power Quality and Utility, Barcelona 2009 IEEE, pp. 1-6.
- [5] Edward R. R. Collins, J. Jiang, "Voltage Sags and the Response of a Synchronous Distributed Generator: A Case Study", JANUARY 2008, pp. 442-448.
- [6] T. GÖZEL M. Hakan, H. U. EMINOGLU A. BALIKCI, "Optimal Placement and Sizing of Distributed Generation on Radial Feeder with Different Static Load Models", Future Power Systems, 2005 International Conference, pp. 2-6.
- [7] S. Kamalinia, S. Afsharnia (1), M. E. Khodayar A. Rahimikian, M.A. Sharbafi, "A combination of MADM and Genetic Algorithm for optimal DG Allocation in Power System", 2007 IEEE, UPEC2007, pp. 1031-1035.
- [8] M. Sedighzadeh, A. Rezzadeh, "Using Genetic Algorithm For Distributed Generation Allocation to Reduce Losses and Improve Voltage Profile", Sustainable Power Generation and Supply, 2009. SUPERGEN '09. International Conference, pp. 954-959.
- [9] M. R. Aghaebrahimi, M. Amiri and S. H. Zahiri, "An Immune-Based Optimization Method for Distributed Generation Placement in order to Optimize Voltage Profile", Sustainable Power Generation and Supply, SUPERGN 2009, pp. 1-7.
- [10] M. Elnashar, R. El Shatshat, M. Salama, "Optimum sitting and sizing of a large distributed generator in a mesh connected system", Power & Energy Society Meeting 2009, pp. 1-6.
- [11] C. Almeida, N. Kagan, "Allocation of Power Quality Monitors by Genetic Algorithms and Fuzzy Sets Theory" Intelligent System Application to Power System, ISAP 2009, pp. 1-6.
- [12] A. Hajizadeh, M. A. Golkar, K.N. Toosi, "Control of Hybrid Fuel Cell/Battery Distributed Power Generation System with Voltage Sag Ride-Through" Power Technology and IEEE Power India Conference, Oct 2008 IEEE, pp. 1-6.
- [13] Mallikarjuna R. Vallem, NM 88003, "Sitting and Sizing of Distributed Generation for Optimal Microgrid Architecture", 2005 IEEE, pp. 611-616.
- [14] L. Wang, and C. Singh, "Reliability-Constrained Optimum Placement of Reclosers and Distributed Generators in Distribution Networks Using an Ant Colony" IEEE Transaction, 2008, pp. 757-764.

- [15] Z. Kuan, Z. Jian-hua, LIU Wen-xia, Distribution Network Reliability Considering, Complementary Distribution Generation with Wind and Photovoltaic Powers, Critical infrastructure, 5th International Conference, 2010 IEEE, pp. 1-5.
- [16] S. Biswas¹ and S.K. Goswami, "Genetic Algorithm based Optimal Placement of Distributed Generation Reducing Loss and Improving Voltage Sag", TENCON, IEEE Region, 2011, pp. 108-112.



*Estimation of Nitrogen Dioxide Concentrations in the Inner Bangkok
by Land Use Regression Model*

Panee Cheewinsiriwat, Pongsri Chanhow

Chulalongkorn University, Thailand

0143

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The Pollution Control Department (PCD) has long been responsible for an hourly measurement of Nitrogen Dioxide (NO₂) concentrations at its twelve stations located within the 430 square kilometer area of Inner Bangkok. In the past, to estimate NO₂ concentrations at any unmeasured location, the proximity model, interpolation model, or dispersion model were employed. These models used distance from a measured location as the sole determinant of any estimation. Toward the end of the 1990's, the more sophisticated Land Use Regression (LUR) model was introduced. This model with its built-in Geographic Information System (GIS) and multiple regression analysis enabled the inclusion of other important determining variables such as land use types, traffic volume and selected meteorological variables. This research aims to apply the LUR model for the estimation of NO₂ concentrations over the study area covering the Inner Bangkok. Monthly average NO₂ concentrations, traffic count, land use types, road area together with humidity, temperature, wind speed, and rainfall data, measured at or within the vicinities of the twelve PCD stations were input into the model. Only humidity, temperature, wind speed, residential land use, industrial land use, and rainfall are found to have influenced the NO₂ concentrations in the Inner Bangkok. The resulting coefficient of determination (R square) of 0.759 implies that seventy-six percent of the variations in NO₂ concentrations in the Inner Bangkok can be explained by model. The research will, however, continue to obtain more precise traffic volume data in terms of time scale to improve the model.

Keywords: Nitrogen Dioxide, Bangkok, GIS, Land Use Regression model, multiple regression analysis, air pollution

1. Introduction

Air pollution is one of the major environmental problems in urban areas especially big cities including Bangkok. Among the different air pollutants, Nitrogen dioxide (NO₂) has been rarely explored over coverage of Bangkok. It is harmful to human health particularly for the respiratory system. High concentration inhaled into human bodies can cause lung cancer. The implementation of air pollutant measurement stations is costly, requires high technical support and is usually limited to a small number of stations within a city. In the case of Bangkok, The Pollution Control Department (PCD) has long been responsible for an hourly measurement of NO₂ concentrations at its twelve stations located within the 430 square kilometer area of Inner Bangkok. Although the NO₂ concentration levels in Bangkok are still below the air quality standard level defined by the Ministry of Technology and Environment of Thailand, the levels need to be monitored to ensure the quality of life of people in Bangkok.

As every location cannot be measured, NO₂ concentrations at unmeasured locations can be obtained only by methods of estimation. In the past, to estimate NO₂ concentrations at any unmeasured location, the proximity model, interpolation model, or dispersion model were employed (Jerrett *et al.*, 2005). These models used distance from a measured location as a sole determinant of any estimation. Distance is, however, not the only factor that affects the concentrations of NO₂. Toward the end of the 1990's, the more sophisticated Land Use Regression (LUR) model was introduced. The model with its built-in Geographic Information System (GIS) and multiple regression analysis enabled the inclusion of other important determining variables such as land use types, traffic volume and selected meteorological variables (Briggs *et al.*, 1997). This is to fill the gaps of the sparse air pollution measurements stations.

The LUR model has been successfully implemented in several urban areas in different countries such as Sheffield in UK, Los Angeles in U.S.A. and Montreal in Canada (Briggs *et al.*, 1997; Gilbert *et al.*, 2005; Beelen *et al.*, 2009; Su *et al.*, 2009). The models implemented in different cities were based on the same concept but different factors or variables. This research aims to apply the LUR model to estimate NO₂ concentrations over the study area covering the Inner Bangkok. Monthly average NO₂ concentrations, traffic volume, land use area, road area together with relative humidity, temperature, wind speed, and rainfall, measured at or within the vicinities of the twelve PCD stations, are the input factors of the Bangkok LUR model.

In the next section, the applications of LUR and GIS on NO₂ concentration issues in previous researches are identified. Then, the study area and datasets used in the Bangkok model are described, followed by the analysis results and conclusions.

2. LUR and GIS Implementations on NO₂ Concentration Issues

As air pollution is one of the major problems in big cities, it has been studied in order to monitor, identify, and predict levels of risk to human health. Estimation methods such as proximity model, interpolation model, LUR model, and dispersion model, have been employed to generate a map of air pollution levels over the study area covering both locations with and without measurements (Jerrett *et al.*, 2005). The proximity model estimates air pollution concentrations

based on distance from sources. Locations nearer to the sources are estimated to have higher concentrations. The proximity model considers distance as the sole factor, although the other factors may also affect the concentration levels. The interpolation model estimates concentrations by employing spatial statistics both deterministic and stochastic methods. The interpolation model uses a set of sample measured concentrations from a number of measurement stations. The accuracy of the results is based on numbers of measurements input to the model.

The dispersion model employs Gaussian plume equations to estimate concentrations. The dispersion model is good to generate the concentrations from sources over time. However, it is costly to obtain input data from sources for this kind of model. The LUR model estimates concentrations from pollution-related factors which are in or around a certain location. The pollution-related factors include traffic volume, land use, climate-related data, etc. At the same quality level of the output, the LUR model provides better results and lower cost than the other three models.

The LUR model has been applied in several researches on air pollution concentrations in big cities (Hoek *et al.*, 2008). Briggs *et al.* (1997) has introduced a regression-based method integrated with GIS, later named LUR model, to generate air pollution maps of three cities in Europe, which are Amsterdam (the Netherlands), Huddersfield (UK), and Prague (the Czech Republic). The input data of this research were road characteristics and traffic volume, land use, elevation, and measured NO₂ concentrations. It was found that NO₂ concentrations generated by road traffic affect areas within 100 meters from roads. The model was able to estimate NO₂ concentrations at unmeasured locations with high accuracy and precision (Briggs *et al.*, 1997). After that, LUR models were implemented in several cities including Los Angeles, Montreal, and Rome (Gilbert *et al.*, 2005; Rosenlund *et al.*, 2007; Hoek *et al.*, 2008; Su *et al.*, 2009).

In regression analysis, the concentrations measured at stations or sites are the samples that are vital in the estimation calculation for unmeasured sites (Jerrett *et al.*, 2005). The number of samples varies in each study area depending on size, from 20 in Texas to 459 in Europe (Hoek *et al.* 2008). The factors used for the study areas are rather similar, but different choices of the factors were selected for a particular study area based on the characteristics of the city. The factors include transportation network, road length, traffic volume, vehicle type, distance from roads, distance from the sea, number of population, population density, number of buildings, land use, physical characteristics, and meteorological data (Jerrett *et al.*, 2005; Arain *et al.*, 2007; Hoek *et al.*, 2008).

For Bangkok, relationships between NO₂ concentrations and related-environment factors were studied in six study areas distributed over Bangkok (Leong *et al.* 2003). The study reported that the levels of NO₂ concentrations relate to various factors included road type, road width, traffic volume and speed, vehicle type, as well as meteorological factors. It was also reported that the concentrations were influenced by seasonal climate; higher in winter and lower in summer. In 2004, a set of air pollution risk maps were also produced using a spatial interpolation technique based on the samples of measured NO₂ concentrations from a number of PCD stations (Pangsang, 2004). The risk maps revealed that the high risk districts (or so-called “Khet”) were Bang Rak, Bueng Kum, Pathum Wan, Lat Phrao, Sathon, and Watthana, which were areas of high density, business centers, and congested traffic.

LUR and GIS have been used to study NO₂ concentrations in several cities and the estimation results were accurate enough to be reliable for health and environment planning (Hoek *et al.*, 2008). Although most factors used in each model are quite similar, a model which is good for one city may not be appropriate for another city because of the differences in built-up areas and physical characteristics of the city (Jerrett *et al.*, 2005). As air pollution in Bangkok is considered one of the major problems of the city and the LUR model had not been previously applied to any area in Thailand, this research attempted to apply the LUR model to estimate NO₂ concentrations in the area of Inner Bangkok. This research included traffic volume, land use, and meteorological data as the input data to the model. A multiple regression equation based on the input data was expected as the result.

3. Study Area and Datasets

The study area is the Inner Bangkok covering 32 districts (Bangkok consists of 50 districts) or 430 square kilometers. Within the study area, 12 PCD stations are located to hourly measure air quality including NO₂ concentrations. In Figure 1, the districts within the study area as well as the PCD stations with their station IDs are shown. The data used in this study consists of the measured NO₂ concentrations, traffic volume, road area, land use, relative humidity, temperature, wind speed, and rainfall. The data were collected in the period of January to December 2010. The NO₂ concentrations, relative humidity, temperature, wind speed, and rainfall data were measured by the PCD, while traffic volume, road area, and land use were collected and digitalized by the Bangkok Metropolitan Authority (BMA).

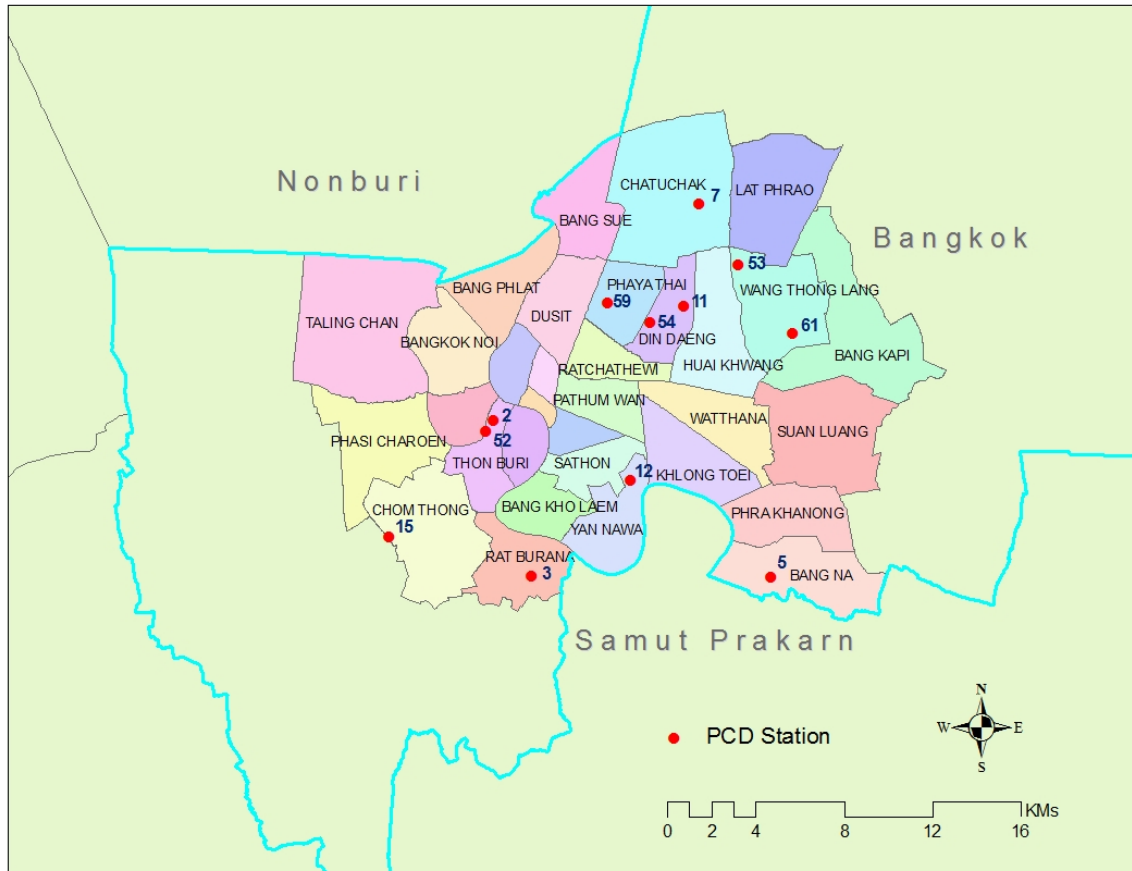


Figure 1 The districts within the study area and PCD stations with their station IDs.

Figure 2 shows that the averages hourly NO_2 concentrations of the 12 stations are of different levels, but mostly in the same direction. This can be interpreted that the NO_2 concentrations in Inner Bangkok are related to season, which corresponds to the previous research. In Figure 3, Traffic volume on each road was estimated based on the traffic count at 251 intersections. This research classified roads into four distinct categories: highway, main road, secondary road, and small road. The traffic counts were also classified according to the category of the road on which they were counted. Traffic counts on the same road category were sorted and the median values were selected to be the estimated traffic volume of each road category. Road areas were also calculated from the length of roads multiplied by their width.

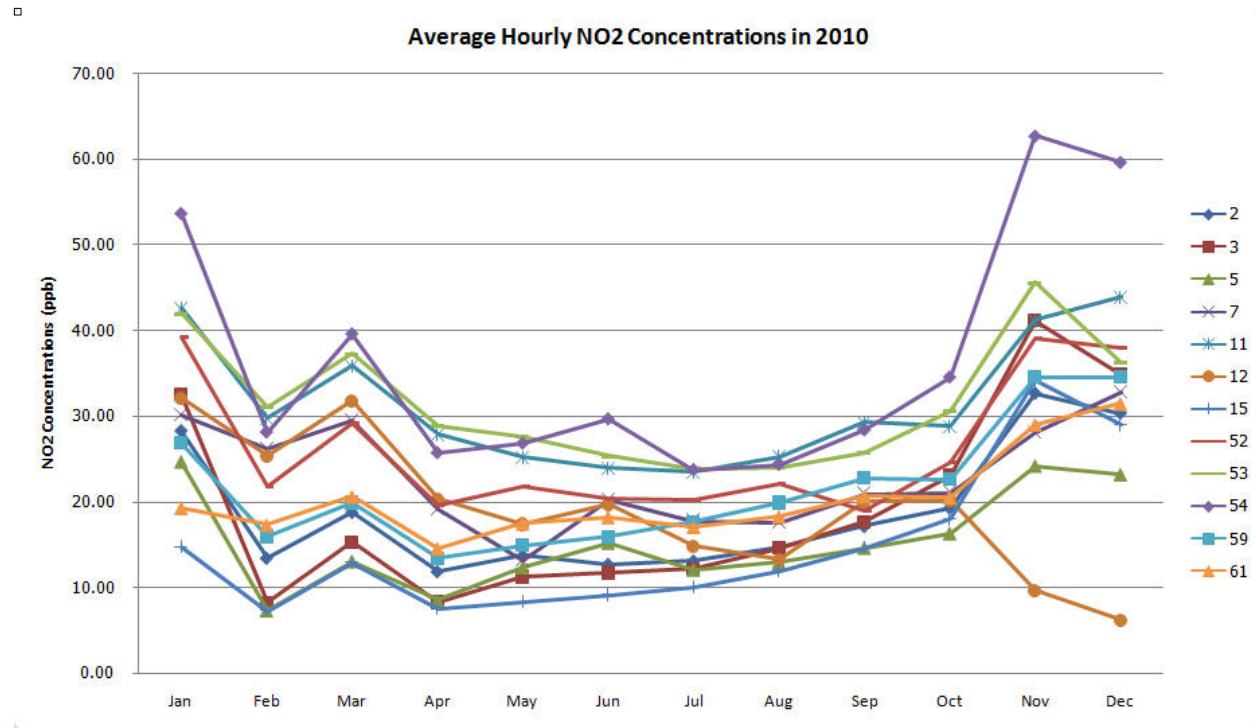


Figure 2 Average hourly NO₂ concentrations in 2010.

This research focused on only four land use categories: residential, commercial, industrial, and agriculture. In this research, building footprints were used as the land use factor. Land use areas were thus calculated from building footprint areas of each building use categories. In Figure 4, the map depicts the four distinct categories of buildings based on their usage over the study area. For climate data, percentages of relative humidity levels in Bangkok range from below 10 up to 100 for the year of 2010 (Figure 5), while temperatures were between 20 -35 degree Celsius (Figure 6). Bangkok is not in a windy area as the highest wind speed of most stations is about 4-5 meter/second (Figure 7). The maximum hourly rainfalls in Bangkok were about 40-50 mm (Figure 8).

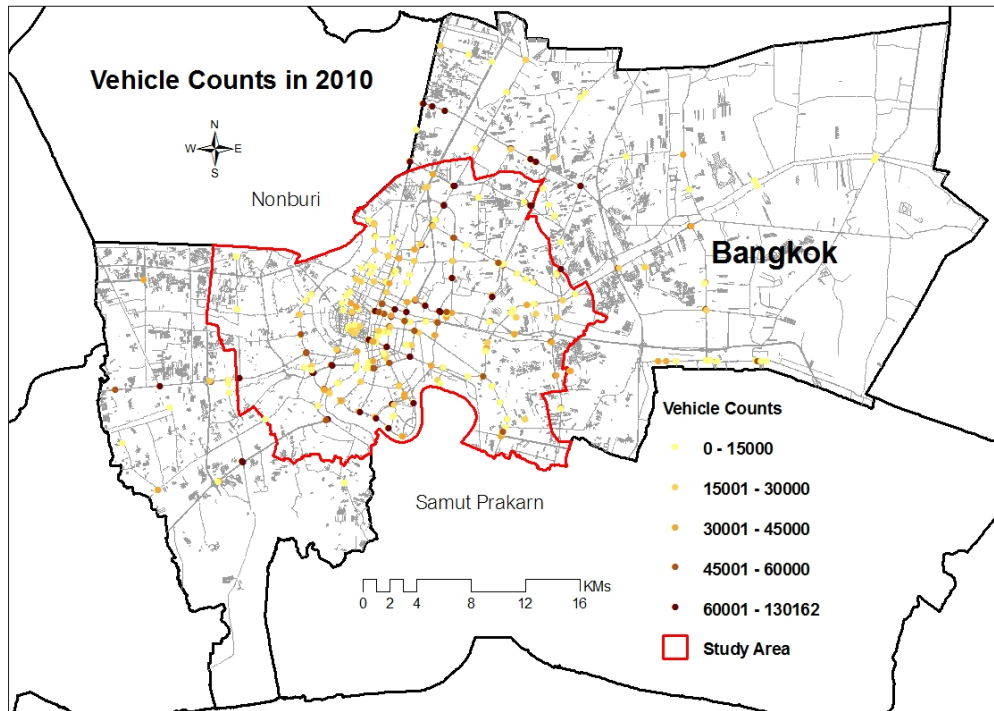


Figure 3 Traffic counts at 251 intersections in 2010.

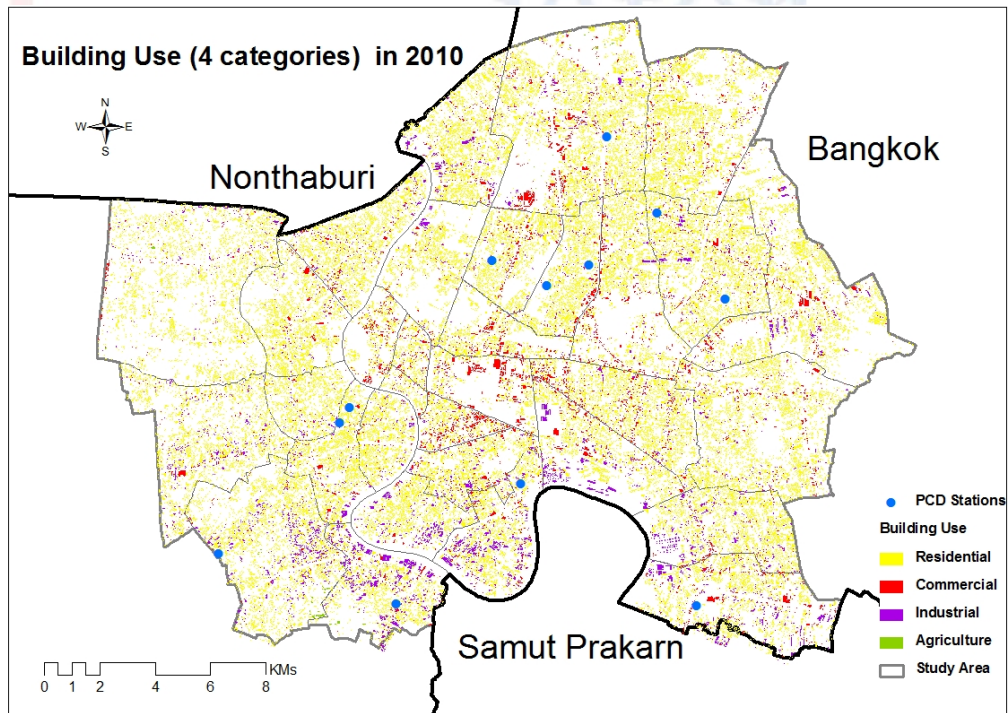


Figure 4 Building footprints categorized by building use within the study area.

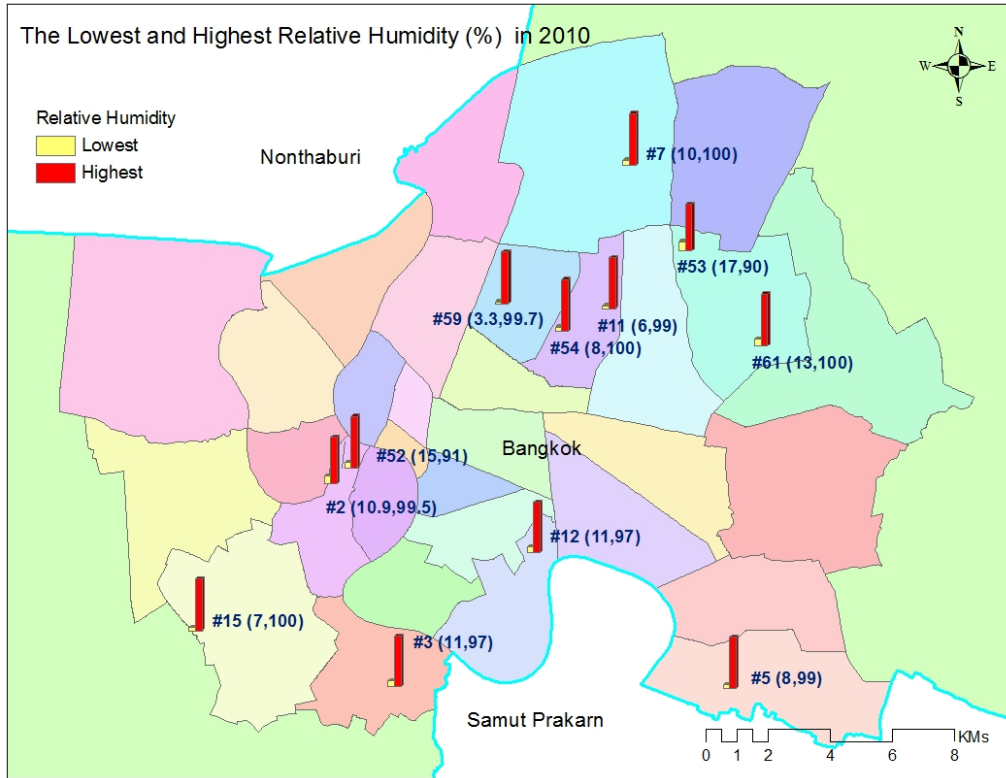


Figure 5 The lowest and highest relative humidity levels (%) in 2010.

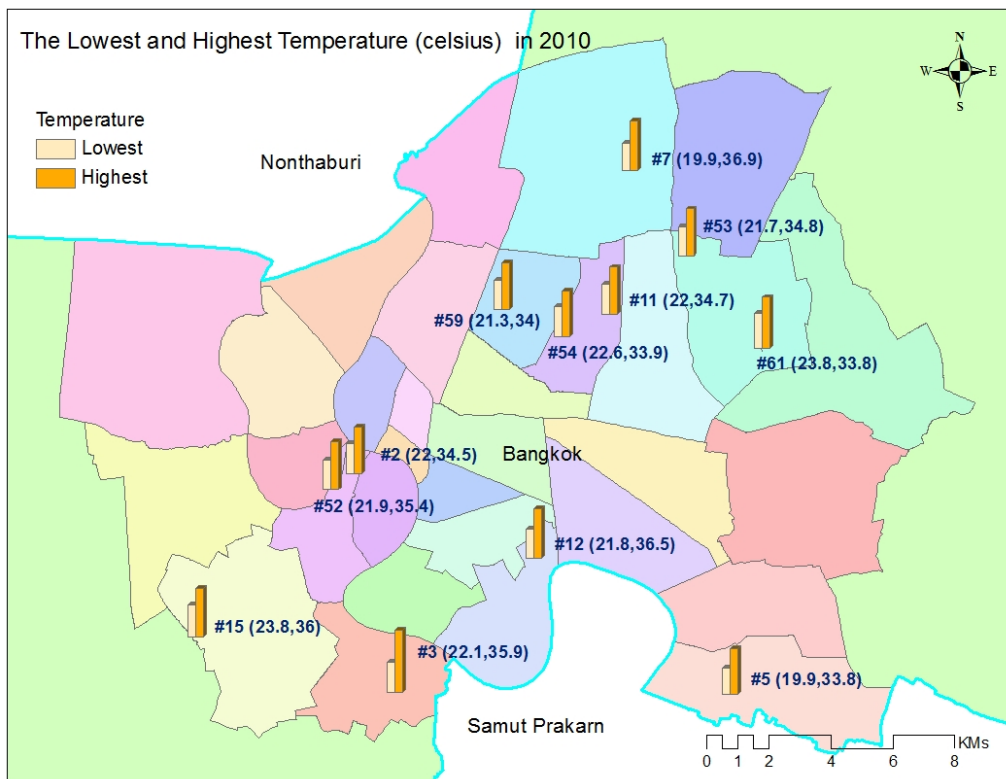


Figure 6 The lowest and highest temperature (celsius) in 2010.

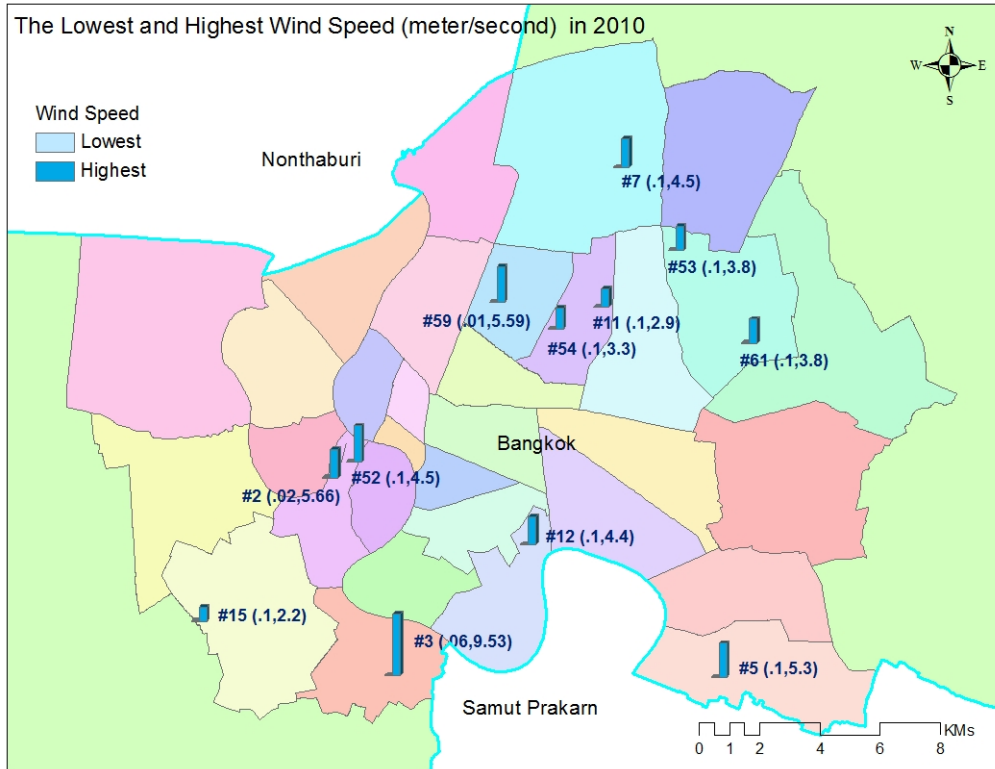


Figure 7 The lowest and highest wind speed (meter per second) in 2010.

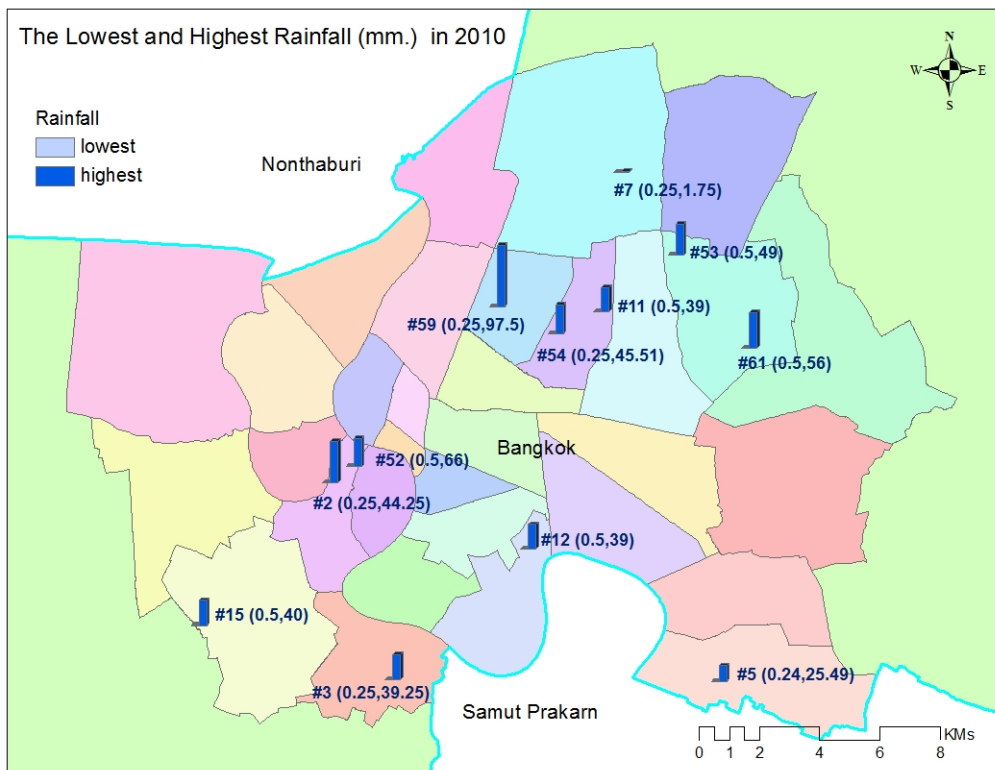


Figure 8 The lowest and highest rainfall (millimeters) in 2010.

4. Analysis and Results

In the analysis process, all data values used in the model are on monthly basis starting from January to December 2010. NO₂ concentrations are in average of hourly concentrations of each month. Values of traffic volume, road area, and land use are assumed unchanged over the year, so their values of each month are the same for each PCD station. The values of meteorological data are also in average of hourly measurements of each month. At the beginning of the analysis process, the input factors were tested from their correlation with hourly average NO₂ concentrations of each month at 12 PCD stations. If values of a factor and NO₂ concentrations had a correlation with a significant level greater than 0.05, the factor was then selected. And if the factor is not collinear with other factors, it is considered one of the input factors to the multiple regression model.

For traffic volume, road area, and land use, it was necessary to find out a distance from the 12 PCD stations that most affect the NO₂ concentrations at the stations. To achieve this, in GIS environment, the area of 1 kilometer around the stations was divided into 20 buffer zones (50 meters each). Values of each factor within 50, 100, 150, ..., 1000 meters were calculated and then input to a statistical software package to find out the distance with the strongest correlation to the NO₂ concentrations. The values of each factor at the selected distance were then input to the multiple regression model.

4.1 Traffic Volume

Traffic volume on roads surrounding the 12 PCD stations were calculated based on estimated traffic counts on roads within a distance from the stations. The monthly volumes of a station were assumed the same throughout the year. It was found that traffic volume within 50 meters from the stations had the strongest correlation with NO₂ concentration at 0.391, with a signification level less than 0.01. Considering only correlation with a significant level greater than 0.05, the correlation indices were decreasing from 0.391 at 50 m to 0.204 at 150 m. At further distance, the indices were increasing from 0.158 at 400 m to 0.311 at 650 m, and then decreasing to 0.176 at 850 m. In conclusion, traffic volumes within 50 meters from the 12 PCD stations were included into the model.

4.2 Road Area

With limitation of the data received, road areas used in this research were also assumed static throughout the year. Thus, road area values of a station are the same for every month. The 50 meter buffer zones within 1 km around the 12 PCD stations were also applied with this factor to find out an appropriate distance that road areas considerably affect NO₂ concentrations. It was found that all of the distances have correlation with NO₂ concentrations with significant level greater than 0.05. The highest correlation index was found at the distance of 650 m with significant level less than 0.01.

4.3 Land Use

In this research, land use areas in 4 categories were selected: residential, commercial, industrial, and agriculture. The areas were calculated by summing up the building footprint areas in the same category. The twenty meter buffer zones were also applied to this factor. Thus, the areas of each category within each buffer zone were calculated, and then used to find out the appropriate distances for each land use category. For residential, the highest correlation index, 0.473, was found at 50 meters. For commercial, the highest correlation index was 0.489 at 150 meters. The industrial areas gave the negative correlation index at -0.312 at 650 meters. Compared to the other three land use categories, the agriculture area gave the least correlation. The highest correlation index for the agriculture was 0.267 at 600 meters. The significant levels of the correlation indices of all four categories were less than 0.01.

4.4 Relative Humidity

The averages of hourly relative humidity (%) in each month of the 12 PCD stations were calculated, and then input to the statistical calculation. It was revealed that the values of relative humidity negatively correlated with the NO₂ concentrations at the index of -0.388 with a significant level less than 0.01.

4.5 Temperature

The monthly average temperature values of the 12 PCD stations were calculated from the recorded hourly measurements. The averages, ranging from 27 to 33 degree Celsius, negatively correlated with the NO₂ concentrations at the index of -0.396 with a significant level less than 0.01.

4.6 Wind Speed

The averages of hourly wind speed (meter/second) for each month were calculated. It was found that wind speed also negatively correlated with the NO₂ concentrations at the index of -0.433 with a significant level less than 0.01.

4.7 Rainfall

The averages of hourly rainfall (mm) for each month were calculated, and then input to the statistical calculation. It was found that the rainfall also negatively correlated with the NO₂ concentration at the index of -0.211 with a significant level less than 0.01.

4.8 Multiple Regression Analysis

Since all factors correlated with the NO₂ concentrations significantly, all of them were input into the multiple regression analysis. The stepwise method was selected to perform the analysis, with the entry of 0.05 and removal of 0.10. The analysis gave the R-squared value of 0.768 and the adjusted R-squared value of 0.758. This means that 76.8% of the variation can be explained by the regression and the given input factors. The resultant regression coefficients are shown in

Table 1. The factors removed from the model are traffic volume, road area, commercial area, and agriculture area. The t-test shows that all included factors are statistically significant at the level of 0.05. Based on the resultant regression coefficients in Table 1, the regression equation was derived and shown in Equation 1.

Table 1 The resultant regression coefficients.

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	160.943	10.550		15.255	0.00000
HUMIDITY	-0.648	0.079	-0.408	-8.242	0.00000
TEMPERATURE	-2.971	0.300	-0.414	-9.909	0.00000
WIND SPEED	-3.440	0.938	-0.170	-3.666	0.00035
RESIDENTIAL	0.008	0.001	0.527	12.008	0.00000
INDUSTRIAL	-0.00014	0.00002	-0.312	-7.001	0.00000
RAINFALL	-7.508	3.195	-0.119	-2.350	0.02021

$$NO_2 = 160.943 - (0.648 * Humidity) - (2.971 * Temperature) - (3.44 * WindSpeed) + (0.008 * Residential_D50) - (0.00014 * Industrial_D650) - (7.508 * Rainfall) \quad \text{Equation 1}$$

The regression coefficients show that relative humidity, temperature, wind speed, industrial area, and rainfall factors are negatively correlated to the NO₂ concentrations, while only the residential area factor is positively correlated. The standardized coefficients also show that the residential area factor has the most influence on the NO₂ concentrations, while wind speed and rain fall has the least influence.

5. Conclusions

The LUR model estimates the NO₂ concentrations based on a set of related NO₂-generated data at measured locations. The data may vary depending on the characteristic of the cities. Therefore, the concept of the LUR model can be applied to a city but not all the datasets may be useful. Bangkok is a big city and has not applied the LUR model for NO₂ concentration estimation yet. This research has investigated the LUR model concept and attempted to apply it on the area of Inner Bangkok. The LUR model of the inner Bangkok reveals that land use only residential and industrial area affect the NO₂ concentrations, while all meteorological data (relative humidity, temperature, wind speed, and rainfall). A few observations comparing to the previous researches

are identified as follows. Firstly, while traffic volume was included in the LUR model of previous researches, it is removed from the Bangkok LUR model. This is possibly because the calculated traffic volume data used in this research was not accurate enough. More precise traffic volume data in terms of time scale should be collected to improve the model. Secondly, meteorological factors were not often used as input data from the previous researches, although a few researches suggested including them to improve the models. In this model, all four meteorological data were used and none of them were removed from the model. As the results, about seventy-six percent of the variations in NO₂ concentrations in the Inner Bangkok can be explained by the Bangkok LUR model.

Acknowledgement

The authors would like to thank Thailand Research Fund, Office of Higher Education, and Chulalongkorn University for their financial support. The authors also would like to express our appreciation to the Thai Meteorological Department, the Pollution Control Department, and the Ministry of Transport for the valuable digital data used in this project.

References

- Arain, M. A., R. Blair, N. Finkelstein, J. R. Brook, T. Sahsuvaroglu, B. Beckerman, L. Zhang and M. Jerrett (2007). "The use of wind fields in a land use regression model to predict air pollution concentrations for health exposure studies." Atmospheric Environment **41**: 3453-3464.
- Beelen, R., G. Hoek, E. Pebesma, D. Vienneau, K. D. Hoogh and D. J. Briggs (2009). "Mapping of background air pollution at a fine spatial scale across the European Union." Science of the Total Environment **407**: 1852-1867.
- Briggs, D. J., S. Collins, P. Elliott, P. Fisher, S. Kingham, E. Lebet, K. Pryn, H. V. Reeuwijk, K. Smallbone and A. V. D. Veen (1997). "Mapping urban air pollution using GIS: a regression-based approach." International Journal Geographical Information Science **11**(7): 699-718.
- Gilbert, N. L., M. S. Goldberg, B. Beckerman, J. R. Brook and M. Jerrett (2005). Assessing Spatial Variability of Ambient Nitrogen Dioxide in Montreal, Canada, with a Land-Use Regression Model, Air & Waste Management Association. **55**: 1059-1063.
- Hoek, G., R. Beelen, K. d. Hoogh, D. Vienneau, J. Gulliver, P. Fischer and D. Briggs (2008). "A review of land-use regression models to assess spatial variation of outdoor air pollution." Atmospheric Environment **42**: 7561-7578.
- Jerrett, M., A. Arain, P. Kanaroglou, B. Beckerman, D. Potoglou, T. Sahsuvaroglu, J. Morrison and C. Giovis (2005). "A review and evaluation of intraurban air pollution exposure models." Journal of Exposure Analysis and Environmental Epidemiology **15**: 185-204.

- Leong, S. T. and P. Laortanakul (2003). "Monitoring Framework for Nitrogen Dioxide Measurement in a Tropical City : A Bangkok Case Study." Environmental Engineering Science **20**: 557-567.
- Pangsang, V. (2004). Geographic Information System for Determining Air Pollution Risk Area in the Bangkok Metropolis. Department of Geography, Faculty of Arts. Bangkok, Thailand, Chulalongkorn University. Degree of Master of Arts in Geography: 186.
- Rosenlund, M., F. Forastiere, M. Stafoggia, D. Porta, M. Perucci, A. Ranzi, F. Nussio and C. A. Perucci (2007). "Comparison of regression models with land-use and emission data to predict the spatial distribution of traffic-related air pollution in Rome." Journal of Exposure Science and Environmental Epidemiology **17**.
- Su, J. G., M. Jerrett, B. Beckerman, M. Wilhelm, J. K. Ghosh and B. Ritz (2009). "Predicting traffic-related air pollution in Los Angeles using a distance decay regression selection strategy." Environmental Research **109**: 657-670.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is enclosed within a large, faint circular graphic composed of two overlapping arcs: a red one on the left and a blue one on the right, which together form a partial circle around the text.

*Selecting Bio-Indicator Fish for Monitoring Organochlorine Pesticide Contamination
in the River*

Khobkul Nongnutch*¹, Jakkaphun Nanuam*², Chawanrat Somnuek*³

*¹Rajamangala University of Technology, Thailand, *²Burapha University, Thailand,
*³Rambhai Barni Rajabhat University, Thailand

0164

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The aim of this study was to select the appropriate bio-indicator to monitor organochlorine contamination in the river and understand the effecting factors. Two species of fish; spot barb (*Puntius bimaculatus*) and naked catfish (*Bagaridge*) were selected as the representatives of planktonivorous fish and omnivorous fish, respectively, because they were found across the country and can bear to organochlorine pesticide. Fish sample was collected from the rivers in the area of Water Resource Development Program, Sakon Naknon province, Thailand. These rivers received organochlorine pesticide from surrounding agricultural area. The results indicated that organochlorine concentration which accumulated in Spot barb was higher than that in Naked catfish. This finding positively correlated to the higher amount of lipid tissue which found in Spot barb. The possible explanation was organochlorine pesticide which is hydrophobic substance tended to accumulate in lipid tissue. In conclusion, Spot barb can be used as a useful bio-indicator for monitoring organochlorine contamination.

Keywords; organochlorine pesticides (OCPs), bio-indicator, spot barb (*Puntius bimaculatus*) and naked catfish (*Bagaridge*)

Introduction

Organochlorine pesticides (OCPs) are agro-chemical which is widely used in developing countries; including Thailand, for controlling and eliminating pests or insects in farm land. Their high hydrophobic and lipophilic characteristic results in persist and long-term accumulate in the environment not only in abiotic part (Guo et al, 2008 ; Guo, 2008 and Carro, 2004) but also in the biotic. The residue of pesticides used in agriculture finds its way to ponds, streams, and rivers. After being assimilated into the aquatic organisms, they can be passed and biomagnified through the food chain causing adverse effect on ecosystem and human health. Monitoring program for OCPs contamination requires the appropriate “sentinel” to precisely detect them. That sentinel must be widely found in contaminated area and tolerate to the pesticide. From literature reviews, it was found that spot barb (*Puntius bimaculatus*) and naked catfish (*Bagaridge*) which is local fish and widely found across Thailand having the potential to meet that requirement.

However, assimilation and accumulation of OCPs in these fishes are influenced by a number of factors; both internal and external, such as metabolic rate which depends on its species, percentage of lipid content, and season. Thus, the influences of these factors have to be studied for further improve the monitoring program efficiency.

The aim of this study was to understand the effect of species, percentage of lipid content and season on OCPs accumulation in spot barb and naked catfish and identify the appropriate bio-indicator to monitor its contamination in the river.

Materials and Methods

In this study, the representatives of planktonivorous fish (lower trophic level) and omnivorous fish (higher trophic level) were spot barb (*Puntius bimaculatus*) and naked catfish (*Bagaridge*), respectively. They were found across Thailand and could bear to OCPs. Fish samples were collected from the rivers in the area of Water Resource Development Program, Sakon Nakhon province, located in Northeastern Thailand. Nine stations collecting sample was located along the river which receives OCPs from surrounding farm land. The samples were taken in both dry and wet season. Their size ranged from 15 to 20 cm and weight was about 50 g. After collection, their flesh was taken, freeze-dried for 3 days, and then ground into fine powders. Next, dried flesh powders were kept in desiccator until extraction.

Soxhlet Extraction

Soxhlet extraction method was modified from Guo (2008). In brief, dried flesh powders were put in an extraction thimble. Then, the thimble was inserted into Soxhlet extractor filled with 150 ml solvent mixture of n-hexane – acetone (4:1, v/v). Extraction process was run continuously for 7 hours and temperature was kept at 50 °C. The remaining extract was concentrated to 6 ml by using rotary evaporator. Finally, the solution was kept at 4 °C until analysis.

Lipid content

Lipid content measurement was performed by the method modified form Oh (2000). Two milliliters of concentrated solution was dried for about 2 h at 60 °C. Lipid content was calculated following the equation:

$$\% \text{ Lipid} = \frac{(W_2 - W_1) \times FV}{10SW}$$

where, W_1 is the weight of aluminum foil cup (g), W_2 the weight of aluminum foil cup and lipid content after dried (g), FV is solvent volume after extracted (ml), and SW is sample weight (g)

OCPs measurement

Four milliliters of concentrated solution was purified by using florisil as described in Hyung (2000). Briefly, the concentrated solution was applied to the head of florisil packed column. The first fraction was eluted with 150 ml of dichloromethane/hexane (1/4 v/v) and discarded. The second fraction was eluted with 70 ml of hexane and retained. The extract was concentrated to 4 ml. Next, the extract was applied into HPLC cleanup column, and then concentrated to 1ml. Finally, surrogate standard (4,4'-Dibromo-octafluorobiphenyl, DBOFB) was spiked before instrumental analysis by using Gas Chromatography, GC.

Results and Discussions

After percentage of lipid content and OCPs concentration in both fish species was measured, the results indicated that OCPs concentration in spot barb (planktonivorous fish in lower trophic level) was higher than that in naked catfish (omnivorous fish in higher trophic level) as shown in fig 1. The higher OCPs concentration found in spot barb was positive significant correlation with its higher lipid content as compared with naked catfish (Fig 2).

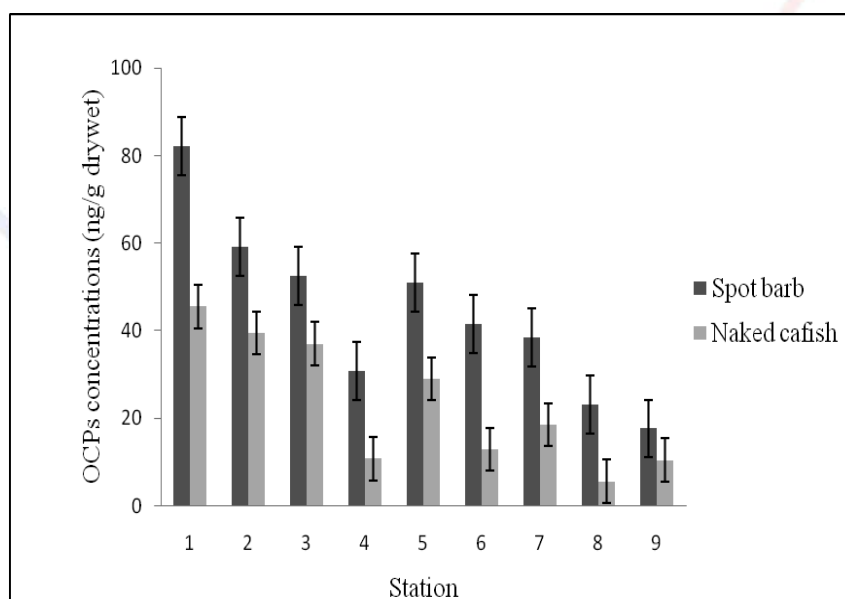


Figure 1 OCPs concentration in spot barb and naked catfish

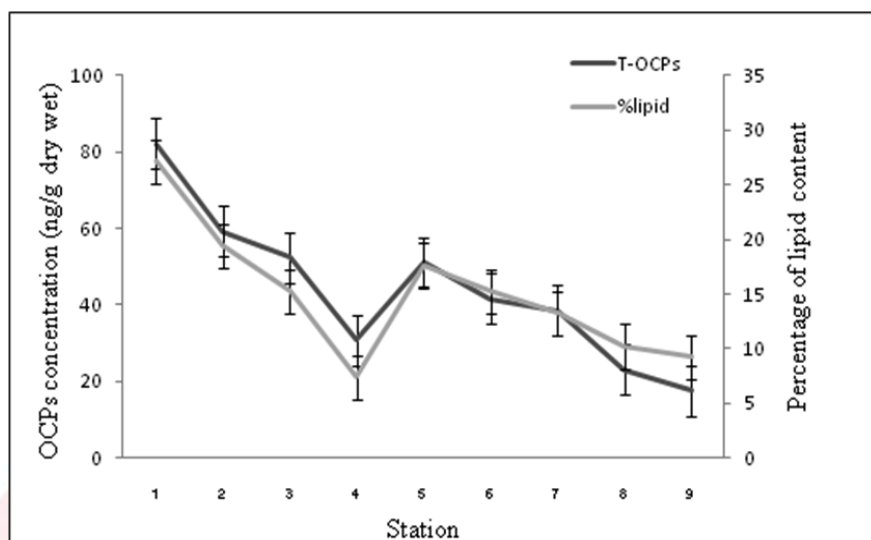
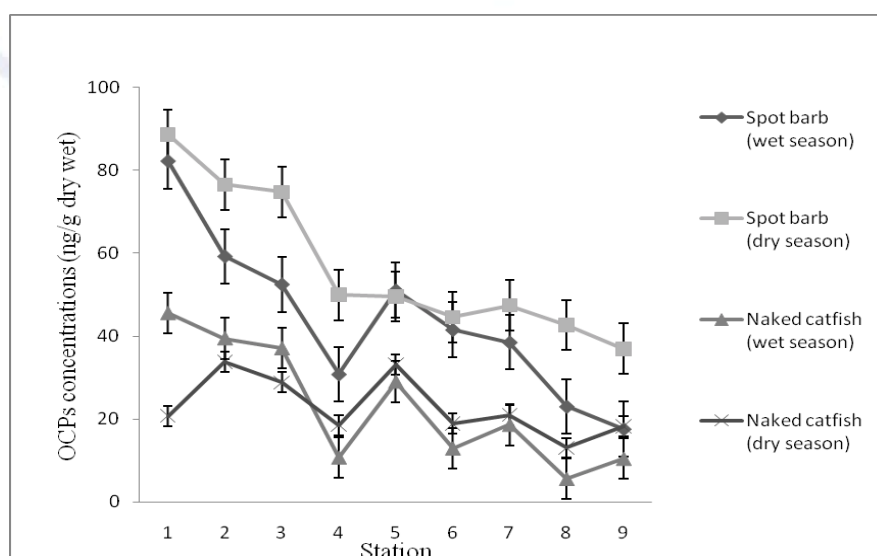


Figure 2 OCPs concentration and lipid content in spot barb

As generally known, hydrophobic contaminant was increasingly biomagnified when passing through food chain. However, the results indicated that OCPs concentration in spot barb which is in lower trophic level was higher than that in naked catfish in the upper level. This phenomenon might be explained by the characteristic of OCPs which is hydrophobic substance thus they tended to accumulate in lipid tissue (bioaccumulation) which found higher in spot barb as compared with naked catfish. This finding was in agreement with the study of Guo et al.(2008) which compare the effect of biomagnification and bioaccumulation by using $\delta^{15}N$ isotope to assess biomagnification of hydrophobic organic compound passed from prey organisms to the predator and found that the influence of higher lipid content in planktonivorous fish (bioaccumulation) overwhelmed the effect of biomagnification in carnivorous fish in the upper trophic level. This explanation was also supported by the study of Das et al. (2002) which measured OCPs residual concentration in catfish, *Tachysurus thalassinus*, from the South Patches of the Bay of Bengal. They found a positive correlation and linear relationship between OCPs and lipid content in fish.

After comparing OCPs concentration in fish samples collected in dry and wet season, the results indicated that OCPs concentration in both fish species collected in dry season was higher than that in wet season (Fig 3).



This finding might be explained by the characteristic of water channel in dry season. Except lack of water input, the water in dry season is stagnant causing the contaminants to settle down or adsorb onto organic matter and then being feed by the fish. The result was in agreement with the study of Das et al. (2002) which found hydrophobic pesticide residual in fish collected in dry season higher than that in wet season.

Conclusion

Based on the results achieved, difference of species, percentage of lipid content and seasonal variation had influence on OCPs accumulation in the fish. Pesticide accumulation in planktonivorous fish (spot barb, *Puntius bimaculatus*) was higher than that in omnivorous fish (naked catfish, *Bagaridge*) because its higher lipid content in which OCPs tend to accumulate. For seasonal variation, it was found that OCPs concentration in fish collected in dry season was higher than that in the wet season because the aquatic contaminant quite concentrated in dry season. Thus, spot barb (*Puntius bimaculatus*) can be used as a potential bio-indicator fish for monitoring OCPs contamination in the river especially in dry season.

Acknowledgement

The authors would like to acknowledge that this study was the collaborative work of three institution; Faculty of Industrial and Technology, Rajamangala University of Technology Isan Sakon Nakhon Campus, Faculty of Science and Social Sciences, Sakaeo campus, Burapha University, and Faculty of Science, Rambhai Barni Rajabhat University. Thus, we would like to thank all three institution in supporting this study.

References

- Biplob Das, Yusuf Sharif Ahmed Khan, Pranab Das, S.M. Shaheen., 2002. Organochlorine pesticide residues in catfish, *Tachysurus thelassinus*(Ruppell,1835), from the South Patches of the Bay of Bengal. *Environmental Pollution* 120, 255-259.
- Hyung, Y.H., Oh, J.R., & Sung, H.K.,2000. *APEC/MOST/KORDI'97 Training workshop on POPs in the marine environment*. Ansan:Korea Ocean Research&Development Institute.
- Lingli Guo, Yaowen Qiu, Gan Zhang, Gene J.Zheng, Paul K.S.Lam, Xiandong Li., 2008. Levels and bioaccumulation of organochlorine pesticides (OCPs) and polybrominated diphenyl ethers (PBDEs) in fishes from the Pearl River estuary and Daya Bay, South China. *Environmental Pollution* 152, 604-611.
- M.Felipe-Sotelo, R.Tauler, I.Vives, J.O.Grimalt., 2008. Assessment of the environmental and physiological processes determining the accumulation of organochlorine compounds in European mountain lake fish through multivariate analysis (PCA and PLS). *Science of the total Environment* 404, 148-161.
- Nieves Carro, Isabel García Ignacio, Ann Mouteira., 2004. Possible influence of lipid content on levels of organochlorine compounds in mussels from Galicia coast (Northwestern, Spain). *Spatial and temporal distribution patterns*. *Environment International* 30, 457-466.
- Oh,J.R., 2000. *APEC/KOICA/KORDI2000 Training course POPs in the marine environment : analysis, bioaccumulation and toxicity*. Paper presented at the meeting of the Korea Ocean Research & Development Institute, Bangkok: Thailand.

Ying Guo, Xiang-Zhou Meng, Hong-Lei Tang, Eddy Y.Zeng., 2008. Tissue distribution of organochlorine pesticides in fish collected from the Pearl River Delta, China: Implications for fishery input source and bioaccumulation. *Environmental Pollution* 155, 150-156.



Future Prospects of Residential Solar Water Heating System in Oman

Abdullah Al-Badi, Mohammed Albadi

Sultan Qaboos University, Oman

0168

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The excessive usage of fossil fuels worldwide is causing environmental problems. One solution to these problems is the exploitation of available renewable energy resources, including solar energy. This exploitation of renewable energy resources becomes essential to meet the large energy demand that resulted in depletion of fossil fuel resources, fuel price uncertainty and volatility, and growing concerns about global warming. Oman is located in a geographical region with an abundant and reliable supply of solar energy throughout the year. This paper presents a thorough financial, economic and technical analysis of using Solar Water Heaters (SWHs) in residential units. It was found that using SWHs in all governorates of Oman can save up to 1859 GWh of electrical energy annually, which is equivalent to the annual energy produced by a power station of 212 MW size. Moreover, the net annual reduction in CO₂ emission exceeds 1.227 million tons. In addition, the economic feasibility of installing SWHs in residential units is presented. The study shows that the dissemination of SWHs in Oman requires setting policies that motivate people to use them. Besides, subsidies to SWHs customers and/or investors will help making the price of these devices more affordable to the public.

Keywords: *Solar water heater; solar energy; Oman.*

1. INTRODUCTION

There are several factors that determine the level of energy consumption in a given society. These factors include population growth, economic performance, and technological developments. Moreover, governmental policies concerning energy will certainly play a key role in the future level and pattern of energy production and consumption [1].

Environmental pollution depends on the amount of energy consumption and the process of energy conversion. Several potential solutions to the current environmental problems have been developed, including harnessing renewable energy as well as the utilization of energy conservation technologies. Today, many countries around the world consider wind, solar and other renewable energy technologies as the key to a clean energy future. Furthermore, renewable energy systems can have a beneficial impact not only on environment but also on economic and political issues of the world.

Renewable energy resources delivered approximately 20% of global electricity supply in 2010, and by early 2011 they encompassed 25% of global power capacity from all sources [2]. Global wind power capacity installations reached a value of 238 GW in 2011, whereas the global existing PV capacity increased to around 70GW in 2011 [2].

Solar heating capacity increased to reach approximately 232 GW thermal in 2011 to provide both water and space heating [2]. Solar water heating technologies are well-known and contributing significantly to hot water production in several countries, lowering energy bills, and reducing the environmental pollution. China, Turkey, Germany, India, and Italy took over the market for newly installed capacity during 2011 [2].

The total solar energy resources in Oman are huge and can satisfy all energy demands as well as provide significant export potential [4]. Several studies on solar energy resource assessment were published [5-17]. In [18] a practical case study was conducted considering a solar PV power plant of 5-MW at 25 locations in Oman. The global average value for solar radiation in the 25 locations is more than 5 kWh/m²/day. The performance and the potential market adoption of SWHs in a number of countries were discussed in details [19-24]. In [25] a preliminary investigation was reported for the potential application of solar water heater for a small area in Oman.

In Oman the residential sector is the largest consumer category for electrical energy with its consumption taking more than half of the total system energy [20]. Part of this electrical energy is used to heat water for almost 5 months a year with an average of 5 hours a day. Considering three 50 liter water heating units in each residential unit, a huge amount of electrical energy is consumed for water heating. As a result, water heating is consuming a large portion of natural gas; therefore, resulting in polluting the environment. The aim of this paper is to evaluate energy savings, the greenhouse gas emission reduction if the electric water heaters are replaced by solar water heaters in residential sector in Oman. In addition, the economic feasibility of installing SWHs in residential units is presented by a case study.

2. USING OF SOLAR WATER HEATERS IN OMAN

Based on 2010 census [28], the total population of Oman is about 2.8 million and there are around 551058 residential units exist. The total number of residential units in the 11 governorates of Oman is presented in Table 1. This study is limited to residential buildings only; it does not include industrial, commercial and governmental sectors. Almost all residential units utilize electric water heaters with an average of 3 heaters in each one. The attributes in Table 1 is calculated based on the parameters presented in Table 2.

Table 2: The model input parameters

Parameter	Value
Water heater rating	1500 W
Number of water heater	3 heaters/unit
Number of hours, heater on	5 hours/day
Number of days, heater on	150 day
Annual energy consumption	3375 kWh/year
Cost of Energy	0.062 US\$/kWh [26]

2.1 Results and Discussions

Utilizing solar water heaters in all governorates in Oman can save up to 1859 GWh annually, as shown in Table 1. This is equivalent to the annual energy produced by power station of 212 MW sizes, which represents 2 frame 9 gas turbine generators operating continuously at rated capacity. This means by replacing the existing electric water heaters with solar heaters, it will be possible to develop and expand future industrial applications without the need for new power station in the short term. Almost all of Oman's domestic electric energy consumption is supplied by burning natural gas. The saving in energy production means reduction in natural gas consumption. This saving will strengthen the economy in Oman that depends mainly on oil and gas revenues. The avoided energy cost in different governorates in Oman is presented in Fig. 1.

Table 3 presents the potential reduction in GHG emissions per MWh of electricity for natural gas generation facilities in Oman. These values are calculated based on the default emission factors, provided by UN's Intergovernmental Panel on Climate Change (IPCC) [29], and considering a 10% transmission and distribution (T&D) losses and the efficiencies indicated [4].

Table 3: Assumed properties for CO₂ calculation

Fuel Type	tCO ₂ /MWh	Efficiency	tCO ₂ /MWh _{Electricity}
Natural Gas	0.20196	0.34	0.66

The other important gain owing to the use of solar water heaters is the reduction of CO₂ footprint. The net annual reduction in CO₂ emission in all governorates exceeds 1.227 million tons, as depicted in Fig. 2. Considering a damage cost of \$20/tCO₂ as in [4], value of avoided emission is quantified as shown in Fig.3. The total annual avoided emission cost in all governorates is about \$ 24.5 million.

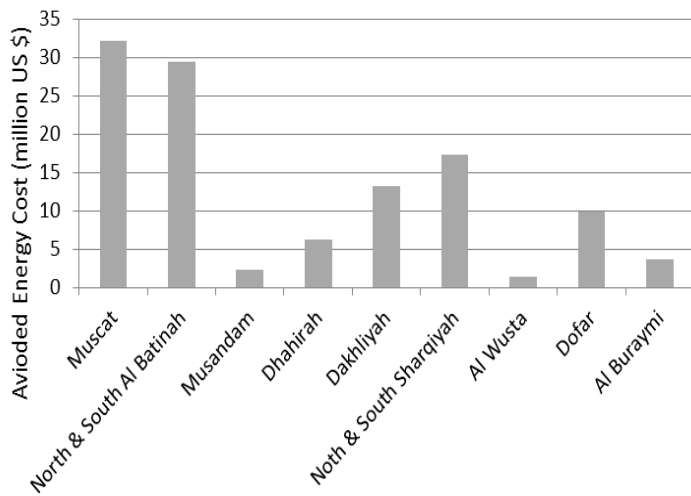


Fig. 1: Avoided energy cost in different governorates of Oman

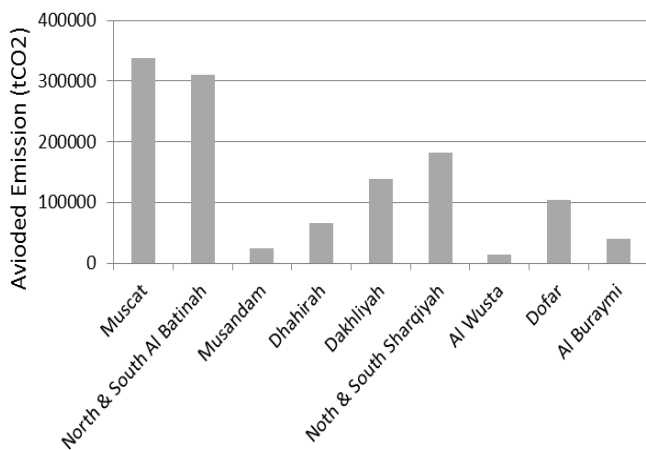


Fig. 2: Annual reduction in CO₂ emission in different governorates of Oman (tCO₂)

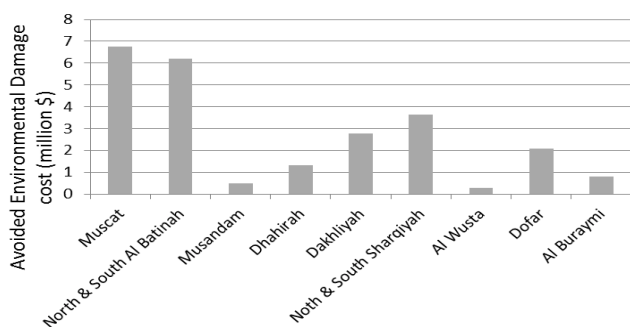


Fig. 3: Annual Avoided Environmental Damage cost in different governorates of Oman

3. TECHNO-ECONOMIC EVALUATION

In this section, the economic feasibility of installing SWHs in a typical residential unit is tested using four economic indicators.

3.1 Economic evaluation methods

The economic feasibility of the project is evaluated using the following indicators: Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR), and the Payback Period (PP)

3.1.1 Net Present Value

Due to the time value of money, a hundred dollars today are more valuable than a hundred dollars in the future. The Net Present Value (NPV) approach uses the time value of money to convert future cash flow into a present value at a certain discount rate.

$$PV = \frac{FV}{(1 + dr)^N} \quad (1)$$

where PV and FV are the Present and the Future Values, respectively; dr is discount rate, and N is number of years in the future.

For a recurring constant annual income, the present value can be found using the following formula [30]:

$$PV_A = A \frac{(1 + dr)^N - 1}{dr(1 + dr)^N} \quad (2)$$

where PV_A is the present value of the recurring annuity, A . The NPV of a project is the difference between revenues and costs in today's money. In any comparison of investing options, the project with the maximum NPV is the winning one.

3.1.2 Benefit-Cost Ratio

The Benefit-Cost Ratio (BCR) is the ratio of the net benefits to costs of the project. Benefits are obtained by summing the present value of annual income, while the cost include capital cost expenditures, O&M costs, replacement costs and taxes, if any. Ratios greater than 1 are indicative of profitable projects. When comparing between different investing options, the project with the maximum BCR is the winning one. Therefore, when ranking different projects, the net BCR leads to the same conclusion as the NPV indicator.

3.1.3 Internal Rate of Return

Mathematically, Internal Rate of Return (IRR) is defined as the discount rate that gives an NPV of zero. IRR is the effective annual return of investment over the life of the project. Therefore, the project will have value for investors if its IRR is greater than the discount rate. When using IRR for project ranking, the project with the highest IRR is the winner.

3.1.4 Payback Period

Payback Period (PP) is defined as the length of time required to recover the initial investment in a project. The shorter the length, the more economically attractive to investors the project is. Although simple PP is easy to understand, it does not account for the time value of money; therefore, it has serious limitations. Using discounted cumulative cash flow, better results can be achieved. Renewable energy investments have intensive capital costs, therefore, relatively long payback periods.

3.2 Economic Assumption

Table 4 shows the cost of the economic assumptions considered in this study.

Table 4: Cost and economic factors of the SWH

Item description	Cost (US\$)
Total initial cost	\$ 1350
Down payment	\$0
Annual O&M	\$15
Inflation rate	3 %
Discount rate	7.55%
Life time	25 years
Salvage value	\$100

3.3 Results and Discussions

Considering the parameters presented in Table 2, replacing the 3 electric water heaters by a solar water heater yields an annual saving of about \$209. The benefit of this investment is represented by the present value of this cash flow, calculated using equation (2). The total cost associated with the project includes the initial cost in addition to the present value of the operation and maintenance cost. The cash flow of the project is presented in Fig. 4.

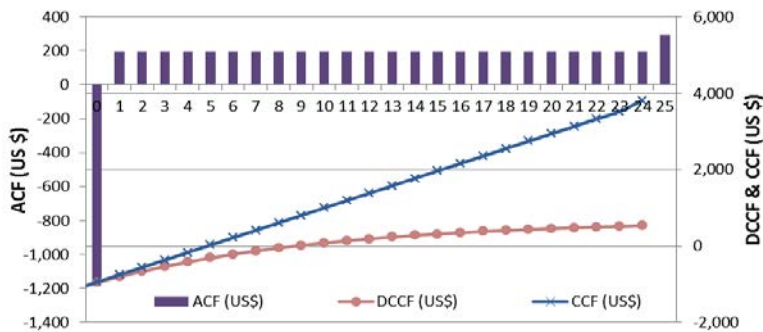


Fig. 4: Cash flow analysis of the project

The annual cash flow (ACF) starts with a high capital cost, at year zero. Starting from year 1, a positive net cash flow occurs annually as a result of earnings from energy saving (+\$209), and O&M costs (-\$15). At year 25, a higher cash flow occurs because of the project salvage value (+\$100).

The NPV of the project is represented by the difference between the present value of the positive and the negative cash flows. Having a present value of the benefits of \$2007 and a present value of costs of \$1471, the NPV of the project is \$536. The ratio of the benefits' present value to that of the costs (BCR) is 1.36.

The simple payback period is about six years, as shown by the cumulative cash flow (CCF). The discounted value of a specific cash flow is obtained using equation (1). Using discounted cumulative cash flow (DCCF), a 10-year payback period is obtained, which represents a more realistic figure. The value of the discounted cumulative cash flow at year 25 represents the NPV of the project.

4. CONCLUSIONS

Solar water heaters are technically feasible in Oman weather conditions. This paper demonstrates that that using SWHs in residential units in Oman can save up to 1859 GWh annually, which is equivalent to the annual energy produced by a power station of 212 MW size operating at rated output. Moreover, the net annual reduction in CO₂ emission exceeds 1.227 million tons. The economic feasibility of installing SWHs in a typical residential unit is tested using four economic indicators; Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR), and the Payback Period (PP). The simple payback period for the typical residential unit was about six years. Besides, using discounted cumulative cash flow, a 10-year payback period was obtained, which represents a more realistic figure.

It is recommended that the Government adopt supports policies that motivate people to use SWHS to save natural gas reserves and the environment. For example, the government should introduce subsidies to SWHs customers and/or investors helps making the price of the SWHs more affordable to the public. In addition, a media campaign to educate people that SWHs are economical, environment friendly and last for long time would help adopting these technologies.

Table 1: Annual energy consumption and energy cost for the residential units in Oman

Governorate	No. Residential Units	No. Heater	Annual Energy Saving (MWh)	Capacity Saving (MW)	Avoided Energy Cost (million US \$)
Muscat	153381	460143	517660.88	59.1	32.1
North & South Al Batinah	140638	421914	474653.25	54.2	29.4
Musandam	10764	32292	36328.50	4.1	2.3
Dhahirah	29697	89091	100227.38	11.4	6.2
Dakhliyah	63225	189675	213384.38	24.4	13.2
Noth & South Sharqiyah	82490	247470	278403.75	31.8	17.3
Al Wusta	6387	19161	21556.13	2.5	1.3
Dofar	46774	140322	157862.25	18.0	9.8
Al Buraymi	17702	53106	59744.25	6.8	3.7
Total	551058	1653174	1859820.75	212.3	115.3

REFERENCES

1. Kalogirou, S.A., 2004. Environmental benefits of domestic solar energy systems. *Energy Conversion and Management* 45 (18–19), 3075–3092.
2. Renewables Global Status Report 2012. (<http://www.ren21.net>)
3. A. H. Al-Badi, A. Malik, K. Al-Arami and A. Al-Mamari," A Power Sector in Oman Today and Tomorrow", *Renewable and Sustainable Energy Reviews* 13 (2009) 2192-2196.
4. Authority for Electricity Regulation - Oman, Study on Renewable Energy Resources in Oman - Final Report by COWI and Partners LLC, Muscat, May 2008.
5. A. H. Al-Badi, "Pre-Feasibility Study of Stand-Alone Hybrid Energy Systems for Applications in Eco-Houses", *International Journal of Sustainable Engineering*, 1st Apr 12, 2012
6. A. H. Al-Badi and H. Bourdosen," Feasibility analysis of renewable hybrid energy supply options for Masirah Island", *International Journal of Sustainable Engineering*, 2011, iFirst Aug 22, 2011.
7. A. H. Al-Badi, A. Malik and A. Gastli," Sustainable Energy Usage in Oman - Opportunities and Barriers" *Renewable and Sustainable Energy Reviews* 15 (2011) 3780-3788
8. A.H. Al-Badi, M. AL-Toobi, S. AL-Harthy, Z. Al-Hosni, A. AL-Harthy," Hybrid Systems for Decentralized Power Generation in Oman", *International Journal of Sustainable Energy*, iFirst Jun 28, 2011.

9. A. Al-Badi and H. Bourdosen, "Study and Design of Hybrid Diesel -Wind Stand-Alone System for Remote Area in Oman", *International Journal of Sustainable Energy*, Volume 31, Issue 2, March 2012, pages 85-94.
10. A. H. Al-Badi, "Hybrid (solar and wind) energy system for Al Hallaniyat Island electrification", *International Journal of Sustainable Energy*, Vol. 30, No. 4, August 2011, 212-222.
11. H. Bourdosen, A. H. Al-Badi, "Design and Evaluation of hybrid standalone electric system for Masirah Island", *ISESCO Science and Technology Vision - Volume 5, Number 8 (November 2009)* (40-45).
12. A. H. Al-Badi, A. Malik and A. Gastli, "Assessment of Renewable Energy Resources Potential in Oman and Identification of Barrier to their Significant Utilization", *Renewable and Sustainable Energy Reviews* 13 (2009) 2734-2739.
13. A.H. Al-Badi, "Hybrid Energy Systems for Applications in Eco-Houses" 2012 Asia-Pacific Power and Energy Engineering Conference (APPEEC 2012), Shanghai China, March 26-28, 2012.
14. A.H. Al-Badi, M. AL-Toobi, S. AL-Harthy, Z. Al-Hosni, "Techno-Economic Analysis for a Hybrid Stand-alone Power Generation", *International Conference on Power Electrical Systems (PES)*, 22-25 March 2011, Sousse, Tunisia
15. M. H. Al-Badi, A. H. Al-Badi, A. M. Al-Lawati and A. S. Malik, "Cost of PV Electricity in Oman", 2011 IEEE GCC Conference and Exhibition, "For Sustainable Ubiquitous Technology", 19-22 February 2011, Dubai, United Arab Emirates.
16. A.H. Al-Badi, H. Bourdosen, "Economic Analysis of Hybrid Power System for Rural Electrification in Oman" 2nd International Conference on Adaptive Science & Technology(ICAST'09), 14-16 Dec 2009, Accra, Ghana, pp. 284-289.
17. A.H. Al-Badi, A. Malik and A. Gastli, "Renewable Energy Resources Potential and Limitation in Oman", *Global Conference on Power Control and Optimization (PCO'2009)*, 1-3 June 2009, Bali, Indonesia.
18. A. H. Al-Badi, M. H. Al-Badi, A. M. Al-Lawati and A. S. Malik, "Economic Perspective for PV Electricity in Oman", *Energy* 36 (2011) 226-232.
19. Hannah Cassard, Paul Denholm, Sean Ong. Technical and economic performance of residential solar water heating in the United States. *Renewable and Sustainable Energy Reviews* 15 (2011) 3789- 3800.
20. Kaldellis JK, Kavadias KA, Spyropoulos G. Investigating the real situation of Greek solar water heating market. *Renew Sustain Energy Rev.* 2005;9(5):499-520.
21. Chang KC, Lin WM, Lee TS, Chung KM. Local market of solar water heaters in Taiwan: review and perspectives. *Renew Sustain Energy Rev.* 2009;13(9):2605-12.
22. Zhai XQ, Wang RZ. Experiences on solar heating and cooling in China. *Renew Sustain Energy Rev* 2008;12(4):1110-28.
23. Allen SR, Hammond GP, Harajli HA, McManus MC, Winnett AB. Integrated appraisal of a solar hot water system. *Energy* 2010;35(3):1351-62.
24. Chandrasekar B, Kandpal TC. Techno-economic evaluation of domestic solar water heating systems in India. *Renew Energy* 2004;29(3):319-32.
25. Gastli A, Charabi Y. Solar water heating initiative in Oman energy saving and carbon credits. *Renew Sustain Energy Rev* 2011;115(4):1851-6.
26. Authority for Electricity Regulation, Annual Report 2009.
27. Garg, H.P. 1987. *Advances in Solar Energy Technology*; Vol.1. D. Reidel Pub. Co.: Holland.
28. Ministry of National Economy, Available from: <http://www.moneoman.gov.om/>.
29. Intergovernmental Panel on Climate Change (IPCC), 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), IGES, Japan, 2006.
30. W. Sullivan, E. Wicks, and J. Luxhoj, *Engineering Economy*. New Jersey: Prentice Hall, 2006

*Contamination of Marine Fish by Heavy Metals from Coastal Sewage Treated
Effluent Runoff*

Salma K. Al-Musharafi*¹, Ibrahim Y. Mahmoud*², Saif N. Al-Bahry*³

*¹Sur College of Applied Science, Oman, *²University of Nizwa, Oman, *³Sultan
Qaboos University, Oman

0177

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Arid regions with low rainfall are under continuous threat and pressure to maintain their stability and to meet public demands, specifically issues relating to the availability of fresh water. Due to the lack of rainfall and continuous population growth, many countries in the arid regions depend mainly on desalination of seawater and brackish water. Most countries in those regions have constructed sewage treatment plants (STP) due to the significant increase in sewage effluents. Many of the STPs constructed in the coastal area dump excess treated effluent into the sea. In this study, Oman was used as a model for the effect of the sewage effluent pollution. In 2006, it was reported that only 11% of sewage produce is recycled while the rest is unused. It is estimated that by 2035 the quantity of treated sewage effluent (TSE) will be more than 70 million m³. If the TSE contains pollutants, it will be disastrous to the environment. The main purpose of sewage treatment is to remove organic matter and microbial contaminants. However, heavy metals from industrial uses remain intact. In this investigation the marine fish around treated sewage dumping points were found to contain heavy metals. The highest heavy metals concentration in TSE was Ni followed by Cu, Mn, Fe, Co, Pb, and Zn. On the other hand, the dominant heavy metals in fish were Ni, Cu, Pb and Zn, although they were at permissible levels. If this trend continues the presence of heavy metals in fish will be a serious public health problem to human.

Keywords: Heavy metal, fish tissue, sewage treated effluent.

INTRODUCTION

Heavy metal infiltration from sources such as treated sewage effluent (TSE) reaching the coastal region can contaminate marine wild life, mainly fish, since they are the major source of food in many coastal regions of the world (Bat *et al.*, 2012). In addition, sewage runoff and contaminated effluents were also the major sources of pollution in the terrestrial and aquatic environment affecting domestic animals and agricultural crops. Heavy metals and multiple antibiotic resistant bacteria (MARBs) were found to be released to the environment from TSE infecting agriculture crops, marine fish and sea turtles. In Oman, heavy metals and antibiotic resistant microbes are released to the environment, mainly through TSE (Al-Bahry *et al.*, 2007, 2009a 2009b, 2009c, 2011a, 2012a, 2012b; Al-Musharafi *et al.*, 2012, 2013a, 2013b; Mahmoud *et al.*, 2013).

Heavy metal contamination, including industrial waste products, mining, burning of fossil fuels, industry and the use of metals by consumers are the major sources of environmental pollution. In addition, heavy metal poor degradability results in the accumulation in water, sediments, soil and food chain (Svobodová *et al.* 1987). In terms of food safety, fish were used as indicators of pollutants, such as heavy metals and other toxic chemicals (Kenšová *et al.*, 2010).

Today, there is a steady increase in the usage of the heavy metals in industry inflicting a serious environmental problem and reaching toxic concentration levels in certain regions of the World (Güven *et al.*, 1999). Some of metals, such as Cu, Zn have essential physiological functions but they may accumulate reaching toxic levels (Al-Bahry *et al.*, 2011a, Hogstrand and Haux 1991; Rietzler *et al.*, 2001). Today, heavy metal accumulation in the industrial world can also affect aquatic environment which has become a serious problem, consequently a decline in fish population and quality (Holm *et al.*, 2002).

In addition, industrial waste and mining can also cause heavy metal pollution in the aquatic environment (Gumgum *et al.*, 1994). Heavy metals like Fe, Cu and Mn are essential in metabolic activity; however, Ar, Cd, Cr, Hg, Ni and Pb are usually toxic (Al-Bahry *et al.*, 2011a). Several studies reveal that there is a close association between MARBs and heavy metal accumulation which originate from several sources. The major source of such association is found in TSE, particularly in semiarid regions of the world where water shortage is one of the major problems. Researchers in Oman reported that the reuse of TSE specifically from industrial origin is becoming a major problem (Al-Bahry *et al.*, 2007, 2009a 2009b, 2009c, 2011b, 2012a, 2012b; Al-Musharafi *et al.*, 2012, 2013a, 2013b; Mahmoud *et al.*, 2013). The accumulation of heavy metals in various habitats is on the rise. Heavy metal discharge into the environment is very common in many regions in the world.

The aim of this study is to investigate the effect of heavy metal contamination in fish population in the coastal region of the Gulf of Oman. This investigation is essential since Oman is a major source of fishing industry. A gradual accumulation of heavy metals could affect both population and quality of fish. This condition will generate a major health and economic problems in the region.

MATERIALS AND METHODS

Study area

The study area is located in Muscat on the Gulf of Oman, near a treated sewage effluent which discharges its effluents directly into the sea.

Sample collection

A total of 40 water samples (250 mL each) was collected from the TSE discharge point and immediately were stored in a cool box and transported to the lab immediately for further analysis.

The following fish species were sampled for heavy metal analysis (*Cephalopholis hemistiktos*, *Diodon liturosus*, *Lutjanus ehrenbergi*, and *Stephanolepis diaspros*) were collected from the dumping site because of their availability. A total of 40 fish was captured by line from the study area, stored in a cool box and transported to the lab. The weight ranged between 20–35 g (329.4 ± 0.7) and total length was 15–120 cm (13.1 ± 1.35).

Sample preparation, analysis and quality control

Fish scales were removed and the fish were washed thoroughly with Milli-Q water. Tissue samples from gills, intestine, kidney, liver and muscles were dried in oven at 1000°C. The samples were grounded to powder for chemical analysis. Each sample (0.5 gm) was digested in a perchloric and nitric acid mixture in a Teflon beaker. Drops of 30% NaCl solution, 10 ml of 65% nitric acid and 70 % perchloric acid were mixed with fish powder. Each sample was placed at 70 °C water bath for 12 hrs to degrade the organic matter and to transfer the metals into the solution. The samples were centrifuged and the supernatant was analyzed (Kumar *et al.*, 2010).

Co, Cu, Fe, Mn, Ni, Pb and Zn concentrations were determined using Flame Atomic Absorption Spectrometry (Thermo, UK). Corrections of background were conducted by using standard addition method to compensate the matrix effects. For the precision of the instrument, standard references at six level dilutions were used to produce a calibration curve. All samples were analyzed in triplicates together with blank samples. Blank samples were used to check for cross contamination. The method accuracy was determined using reference material. Heavy metal concentrations were reported on dry weight mg/L. Heavy metal concentration in TSE was compared to the Minimum Permissible Levels (MPL) of the Omani Standard, which was adopted from FAO, for the waste water reuse and discharge (Table 1).

Table 1. Heavy metal standards of wastewater reuse in Oman (MEMWR, 1998).

Metal	Symbol	Minimum Permissible Levels (MPL)
Cobalt	Co	0.05
Copper	Cu	1
Iron	Fe	5
Manganese	Mn	0.5
Nickel	Ni	0.1
Lead	Pb	0.2
Zinc	Zn	5

Statistical analysis

All data were statistically analyzed using SPSS statistical package. The *t* test at 5% levels of significance differences between the means was tested. The *p*-values of less than 0.05 indicated statistical significance.

RESULTS

TSE heavy metal concentration varied in the seven metals. Co, Cu and Ni were at high concentrations but they do not vary significantly. While Mn concentrations were significantly higher than Fe and Zn ($p < 0.05$). Pb was the lowest amongst the metals (Fig 1).

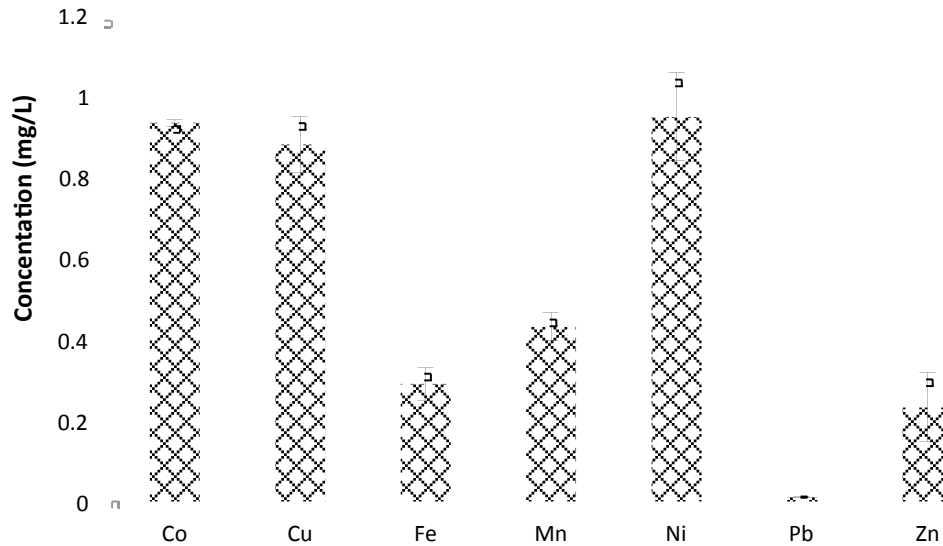


Fig 1. Concentration of heavy metal in TSE

Heavy metal concentration taken from sediment, Ni was significantly higher than the rest ($p < 0.05$). However, Co concentration was next to Ni and was significantly higher than the rest of the heavy metals. Pb concentrations were the lowest, as in the case in TSE (Fig 2).

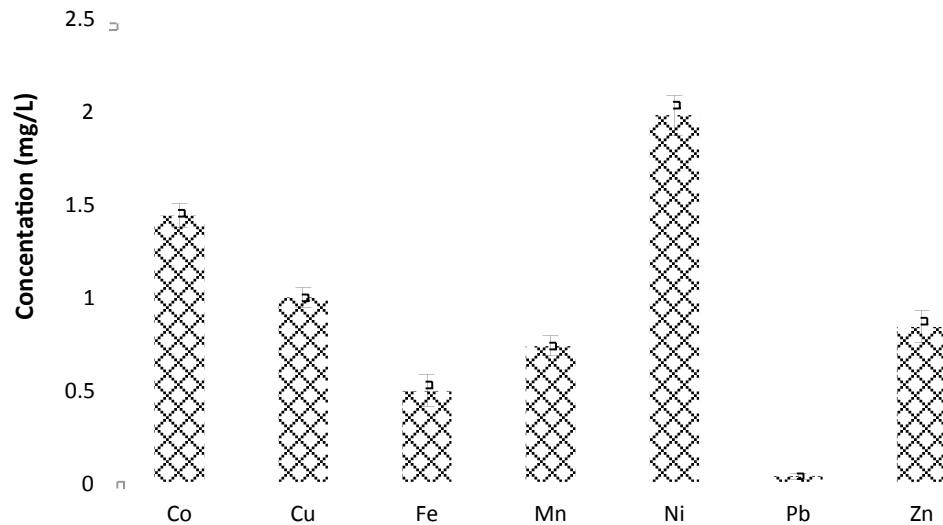


Fig 2. Concentration of heavy metal in sediment

Heavy metal concentrations of combined fish tissues taken from gills, intestine, kidney, liver and muscle varied. Cu concentrations were the highest ($p < 0.05$) followed by Co, Mn, Zn and Ni. Pb concentrations, as in the case of TSE and sediment were the lowest among the group (Fig 3).

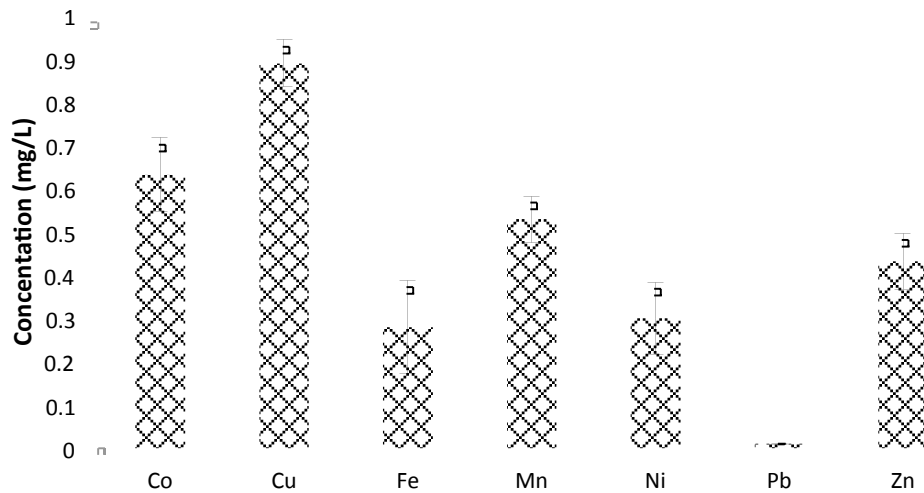


Fig 3. Total heavy metal concentration in fish tissues (gills, intestine, kidney, liver and muscle).

Heavy metal concentrations from gills, intestine, kidney, liver and muscle were analyzed (Fig 4). There is no specific concentration pattern for all the metals taken from five organs. However, liver has the dominant metal concentrations over the rest of the organs except for Ni. Pb was the lowest in all organs. In general, Co, Cu, Ni concentrations were higher than the rest in both TSE and sediment. In the combine fish tissues, taken from gills, intestine, kidney, liver and muscle, Cu was the dominant heavy metal. In the individual tissues Cu was the dominant. Looking at the individual organs, liver was the dominant in containing most of the heavy metals followed closely by gills, kidney, intestine and muscle.

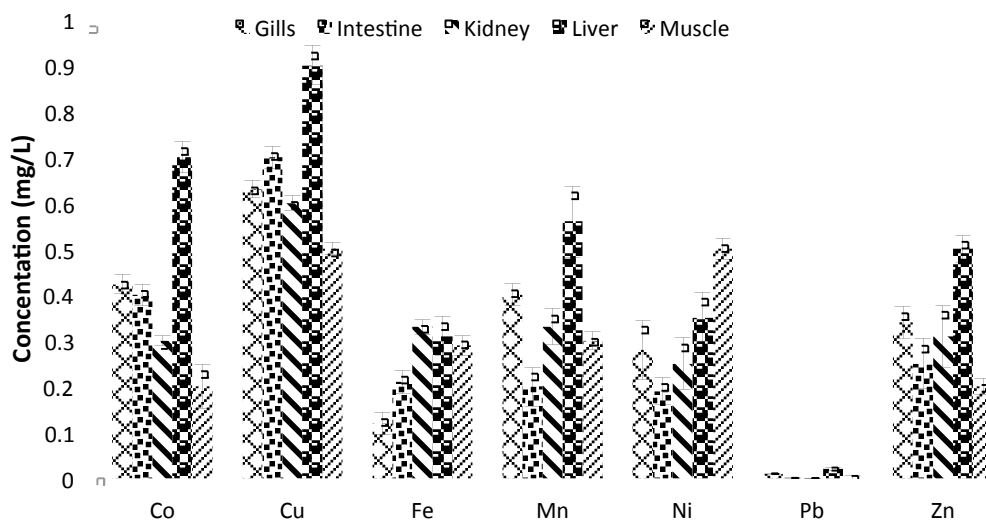


Fig 4. Heavy metals concentration in different fish organs.

DISCUSSION:

The heavy metal accumulation in sediment and aquatic, both fresh water and salt water habitats, is becoming a serious problem in Oman. One of the reasons for such accumulation is the reuse of TSE from industry which is not entirely removed from toxic heavy metals (Al-Musharafi *et al.*, 2012).

Heavy metals are naturally found in marine environment at certain concentrations. However, domestic, industrial, agricultural and mining activities have resulted in increasing concentration of toxic metals affecting marine habitats (Bat *et al.*, 2012).

The main purpose of this investigation is to analyze the heavy metal concentrations in three different ecological niches in order to compare the degree of heavy metal infiltration and concentration in the sampling areas. The sampling areas were chosen because TSE dumping site is located on the shoreline contaminating aquatic environment including sediment and fish.

The most significant aspect in this investigation is that the fish samples were contaminated with the same heavy metals which were found in the TSE and the sediment. In addition, the toxic heavy metals found in the TSE, sediment and fish had similar concentration patterns throughout the study period. Based on this data it is crucial to assure that sewage effluent does contain heavy metals even after treatment. This indicates that TSE is one of the sources of heavy metal contamination to the environment.

During the last few years in Oman, there is a steady increase in toxic heavy metals such as Hg, Zn, Pb, Sn, and Co (Al-Musharafi *et al.*, 2012, 2013a, 2013b). Although Co is essential for vitamin B12, it can be toxic at high concentrations. On the other hand, Hg, Pb are nonessential metals (Al-Rawahy *et al.*, 2007). Due to slow process of elimination and by the ageing process these metals have the ability to bind and bioaccumulate in tissue (Harrison, 2001; Nigro and Leonzio 1996). Some of the metals have a tendency to bind to proteins (Shahidul and Tanaka, 2004).

In this study, the level of heavy metals in fish was slightly lower than the sediments. However, others reported that the level of heavy metals in marine fish were many times higher than in sediments (Bat *et al.*, 2012; Boran and Altinok, 2010). Probably the site of the present study is less contaminated compare to the others.

In conclusions, based on the data from this research there is heavy metal contamination in the marine environment originated from TSE. Efficient methodologies for removing toxic heavy metals from sewage effluents are urgently needed before releasing the effluent to the environment to avoid environmental pollution. Periodic examinations of wild life such as fish must be implemented before fish consumption which may have impact on public health.

References:

- Al-Bahry, SN., Elshafie, AE., Al-Busaidy, S., Al-Hinai, J., Al-Shidi, I. 2007. Antibiotic-resistant *Salmonella* spp. from human and non-human sources in Oman. *Eastern Mediterranean Health Journal*. 13: 49-55.
- Al-Bahry, SN., Mahmoud, IY., Al-Belushi, KI., Elshafie, AE., Al-Harthy, A., Bakheit, CK. 2009a. Coastal sewage discharge and its impact on fish with reference to antibiotic resistant enteric bacteria and enteric pathogens as bio-indicators of pollution. *Chemosphere*. 77: 1534-1539.
- Al-Bahry, SN., Mahmoud, IY., Elshafie, AE., Al-Harthy, A., Al-Ghafri, S., Al-Amri, IS., Alkindi, AY. 2009b. Bacterial flora and antibiotic resistance from eggs of green turtles *Chelonia mydas*: An indication of polluted effluents. *Marine Pollution Bulletin*. 58: 720-725.
- Al-Bahry, SN., Mahmoud, IY., Al-Khaifi, A., Elshafie, AE., Al-Harthy, A. 2009c. Viability of multiple antibiotic resistant bacteria in distribution lines of treated sewage effluent used for irrigation. *Water Science and Technology*. 60: 2939-2948.
- Al-Bahry S., Ibrahim Y., Al-Rawahi S., Paulson J. 2011a. Egg contamination as an indicator of environmental health. Nova Science Publisher, Inc. New York, USA.
- Al-Bahry, SN., Mahmoud, IY., Al-Zadjali, M., Elshafie, A., Al-Harthy, A., Al-Alawi, W. 2011b. Antibiotic resistant bacteria as bio-indicator of polluted effluent in the green turtles, *Chelonia mydas* in Oman. *Marine Environmental Research*. 71: 139-144.
- Al-Bahry, SN., Al-Zadjali, MA., Mahmoud, IY., Elshafie, AE. 2012a. Biomonitoring marine habitats in reference to antibiotic resistant bacteria and ampicillin resistance determinants from oviductal fluid of the nesting green sea turtle, *Chelonia mydas*. *Chemosphere*. 87: 1308-1315.
- Al-Bahry, SN., Mahmoud, IY., Al-Musharafi, SK. 2012b. Antibiotic resistant bacteria used as bioindicators of environmental pollution produced by tertiary treated sewage effluent. *Water Pollution XI*, 313. New Forest, UK. Page 313-321.
- Al-Musharafi, SK., Mahmoud, IY., Al-Bahry, SN. 2012. Heavy metal contamination from treated sewage effluents. *Water Pollution XI*, 313. New Forest, UK. Page 381-389.
- Al-Musharafi SK., Mahmoud, IY., Al-Bahry, SN. 2013a. Heavy metal pollution from treated sewage effluent. ICESD2013. Dubai UAE. Dubai UAE. *Procedia APCBEES* 5. Page 344-348.
- Al-Musharafi SK., Mahmoud, IY., Al-Bahry, SN. 2013b. Heavy metals infiltration from sewage treated effluent into soil and tomato plants. *IPCBEES* (In press).
- Al-Rawahy, SH., Al Kindi, AY., Elshafie, A., Mahmoud, IY., Al-Bahry, SN., Al-Siyabi, SS., Mansour, MH., Al-Kiyumi, AA. 2007. Accumulation of metals in the egg yolk and liver of hatchling of green turtles *Chelonia mydas* at Ras Al Hadd, Sultanate of Oman. *ANSI: Journal of Biological Sciences*, 7: 925-930.

- Bat, L., Sezgin, M., Üstün, F., Şahin, F. 2012. Heavy metal concentrations in ten species of fishes caught in Sinop Coastal Waters of the Black Sea, Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*. 12: 371-376.
- Boran, M., Altinok, I. 2010. A review of heavy metals in water, sediment and living organisms in the Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences*, 10: 565-572.
- Gumgum, B., Unlu, E., Tez, Z., Gulsun, N. 1994. Heavy metal pollution in water, sediment and fish from the Tigris River in Turkey. *Chemosphere*, 290: 111-116.
- Güven K., Özbay C., Ünlü E., Satar A. 1999. Acute lethal toxicity and accumulation of copper in *Gammarus pulex* (L.) (Amphipoda). *Turkish Journal of Biology*. 23: 51.
- Harrison, RM. 2001. Pollution: Causes, Effects and Control. Royal Society of Chemistry, Cambridge. UK
- Hogstrand, C., Haux C. 1991. Binding and detoxification of heavy metals in lower vertebrates with reference to metallothionein. *Comparative Biochemistry and Physiology. Part C*. 100: 137.
- Holm, PB., Peter, A., Segner, H. 2002. Decline of fish catch in Switzerland. *Aquatic Science*. 64: 36-54.
- Kenšová¹, R., Čelechovská, O., Doubravová, J., Svobodová, Z. 2010. Concentrations of metals in tissues of fish from the Věstonice Reservoir. *Acta Veterinaria Brno*. 79: 335-345.
- Kumar, B., Sajwan, K.S., Mukherjee, D. P. 2012. distribution of heavy metals in valuable coastal fishes from north east coast of India. *Turkish Journal of Fisheries and Aquatic Sciences*. 12: 81-88.
- Mahmoud, I.Y., Al-Musharafi S.K., Al-Bahry, S.N. 2013. Fresh water habitat pollution by treated sewage effluent in relation to multiple-antibiotic-resistant bacteria. *Procedia APCBEES*. 5. Page 363-367.
- Ministry of Regional Municipalities and Water Recourses (MEMWR). Regulation for wastewater reuse and discharge. Ministry of Regional Municipalities and Water Recourses. 1998.
- Nigro, M., Leonzio, C. 1996. Intracellular storage of mercury and selenium in different marine vertebrates. *Marine Ecology Progress Series*, 135: 137-143.
- Rietzler AC., Fonseca AL., Lopes GP. 2001. Heavy metals in tributaries of Pampulha reservoir. Minas. Gerais. *Brazilian Journal of Biology*. 61: 363.
- Shahidul, I. and Tanaka, M. 2004. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. *Marine Pollution Bulletin*. 48: 624-649.
- Svobodová, Z., Gelnarová, J., Justýn, J., Krupauer, V., Máchová, J., Simanov, I., Valentová, V., Vykusová, B., Wohlgemuth, E. 1987. Toxikologie vodních živočichů (Toxicology of water animals). SZN Praha. Page 232.

A Lighting Controller for LED Lamp Cooperated with Daylighting in Thailand

Phumiphat Kakham*¹, Bancha Ounpanich*¹

*¹Rajabhat Rajanagarindra University, Thailand, *²Chulalongkorn University,
Thailand

0183

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This research aimed to develop a lighting controller for LED lamps cooperated with daylighting (LCTL) for replacing the lamps that were installed near windows. This device would control LED lamps to work appropriately at daylight levels. The results revealed that the developed device could control the lighting of LED lamps cooperated with daylighting between 0 and 338 lx. This device consumed about 18.83 W. It could save 9.17 W of energy when compared to a 28 W T5 fluorescent lamp. The measurement and calculation of the energy saving of this device showed that it could save approximately 0.23 kWh/lamp/day. A computer simulation was employed to analyze the daylighting through windows in two levels, i.e., high and low transmittance of glazed window. The simulations showed that the device could save 66 kWh/lamp/year for a high transmittance window. The device could save 21 kWh/lamp/year from the north side, 35 kWh/lamp/year from the south side, and 33 kWh/lamp/year from the east and the west sides for low transmittance window. Further studies would adapt this device into microcontroller-based systems, integrated LCD to monitor a setting illuminance and a work plane illuminance. A wireless control system would be used for this system.

Keywords : Lighting control, LED lamp controller, Energy saving

Introduction

An increasing demand in the development in economy, industry and society in Thailand has resulted in an increase in energy requirement every year. In 2012, the maximum demand of Thailand was approximately 26,121 MW, which it was increased 368% from 1990, while the rest power generation was approximately 6,169 MW (EGAT, 2013). Thailand has a 15 years renewable energy development plan (2008-2022) to increase the usage of renewable energy up to 20.3% of the total energy usage in 2022 (DEDE, 2008). Thailand has enacted an act for promotion of energy conservation since 1992 (Ministry of Energy, 1992). The royal decree on designated building and a set of ministerial regulations was enacted in 1995 (B.E. 2538) (Ministry of Energy, 1995a; Ministry of Energy, 1995c). The law mandates issuance of ministerial regulations for energy conservation in large commercial buildings. Thailand's building energy code was gazetted and implemented on new and existing large buildings (Ministry of Energy, 1995b). The code comprises mainly of performance-based requirements on building envelope system, lighting system and air-conditioning system. The earlier study found that air-conditioning and electric lighting typically accounted for 50-60% and 20-30%, respectively, of the electricity consumption of a commercial building in Thailand (Chirattananon, 2005).

According to the electricity consumption mentioned above, if buildings reduce the lighting energy consumption, it will result in an increase energy efficiency of building. As Thailand is located in the tropics, most part of the country receives the highest global illuminance in April, with a monthly average of hourly values of about 80-100 klx, and 44.1% of the total area of the country receive the yearly average of hourly illuminance in the range of 75-80 klx. The areas, which receive the highest global illuminance are in middle part of the central region of the country and the lower part of the south (Janjai, 2004). Generally, recommended interior illuminance for office is 300-500 lx with existing daylight. However, daylighting will initiate the cooling load, visual comfort and thermal comfort (Chirattananon and Chaiwiwatworakul, 2006).

As electrical energy saving in lighting system comes in many ways, an automatic lighting control device is one efficient way. To date, as LED lamps are in the state of the art, they exhibit high efficacy and long life. Some types of LED lamps can even replace the conventional lamps. Thus, the objective of this research was to develop a lighting controller for LED lamps cooperated with daylighting.

Materials and Methods

Designing of a lighting controller

A lighting controller for LED lamps cooperated with daylighting (LCTL) was aimed to control a work plane illuminance level, which comprised of 5 parts, i.e., photo sensor saw-tooth wave generator, voltage comparator, switching device, and LED lamps module, as shown in Fig. 1.

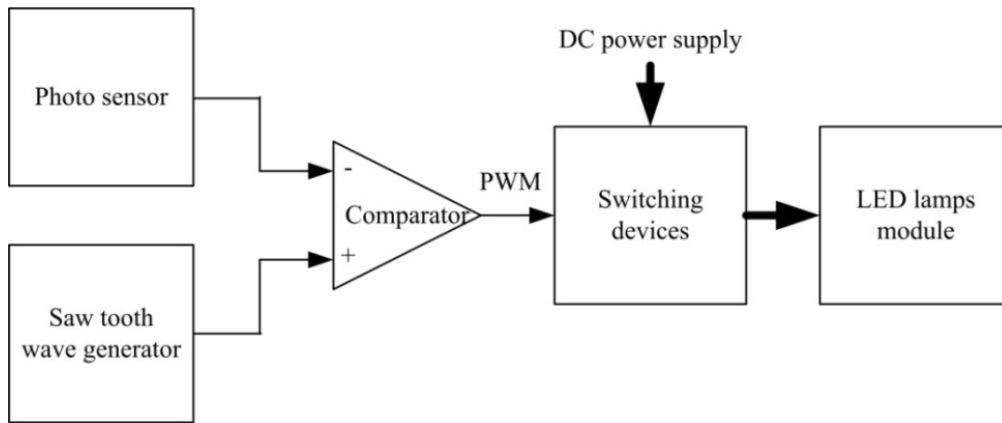


Figure 1. Block diagram of a lighting controller for LED lamps cooperated with daylighting.

A pulse width modulation technique (PWM) was used in the design of LCTL to operate a LED lamps module. Its lighting level would be converted the daylight. The PWM signal generated by a comparator compared a photo sensor voltage (V_{Photo}) with a saw-tooth voltage (V_{Saw}). The LED lamps were turned on when the photo sensor voltage was less than the saw-tooth voltage for the duration of $t_{\text{LED-on}}$, as shown in Fig. 2.

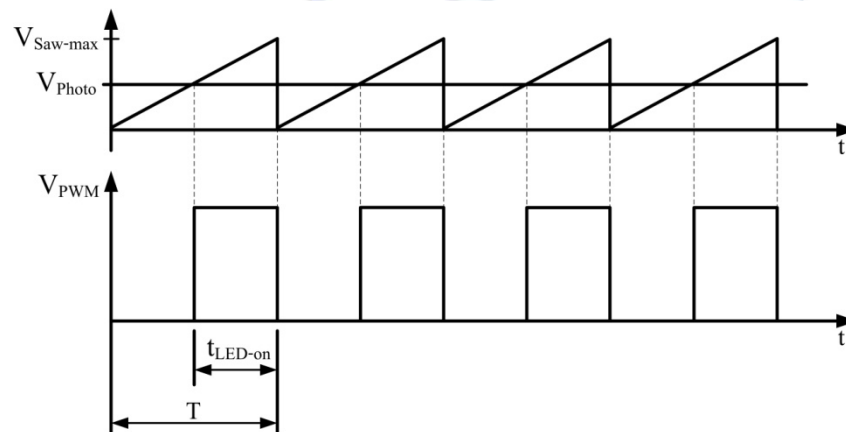


Figure 2. Showing the diagram of pulse width modulation signal.

A photo diode OPT310M was used as the photo sensor. It had a spectral sensitivity in the range of visible light (380-780 nm), which was appropriated for this research, as shown in Fig. 3. The sensor was converted light into electrical voltage. This voltage was gained in the range of 0-10 volts.

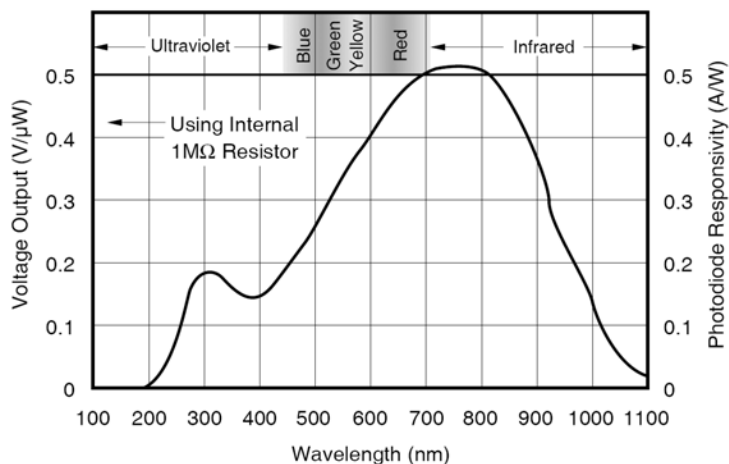


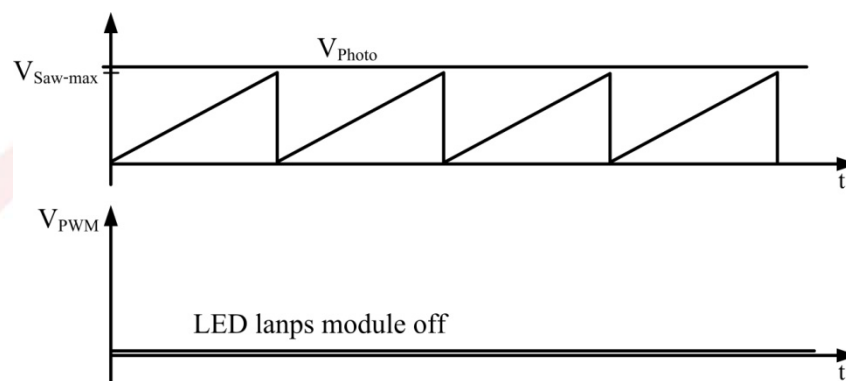
Figure 3. Showing the spectral responsivity of selected photo diode (Burr-Brown Corporation, 1994).

A 555 timer circuit was generated the 10 kHz saw-tooth signal at the maximum voltage of 9 volts. A voltage of 12 volts was supplied the circuit. A 10 nF capacitor and a 10 kΩ resistor were used. The frequency of the saw-tooth signal can be calculated from:

$$f = (V_{cc} - 2.7) / (R \cdot C \cdot V_{pp})$$

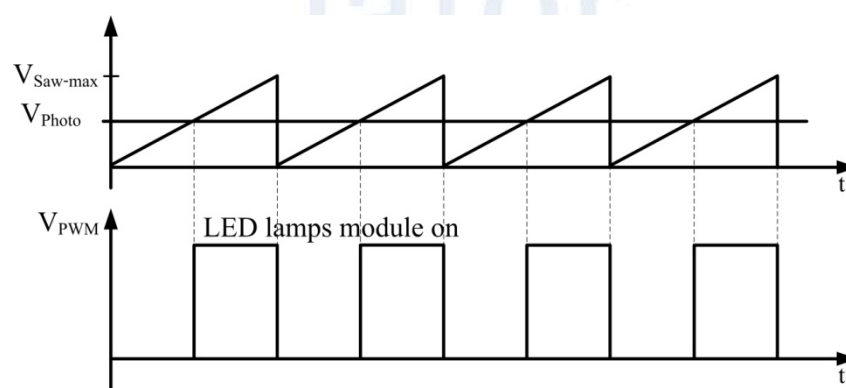
Where V_{cc} was the supply voltage and V_{pp} was the maximum voltage of the saw-tooth signal.

An operational amplifier LM311N was used as the comparator, and the output must pull up with a resistor. The LCTL was maintained a work plane illuminance at 300 lx. The comparator operated the LED lamps in 2 modes, i.e., turn off mode, which occurred when the work plane illuminance exceeded 300 lx, where the PWM mode the illuminance was less than 300 lx, the LCTL would turn-on the LED lamps to supplement the lack of daylight, bringing it up to 300 lx.



a. Turn off mode ($E > 300$ lx)

Figure 4. Diagrams showing the PWM signal output from the comparator circuit.



b. PWM mode ($E < 300$ lx)

Figure 4(con't). Diagrams showing the PWM signal output from the comparator circuit.

A power MOSFET MTP12N10E was used as a switching device. It can be handle a current of 12 amperes and a voltage of 100 volts. The LED lamps module was constructed from 324 supper bright LEDs as shown in Fig. 5. A light flux of nearly 28W T5 fluorescent lamp was obtained. A complete schematic diagram of LCTL is shown in Fig. 6.

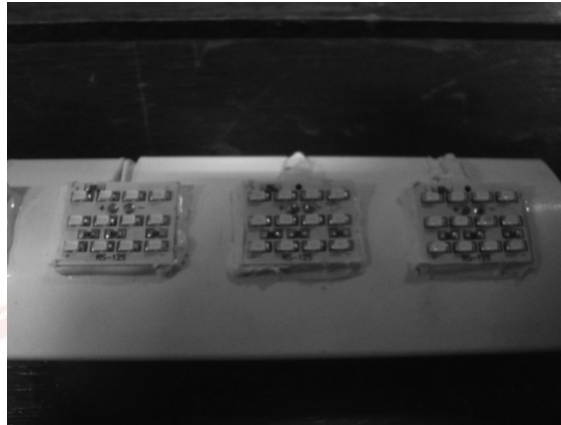


Figure 5. Showing LED lamps module.

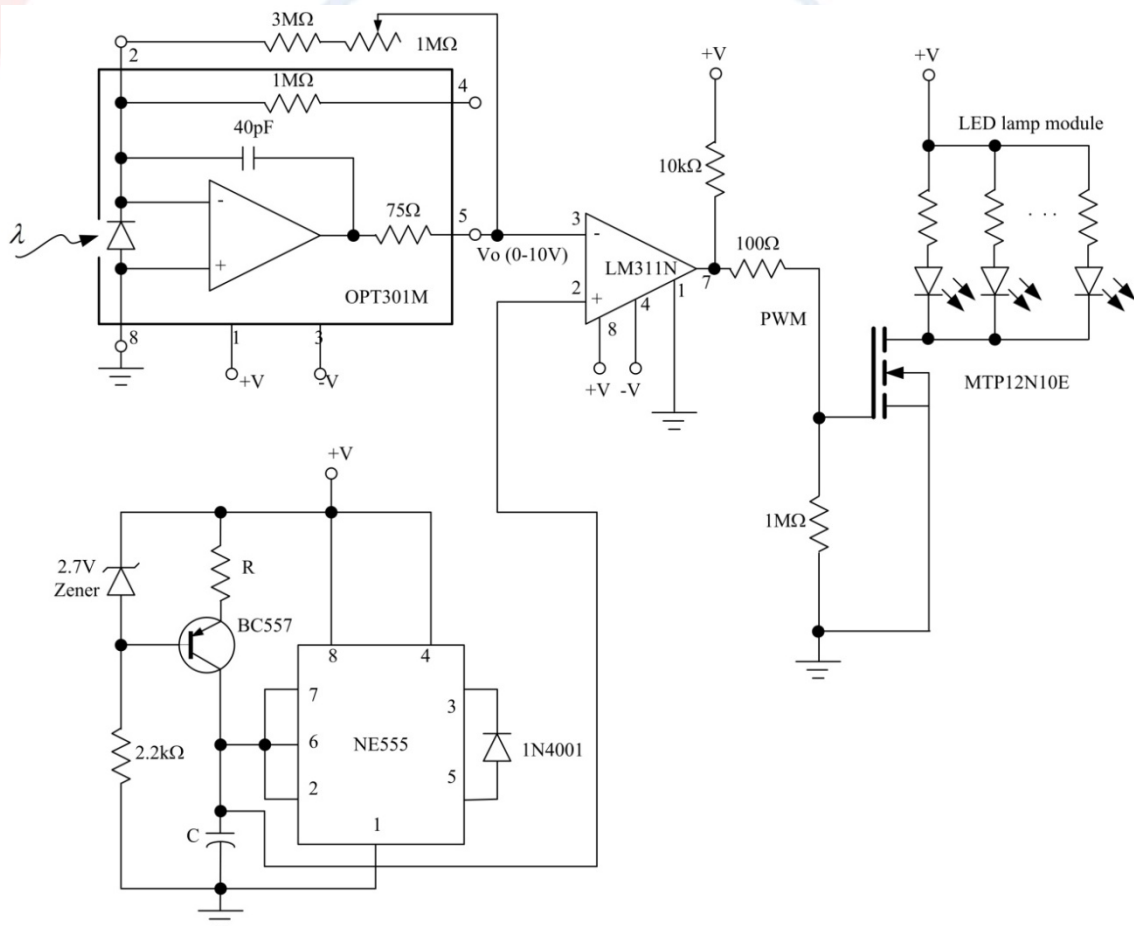


Figure 6. Schematic diagram of a lighting controller for LED lamps cooperated with daylighting.

Calculation for the investigation of the saving of LCTL.

In our study, the calculation of daylight illuminance through double pane window with internal fixed-angle slats was done followed the procedure adapted by Chaiwiwatworakul et al. (Chaiwiwatworakul et al., 2009). The calculation of reflection of light flux on surfaces of slats was described in the Engineering Reference of Energy Plus (US-DOE, 2009). The ASRC-CIE sky model was adopted for calculating the result-diffuse skylights on slat surfaces and the luminances of the sky patches viewed through the slats by points in the simulated room (Chaiwiwatworakul et al., 2009).

Experimental setup

The experiments were conducted at a full-scale building equipped with double pane window with internal fixed-angle slats (DWFS). The illuminance sensors were connected to a data logger. Records of required data were obtained from a daylight and solar radiation measurement station installed on the roof of a nearby building. The test building was located in King Mongkut's University of Technology Thonburi (KMUTT), Bang Khun Tien Campus (latitude 13.4°N and longitude 100.3°E).

Configuration of the test building and fenestration.

The experiment was set up to measure the work plane illuminance in the room installed with the DWFS on the South façade. The windowpanes were green glass (tinted float) of 6 mm thickness. The size of the windowpane was 2550 x 1540 mm, with the gap of about 100 mm. The windowpanes were installed in the aluminum frame with the lower edge located about 900 mm above the floor. The aluminum slats were white with the width of 50.4 mm. Optical properties of blind slats and windows glasses were measured using a spectrophotometer. The visible reflectance of each slat was 0.7. The visible transmittance and reflectance of each 6 mm tinted float (green) glass were 0.42 and 0.05, respectively.

The daylight measurement station.

The daylight measurement station was installed at KMUTT, Bang Khum Tien campus since 2009. The illuminance sensors were supplied by Eko of Japan. Beam normal illuminance and diffuse illuminance were measured directly by suntracker as shown in Figure 7. All measured data were acquired by the data acquisition system (DAQ) of National Instrument Inc., and recorded onto a computer hard disk at 1-minute interval.



Figure 7. Showing a photograph of the daylight measurement station at KMUTT, Bang Khun Tien Campus.

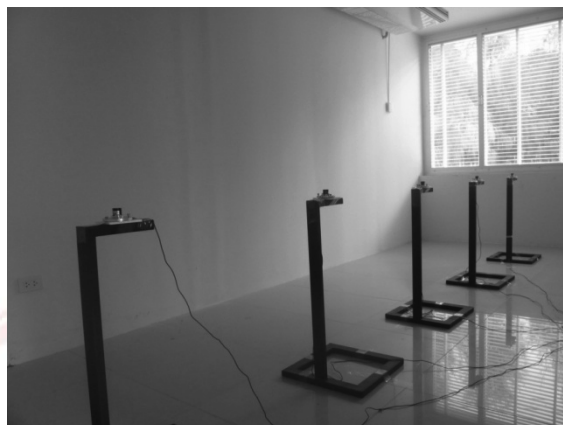
The illuminance measurement and data acquisition system.

Five illuminance sensors were placed about 750 mm above the floor at 10, 30, 50, 70, and 90% depth in the middle of the window to measure work plane illuminance. All illuminance sensors were supplied by Licor.

The data acquisition system (DAQ) was developed from National Instrument Inc. All measurement data from illuminance sensors were acquired by the NI-DAQ system and recorded onto the computer hard disk at 1-minute interval. Both computers of NI-DAQ system (station and test building) were synchronized with an Internet time.



a. South façade of the test building



b. The interior of the experimental room

Figure 8. Photographs showing configurations of the test building at KMUTT, Bang Khun Tien Campus.

Table 1. Details on the experimental room and the surrounding environment

Item	Internal dimension(m)	Material	Reflectance	Transmittance
Interior				
Wall	5.90 x 2.56 (E and W walls) 2.75 x 2.56 (N and S walls)	Gypsum board	0.7	-
Ceiling	5.90 x 2.75	Gypsum board	0.7	-
Floor	5.90 x 2.75			
Window	2.55 x 1.54	Tinted float (Green)	0.05	0.42
Environment				
Ground		Green grass	0.2	-

Table 2. Slat properties used in the experiment

Blind description	Color	Slat width (mm)	Slat spacing (mm)	Slat reflectance ^a	Slat abrorptance
Aluminum	White	50.4	40	0.7	0.3

Remark ^a Measured at wavelength from 300 to 2,700 nm.

Results

Saving of the LCTL.

An experiment for the LCTL was conducted. Two light sources were used as follows: the LCTL, LED lamps installed with lighting fixture on a ceiling, its height was 2 meters from a work plane level, and the incandescent lamp with a dimmer, use for simulating the daylight, the illuminance can be varied from 0 to 450 lx. In case of night time, the LCTL consumed a power of 18.83 W, at a work plane illuminance of 182 lx. In the case when the daylight exceeded 338 lx, the LCTL would turn-off the LED lamp, but it was still consumed an electrical power of 1.18 W for supplying the electronic devices. Thus, the LCTL could save an maximum power of 26.82 W, compared with 28 W T5 fluorescent lamp. The measured data and calculated saving results are shown in Table 3.

Table 3. Measured electrical power of the LCTL

No.	Measured work plane illuminance (lx)		LCTL Current (A)	Electrical power (W)	
	Controlled illuminance ¹	Total illuminance ²		LCTL	Saving ³
1	0	182	1.60	18.83	9.17
2	50	236	1.59	18.71	9.29
3	100	283	1.54	18.13	9.87
4	150	329	1.53	18.01	9.99
5	200	374	1.46	17.18	10.82
6	250	407	1.31	15.42	12.58
7	300	402	0.85	10.00	18.00
8	350	350	0.10	1.18	26.82
9	400	400	0.10	1.18	26.82
10	450	450	0.10	1.18	26.82

Remarks

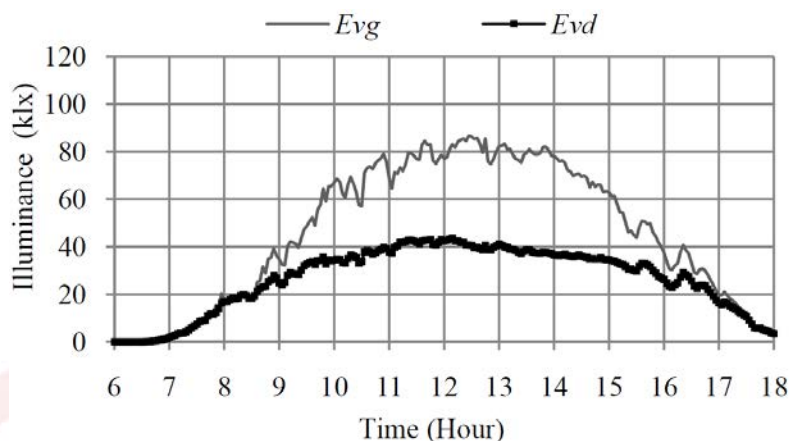
¹ illuminance from lighting with dimming device

² illuminance from LCTL and illuminance from Lighting with dimming device

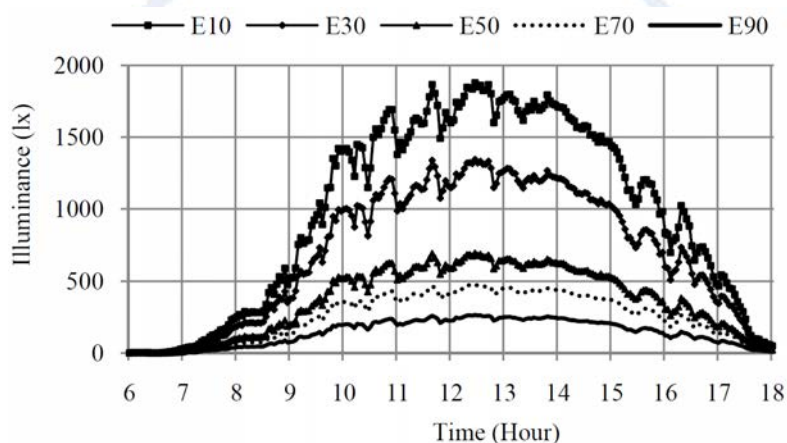
³ compared with 28 W T5 fluorescent lamp

One day saving of LCTL.

The DWFS with the slat angle of 0° was experimented on 17th January 2011. Fig. 9a exhibited the variations of the global (E_{vg}) and diffuse horizontal illuminance (E_{vd}) obtained from the daylight station. Values of the global illuminance reached the peak at 83 klx during noon time with the corresponding peak of the diffuse illuminance at 41 klx. The sky was rather clear on that day.



a. Global and diffuse horizontal illuminances



b. Work plane illuminance

Figure 9. Showing results of measured illuminance on 17th January 2011.

Fig. 9b exhibited the variation of the interior daylight illuminance on the work plane at 10% to 90% of room depth from the window. At 10% and 30% of room depth, it was observed that the daylight sufficiently illuminated the room over 500 lx for most of the daytime (10:00-16:00 hrs). The calculation of electrical saving of LCTL, using the saving value from work plane illuminance in 6 levels, i.e., >338 lx, >300 lx, >250 lx, >200 lx, >150 lx, and >100 lx, respectively as shown in Table 3. When the LCTL was installed at 30% of room depth, it saved an electrical energy of 0.23 kWh/lamp/day, when compared with 28 W T5 fluorescent lamp.

Yearly saving of LCTL.

In this section, the calculation of work plane illuminance was conducted. A computer programming was used for this calculation with the room model identical to that of the experiment. As since 2003, Thailand's building regulation for safety has enforced that

the glazed windows of buildings taller than 23 meters must be the laminated type only. In this study, two laminated glasses were used as the outer glass of the DWFS, i.e., heat reflective glass laminated with green glass (HG) that had widely been used for windows of the high-rise buildings in Thailand, and green glass laminated with clear glass (GC) that offers higher visible transmittance than the first one. For all of simulation cases, the inner glass of DWFS was 6 mm clear glass. Table 4 gives the properties of the glasses.

Table 4. Properties of the glasses for the DWFS simulation.

Glass	Thickness (mm)	Reflectance	Transmittance
Green-Clear	12.38	0.12	0.67
Heat reflective-Green	12.38	0.22	0.12
Clear	6	0.08	0.80

A series of calculation was conducted on the slat angle of 0° and changing the types of the DWFS outer glass, including the window orientations. The one-year hourly record of the daylight measured in Thailand was used for the simulation. The simulation results were analyzed from 08:00 to 17:00 hrs and for 5 working days (Monday-Friday).

The calculation of electrical saving of LCTL was performed using the saving value from work plane illuminance in 6 levels, which mentioned above. The tables were used to present the monthly averages of the interior daylight at 10%, 30%, 50%, 70%, and 90% depths of the room (D), percentage of time of the interior daylight exceeded 6 illuminance levels at 30%D and electrical energy saving.

In case of the high transmittance of laminated green-clear glass, Tables 5 to 8 showed that the interior daylight at 30%D exceeding 338 lx varied from 57-73% of time in a working day in a month. The LCTL could save the electrical energy of about 5.21-6.18 kWh/month. While the low transmittance of laminated heat reflective-green glass spread the interior daylight level, the LCTL would save the energy only 50% of the laminated green-clear glass, except the north. The total electrical energy saving is shown in Fig. 10.

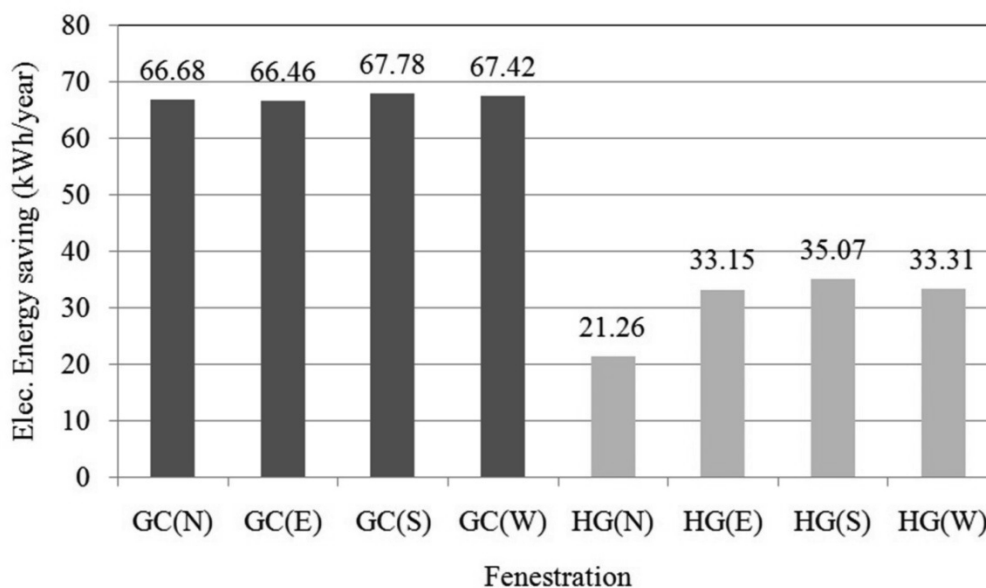


Figure 10. Showing results of electrical energy saving of LCTL with the DWFS at slat angle of 0°.

Table 5. The simulation results of the DWFS facing north and saving of LCTL

Month	Average of the interior daylight (lx)					The interior daylight at 30%D (Percentage of time)						Saving (kWh/month)
	10%D	30%D	50%D	70%D	90%D	>338 lx	>300 lx	>250 lx	>200 lx	>150 lx	>100 lx	
Laminated green-clear glass												
Jan	996	621	367	228	172	57	4	5	2	0	0	5.21
Feb	1038	646	382	237	178	67	3	1	1	1	1	5.42
Mar	1148	708	414	255	191	68	1	1	1	0	0	5.73
Apr	1337	816	466	284	210	62	1	2	1	2	1	5.25
May	1599	979	569	349	260	73	0	0	0	0	0	6.07
Jun	2005	1220	694	422	312	69	0	1	0	0	0	5.59
Jul	2039	1239	703	427	315	66	1	0	0	0	0	5.53
Aug	1699	1039	597	366	271	72	0	3	0	2	0	6.15
Sep	1520	929	532	325	241	65	1	1	1	1	0	5.34
Oct	1256	774	450	277	207	67	2	2	1	1	1	5.81
Nov	1007	633	380	238	180	63	1	3	2	0	1	5.31
Dec	949	599	360	226	172	59	2	2	4	1	0	5.26
Laminated heat reflective-green glass												
Jan	181	113	67	41	31	0	0	0	1	8	35	1.37
Feb	188	117	69	43	32	0	0	0	0	11	39	1.44
Mar	208	129	75	46	35	0	0	0	0	22	34	1.71
Apr	243	148	85	52	38	0	0	0	3	32	22	1.71
May	291	178	103	63	47	0	0	2	15	28	23	2.17
Jun	364	221	126	77	57	1	5	16	23	15	7	2.37
Jul	370	225	128	78	57	1	5	15	18	14	8	2.24
Aug	309	189	109	66	49	1	2	8	23	17	14	2.19
Sep	276	169	97	59	44	0	0	2	20	22	14	1.80
Oct	228	141	82	50	38	0	0	0	1	30	26	1.77
Nov	183	115	69	43	33	0	0	0	0	8	37	1.35
Dec	172	109	65	41	31	0	0	0	0	6	31	1.15

Table 6. The simulation results of the DWFS facing east and saving of LCTL

Month	Average of the interior daylight (lx)					The interior daylight at 30%D (Percentage of time)						Saving (kWh/month)
	10%D	30%D	50%D	70%D	90%D	>338 lx	>300 lx	>250 lx	>200 lx	>150 lx	>100 lx	
Laminated green-clear glass												
Jan	2327	1403	729	450	335	60	1	4	2	1	0	5.30
Feb	2515	1746	946	532	362	66	3	2	1	0	1	5.41
Mar	2294	1503	948	475	358	65	2	1	1	0	0	5.66
Apr	2097	1404	737	479	373	62	2	2	1	1	1	5.27
May	2851	2032	1052	639	411	70	1	2	0	0	0	5.98
Jun	2196	1426	770	436	322	69	0	1	0	0	0	5.58
Jul	2332	1502	808	496	345	66	1	0	0	0	0	5.53
Aug	2875	1980	1015	671	493	72	0	3	1	2	0	6.15
Sep	2392	1563	830	521	395	64	1	1	1	1	0	5.29
Oct	2487	1657	851	525	391	65	1	2	4	1	1	5.73
Nov	2777	1947	936	527	393	63	0	1	5	1	1	5.30
Dec	2797	1579	832	518	386	61	0	1	4	2	0	5.28
Laminated heat reflective-green glass												
Jan	422	254	133	82	61	14	7	6	7	8	10	2.62
Feb	456	316	172	97	66	22	3	3	4	10	13	2.79
Mar	417	272	172	86	65	21	4	1	5	8	15	2.86
Apr	381	254	134	87	68	16	2	2	5	9	18	2.41
May	518	368	191	116	75	21	1	4	3	9	20	2.97
Jun	399	259	140	79	59	14	4	4	7	14	17	2.66
Jul	424	273	147	90	63	14	2	6	10	13	13	2.63
Aug	522	359	184	122	90	24	2	3	8	14	14	3.29
Sep	434	283	151	95	72	19	2	4	8	11	13	2.77
Oct	452	300	155	95	71	19	4	5	7	10	14	2.91
Nov	504	353	170	96	71	19	1	4	6	6	19	2.60
Dec	508	287	151	94	70	19	1	4	6	8	13	2.63

Table 7. The simulation results of the DWFS facing south and saving of LCTL

Month	Average of the interior daylight (lx)					The interior daylight at 30%D (Percentage of time)						Saving (kWh/month)
	10%D	30%D	50%D	70%D	90%D	>338 lx	>300 lx	>250 lx	>200 lx	>150 lx	>100 lx	
Laminated green-clear glass												
Jan	3172	1943	1112	676	498	66	1	1	0	0	0	5.57
Feb	2607	1588	918	560	414	70	1	1	0	1	1	5.52
Mar	1848	1129	651	398	295	68	0	0	1	0	0	5.76
Apr	1471	896	510	310	229	62	1	2	1	2	1	5.25
May	1277	788	462	285	213	72	1	1	0	0	0	6.05
Jun	1465	895	514	314	233	69	0	1	0	0	0	5.59
Jul	1612	983	561	342	253	66	1	0	0	0	0	5.53
Aug	1677	1025	590	361	268	72	0	3	0	2	0	6.16
Sep	2049	1248	709	431	318	65	0	1	1	1	0	5.35
Oct	2627	1602	916	557	411	69	1	2	1	1	0	5.88
Nov	3411	2081	1223	749	552	69	0	0	0	0	1	5.58
Dec	3718	2270	1331	814	599	66	0	0	1	0	0	5.54
Laminated heat reflective-green glass												
Jan	578	354	203	123	91	38	4	7	4	3	7	4.06
Feb	475	289	167	102	75	31	5	11	7	4	11	3.70
Mar	337	205	119	72	54	3	5	16	15	9	14	2.42
Apr	267	163	93	56	42	0	0	2	12	28	17	1.80
May	232	143	84	52	39	0	0	0	3	24	32	1.79
Jun	266	163	93	57	42	0	0	0	11	28	24	1.92
Jul	293	178	102	62	46	0	0	3	19	21	18	1.94
Aug	305	186	107	66	49	0	2	11	19	15	19	2.24
Sep	373	227	129	78	58	5	11	16	11	11	7	2.49
Oct	479	292	167	102	75	29	6	10	6	5	8	3.74
Nov	624	380	224	137	101	47	2	6	4	2	6	4.47
Dec	680	414	243	149	110	46	2	8	2	3	4	4.51

Table 8. The simulation results of the DWFS facing west and saving of LCTL

Month	Average of the interior daylight (lx)					The interior daylight at 30%D (Percentage of time)					Saving (kWh/month)	
	10%D	30%D	50%D	70%D	90%D	>338 lx	>300 lx	>250 lx	>200 lx	>150 lx		>100 lx
Laminated green-clear glass												
Jan	2240	1340	716	440	327	62	0	4	1	1	0	5.35
Feb	2284	1573	866	485	342	65	2	4	0	1	0	5.34
Mar	2234	1520	952	461	350	67	2	0	1	0	0	5.74
Apr	1951	1230	761	403	303	63	1	2	1	2	0	5.29
May	2332	1488	963	461	333	73	0	0	0	0	0	6.10
Jun	2451	1584	1001	469	346	69	0	1	0	0	0	5.59
Jul	2503	1615	982	489	361	66	0	0	0	0	0	5.54
Aug	2311	1450	875	478	356	72	0	2	0	2	0	6.18
Sep	2258	1479	820	519	335	65	1	1	0	1	0	5.35
Oct	2408	1606	846	525	370	69	1	1	1	1	0	5.91
Nov	2751	1852	908	523	390	68	1	0	0	1	0	5.57
Dec	2445	1364	763	471	351	63	4	0	1	0	0	5.47
Laminated heat reflective-green glass												
Jan	406	243	130	80	60	19	4	5	7	7	10	2.74
Feb	415	285	157	88	62	20	4	2	6	11	14	2.71
Mar	406	275	172	84	64	17	2	5	5	8	19	2.71
Apr	354	223	138	73	55	12	2	6	4	7	22	2.33
May	424	270	175	84	61	18	3	4	5	9	21	2.89
Jun	445	287	182	85	63	20	2	4	6	15	14	2.96
Jul	455	293	178	89	66	15	1	6	7	12	16	2.71
Aug	420	263	159	87	65	19	1	5	5	15	15	2.98
Sep	410	268	149	94	61	14	5	4	10	13	13	2.64
Oct	437	291	154	95	67	17	5	3	10	13	14	2.91
Nov	499	336	165	95	71	24	2	5	4	7	16	2.99
Dec	444	248	139	86	64	20	2	5	4	8	12	2.75

Discussions and Conclusions

The lighting controller for LED lamps cooperated with daylighting is a simple design. The device uses the pulse width modulation technique to adjust the LED light level, it could work appropriately. The devices will turn-off the LED lamps, if daylight exceeds 338 lx. The LED lamps give the maximum illuminate of 182 lx, it consumes about 18.83 W. The measurement and calculation indicated that it could save about 0.23 kWh/lamp/day, when compared with 28 W T5 fluorescent lamp. Moreover, the calculations were conducted to investigate the electrical energy saving for a daylight application through the double pane window with internal fixed-angle slats in Thailand. The results from the calculations demonstrated that the LCTL installed near window could offer a potential energy saving in the tropics.

Acknowledgement

The authors appreciate the financial support from Rajabhat Rajanagarindra University.

References

- Burr-Brown Corporation, 1994, Integrated Photodiode and Amplifier: OPT301, USA.
- Chaiwiwatworakul, P., Chirarattananon, S., and Rakkwamsuk, P., 2009, Application of automated blind for daylighting in tropical region. *Energy Conservation and Management*, 50(2009):2927-2943.
- Chirarattananon, S., 2005, Building for Energy Efficiency, AIT., Bangkok, Thailand.
- Chirarattananon, S. and Chaiwiwatworakul, P., 2006, An Experimental Study on the Use of Automated Venetian Blind for Daylighting in Tropical Region, [Electronic], Available at URL : <http://www.energy-based.nrct.go.th> [Retrieved on March 27, 2009].
- Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, 2008, Renewable Energy Development Plan 15 year (2008-2022), [Electronic], Available at URL : <http://www.dede.go.th/> [Retrieved on Feb 25, 2013], (in Thai).
- Electricity Generating Authority of Thailand (EGAT), 2013, The statistics of maximum power demand in 1990-2012, [Electronic], Available at URL : <http://www.egat.co.th> [Retrieved on Feb 21, 2013], (in Thai).
- Janjai, S., 2004, Development of Daylight Potential Maps and Database from Satellite Data for Thailand, Department of Alternative Energy and Efficiency, Ministry of Energy and Department of Physics, Faculty of Science, Silpakorn University, Bangkok, Thailand, (in Thai).
- Ministry of Energy, 1992, The Energy Conservation Promotion Act B.E. 2535, Thailand, (in Thai).
- Ministry of Energy, 1995a, A set of Ministerial Regulations B.E. 2538, Thailand, (in Thai).
- Ministry of Energy, 1995b, Thailand's Building Energy Code B.E. 2538, Thailand, (in Thai).
- Ministry of Energy, 1995c, The Royal Decree on Designated Building B.E. 2538, Thailand, (in Thai).
- U.S. Department of Energy(US-DOE), 2009, EnergyPlus engineering document: the reference to EnergyPlus calculations. The University of Illinois, The Ernest Orlando Lawrence Berkeley National Laboratory, CA.

Effect of Acidic Soil on Free Fatty Acid of Palm Oil in Thailand

Pitchayasinee Ariyatanakatawong*¹, pannavich Ariyatanakatawong *²

*¹Rajabhat Rajanagarinra University, Thailand, *²King Mongkut's Institute of
Technology, Thailand

0202

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Oil palm is the most important plants that serve as raw materials for producing biodiesel and is considered as an important part of energy sources in Thailand. Some oil palm plantations were grown in soil pH with acid conditions, which lacked of supporting data for agriculturalist. Attempts were made to study the effect of the level of soil pH on the quality of palm oil. Three palm varieties were used for studying the production of the fruit and the kernel. Free fatty acids (FFA) existed in three levels of soil pH with acid conditions were analyzed using AOCS Ca 50-40 method. It was found that *UV*, *Tenera*, and *Deli Compact* were varieties that could grow in acidic-pH soil. The highest yields of the production of the fruit and the kernel from the oil palm plantations that were grown in soil-pH conditions less than 6 were 3,855.2, 3,172, and 2,623 kg/ha in the variety *UV*, *Tenera*, and *Deli Compact*, respectively. Results of FFA found in three varieties of acidic soil in the three varying levels were not different. The mean values of FFA of *UV*, *Deli Compact*, and *Tenera* species were 3.59, 3.65, and 3.72 %, respectively, while the FFA of three varieties of oil palm that were grown in soil pH conditions greater than 6 were 3.48, 3.66, and 3.50 %, respectively. This finding suggested that acidity conditions of soil did not affect the quality of production yield of oil palm and can use as a guideline in the planning for more effective expansion of oil palm plantations in the future.

Keywords: Acidic soil, free fatty acid, palm oil, Thailand

1. Introduction

Oil palm (*Elaeis guineensis*) is a monocotyledon and a perennial plant which has the highest production per hectare among oil crops, i.e., seven to eight times of peanut's yield, and 9 to 10 times of soybean's yield. It was shown that an average of 3.7 tons of oil per hectare per year was obtained from the extraction in Malaysia (Sundram et al., 2003).

In Thailand, there has been rapid expansions in oil palm plantations throughout the country since 2006. There are variations in yields of oil palm among the productions of oil palm in the South, Northeastern, Eastern, and the Central part of Thailand where the average value was ranged from 1.07 tons/rai/year to 6.49 tons/rai/year. Factors that cause the variations of the production of oil palm were nutrient supply, water stress, weed, pests, diseases, pollination, and shading (Therapong, 2011).

The crop produces two types of oil. The fleshy mesocarp (palm meat) produces palm oil which is used mainly for its edible properties, and the kernel produces palm kernel oil which has wide application in the oleochemical industry. The palm oil (PO) is very unique in that it contains 50% saturated fatty acids, 40% unsaturated fatty acids, and 10% polyunsaturated fatty acids (Naiyana and Wahlqvist, 2003). The quality of PO is determined by different factors, where free fatty acid (FFA) is one of the most frequently used as quality indices during the production processes, storage, and marketing, whereas the price of PO in the market is dictated by FFA content (Saad et al., 2007). Other parameters that dictate the price of a palm oil product include moisture, impurities and iodine value (IV). Many researchers have reported FFA content (Saad et al., 2007) and IV (Haryati et al., 1997) of PO, but most of the material of PO were refined PO, not extracted from fresh palm meat (PM). The fatty acid components of PO (Sundram et al., 2003) and palm kernel oil (PKO) (Kritchevsky et al., 2000), the tocopherol and carotene content of PO (Ping et al., 2002) were also studied.

In Thailand, the expansion of oil palm plantation is very rapid. Thai government has set its policy on producing palm oil-based biodiesel as a renewable energy. Attempts on the mixing 2% of the B2 biodiesel with 98% of diesel oil on trucks was done during 2006 – 2010, and B5 biodiesel was used with other types of car in 2011 where the percentage of biodiesel combination was changed to B10 in 2013. The plan to envision the bright future of a sustainable development of the palm oil industry and an increase in the production of value-added products is pursued. It targets a yearly development of new plantings of oil palm in 80,000 ha and a yearly replanting of oil palm in 16,000 ha until 2011. The average overall oil extraction rate (OER) is aimed to increase to 18.5% and the average fresh fruit bunch (FFB) yield to 21 t/ha by 2011. The expansion of oil palm plantations is explicitly targeted at “waste” land such as abandoned paddy fields, degraded land, abandoned fruit orchards, land with acid soils and land with previously used for rubber cultivation. Research has shown that actual expansion of oil palm plantations in the Southern provinces are mainly taken place in paddy fields and land that is previously grown rubber plantation, i.e., in Chon Buri and Chachoengsao Provinces, and also on the land that is formerly used for cassava, pineapple, and rice cultivation.

Acid soils in Thailand are found scatter throughout the country with a total area of 22.8 million ha. Acid soils are mainly found in the Northeast Thailand, with an area of 10.4 million ha. Some areas in the South, the Central Plain, Northern, Western, and Eastern Thailand are 4.3, 4.0, 3.04, and 1.12 million ha, respectively (Chareonchamratcheap et al., 1997). The vast majority of the acid soils composition is Ultisols (around 22.6 million ha) while the remaining is Oxisols. These soils are characterized by low pH and their major

constraints are low cation exchange capacity (CEC), base saturation, high acidity, aluminum toxicity, manganese toxicity, iron toxicity and infertility. Even though acid soils are considered as a problem soil that has long been experienced in the country, their magnitude and intensity are continuously increasing as a result of inappropriate use for agriculture, deforestation, and soil mismanagement have been occurred in recent decades, thus an increasing in the magnitude of the problems should be solved in order to face the demands of future food needs. Increasing interest in studying the problem of acid soils is a result of their widespread distribution in the country, representing 44% of the total land, which is generally used for agricultural production. To fulfill the demand, a daily production of 8.5 million liters of biodiesel must be met. That means another five million rai (or about 800,000 hectares) of oil palm plantation areas must be expanded into a total of eight million rai (1.2 million hectares) of the palm cultivation and reach 10 million rai (1.6 million hectares) by 2029. So, a variety of discourse on oil palm has emerged to promote as a renewable source of energy and a transformation of deserted rice fields into palm field especially in the Eastern Thailand, such as Chachoengsao and Nakhonnayok Province where the soils are mostly consisted of acid soil condition. Thus, the appropriate palm variety, and quality of palm oil should be addressed to serve as a guideline in decision-making in the planning and more effective expansion of oil palm plantations in acid soil area to reduce a great concern of environmental impact from an expansion of oil palm plantation.

2. Methodology

2.1 Data sampling

The study was carried out in 6 districts, i.e., Sanam Chai Khet, Tha Takiab, Plang Yao, Phanom Sarakham, Ratchasan, and Muang districts of Chachoengsao province, Thailand. The survey area was composed of a variety of acidic soil, i.e., pH<4, pH 4-6, and pH>6, respectively. The data of management of palm plantation were collected from Land Development Station, Department of Agriculture Extension, palm fruit milling industry, and palm owners by indepth interview approach. FFB yields were recorded at each harvesting round of every 15 days. These values were then extrapolated to a yield in tons of FFB per hectare per years.

2.2 Determination of Free Fatty Acid value: The FFA value of the oil samples was determined in duplicated manner using standard analytical methods for fats and oils by the American Oil Chemists Society(AOCS, 1990) at 95% confidence limit. The percentage FFA value was calculated from the equation below:

$$\text{Free fatty acids (FFA)\%} = \frac{VmM}{10w}$$

where, w = weight (in grams of samples), v = volume (in milliliters) of sodium hydroxide solution, m = molarity of sodium hydroxide solution, and M = molecular weight of the FFA.

3. Results and Discussion

Plantation and management

The data clarification by the farmers for palm oil plantations and management in Chachoengsao province were as follows:

1. Palm oil started producing at around 4/5 year, while first few years were around 15 kilograms per palm then 30 kilograms per palm after 6 years. Palm was cut at every 20 days with 22 palm trees per rai. Forty percent of the plantation management went back into the trees as fertilizer cutting and pruning. The farmers visited every tree at least once a month and paid a visit more during the period of heavy rain. The actual harvesting times were determined by looking at the fruit bunches, and harvesting the ripe ones.

2. Farmers got approximately 80 kg/tree or more when the trees were about 8 years of age. Yields dropped considerably when the precipitation was low. Most of farmers planted 22-24 palm trees per rai resulted in low density of palm trees. In generally in Thailand, the farmers recommended to use 8.5 meter grid (or less) when the precipitation was low. To maximize the revenue usually meant that the oil palms were planted at higher densities, where the trees were planted upwards of 160 trees per hectare or more. But some of farmers planted the palm upto 185 trees per hectare. The farmers needed to put more afford on the investment and had access to water, where a drip irrigation system was used more than paying for itself.

3. Total costs for oil palm palntation depended on paying and how efficient they were. The current Thai prices of fruits were 5 baht/kg, and 29 baht/kg for crude palm oil (CPO), 40% was a hefty chunk unless including interest on capital for purchase of the land. The high yields of input (such as irrigation) decreased overall costs as a percentage of income. Fertilizers were the most effective factor during the early years of investment, whereas there was a significantly less demand when trees were mature. So, this factor is highly variable, where it is estimated for labor in the maintainance of the plantation.

4. Rats are a big problem that reduce the yield of the oil palm. It was estimated that about 5% attribution rate during the early years of plantation occurred if there was less effective rodent control plan.

Results of survey on varieties of Palm Tree in the study areas of Chachoengsao Province

Results in Table 1 showed that Univanich (UV) variety was the most popular one that planted in Chachoengsao because it was a hybrid produced by the Suksomboon Palm Oil Company Ltd, where all kinds of knowledge were provided and supported to agriculturists from cultivating to harvesting crops. The second popular variety was Tenera (DxP) which the plantation was supported by Eastern Palm Oil Company Ltd. that was located in the boundary area between Chachoengsao and Chon Buri; and some agriculturists bought it from Lamae district, Chumphon Province. Moreover, it was found that there were three varieties of palm trees planted in the acid soil area, i.e., Univanich (UV), Tenera (DxP), and Deli Compact. Tha Takiep District was the most populous planting area (39.48%), whereas Sanam Chai Khet District was a less popular one (21.43%). The least populous planting area was in the Dong Noi Sub-district, Rachasarn District where it was a newly planting area with a very acidic soil which attempts were made to grow oil palm (Table 2).

Table 1. Showing results of survey on varieties of palm tree in each district in Chachoengsao Province.

Palm varieties	District	Area(rai)	Hectare(ha)	Percent(%)
Univanich	Sanam Chai Khet	2,690	430.4	30.04
	Tha Takiap	3,475	556	38.80
	Plaeng Yao	1,620	259.2	18.09
	Phanom Sarakham	200	32	2.23
	Ratchasan	50	8	0.56
Tenera(DxP)	Tha Takiap	554	88.64	6.19
	Plaeng Yao	50	8	0.56
	Phanom Sarakham	30	4.8	0.33
	Mueang	50	8	0.56
	Ratchasan	10	1.6	0.11
Deli x Lamae	Sanam Chai Khet	60	9.6	0.67
Surat Thani	Plaeng Yao	62	9.92	0.69
Deli x Compact	Phanom Sarakham	75	12	0.84
Nhongped(DxP)	Phanom Sarakham	30	4.8	0.84
		8,956	1,432.96	100.00

Remark: 1 Hectare(ha) = 6.25 Rai

Table 2. Showing varieties of palm tree in Chachoengsao province.

Palm varieties	Area(rai)	Hectare(ha)	Percent(%)
Univanich	8,035	1,285.6	89.72
Tenera(DxP)	694	111.04	7.75
Deli x Lamae	60	9.6	0.67
Surat Thani	62	9.92	0.69
Deli x Compact	75	12	0.84
Nhongped(DxP)	30	4.8	0.33
	8,956	1,432.96	100.00

According to the survey of palm tree grown in Chachoengsao, it was found that the average age of palm trees was 11.5 years. Those trees that less than four years of age were planted in an area of 2,843 Rai; those of 4 – 8 years were 1,866 Rai; of 8 – 15 years were 3,913; and

more than 15 years were 200 Rai, which were equivalent to 31.84%, 20.92%, 43.83%, and 2.24%, respectively. To sum up, the tendency of growing palm oil in the area of Chachoengsao had been increasing (Figure 1).

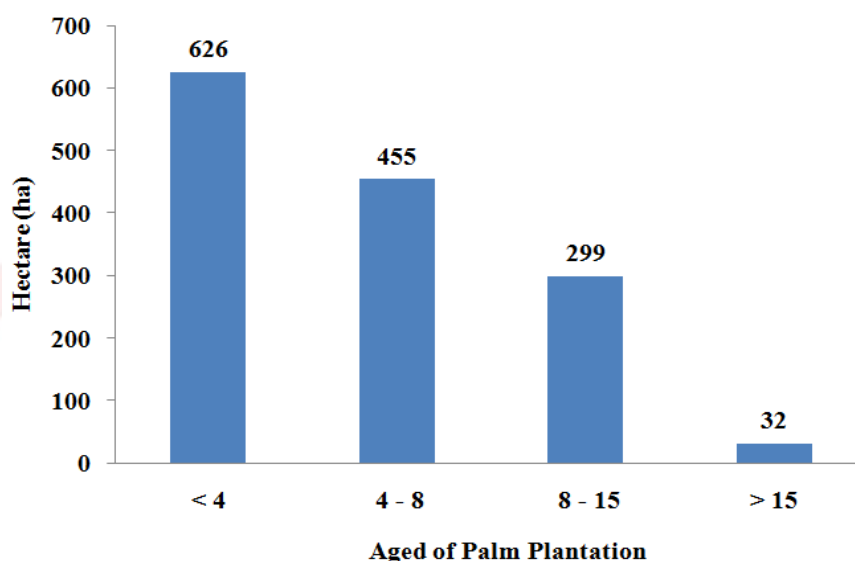


Figure1. Showing the age of Palm tree grown in 6 districts of Chachoengsao Province.

The Spreading of Oil Palm Tree varieties in Acid Soil in the Chachoengsao Province

It was found that Univanich (UV) variety was the most popular variety in Chachoengsao because it was supported by Suksomboon Palm Oil Company Ltd, where all knowledge concerning systematic techniques of how to cultivate through the harvestation of crops were provided to agriculturists. The second rank of the popular variety of oil palm tree was Tenera (DxP) which was supported by Eastern Palm Oil Company Ltd., where it was grown in the boundary area between Chachoengsao and Chon Buri. Some agriculturists bought it from Lamae district, Chumphon Province. It was incidentally found that 3% of soil in the planting area was very severe acidic level with the value of **pH below 4**, 51 % had moderate acidic level with the values of pH ranged from 4 to 6, and 46 % were non acidic level with the values of pH were 6. Moreover, more than 50% of palm planting was done in an acidic area (Table 3).

Table 3. The spreading of varieties of oil palm that found in various pH level soils in Chachoengsao Province.

Palm varieties	pH			Area	
	<4	4-6	>6	Rai	Hectare
Univanich	250	3,695	585	4,530	724.8
Tenera(DxP)	10	554	1,886	2,450	392
Deli x Lamae	-	80	1,189	1,269	203.04
Surat Thani	-	-	431	431	68.96
Deli x Compact	-	-	60	60	9.6
Nhongped(DxP)	-	-	62	62	9.92
Total	260	4,329	4,231	8,802	1,408.32

Products of Oil Palm in Chachoengsao province

Results in Table 4 suggest that the pH level of soil at 6 was the suitable soil conditions for oil palm cultivation (Theerapong, 2011). The hybrid variety, Tenera (DxP) could produce the highest yield, which was commonly grown in Tha Takiap, Pleang Yao, Phanom Sarakham, Mueang, and Ratchasan District, respectively. All of them were highly suitable for the cultivation. The soil with pH level less than 6 was suitable for the cultivation of the Univanich variety which yielded 632 kgs per rai, whereas the Tenera variety (DxP) and Deli Compact yielded 30 and 520 kgs per rai, respectively. In addition, it was found that the plantation of the Univanich variety in acid soil where the pH level was less than 4 yielded a good level of the product in several areas, i.e., Bang Khla sub-district of Ratchasarn District, and Khao Hinson sub-district of Phanom Sarakham.

Table 4. Showing FFB yields of various varieties of oil palm in Chachoengsao Province.

Palm varieties	FFB yield (kg/rai/time of harvesting)		
	pH <4	pH 4-6	pH >6
Univanich	332	632	650
Tenera(DxP)	200	430	700
Deli x Lamae	-	520	550
Surat Thani	-	-	500
Deli x Compact	-	-	570
Nhongped(DxP)	-	-	510
Total	532	1,582	3,480

The Quality of Oil Palm in Acidic Soil in Chachoengsao Province

Due to the fact that this research was to investigate the quality of oil palm from the fresh palm fruits after the extracting process during each period of extraction. After three months of recording of the oil quality (June – August, 2012) using Free Fatty Acid (Analysis method = AOCS Ca 50-40) and the process of separating the plantation areas in the soils with the pH levels of soil were less than and greater than 6, it was found that 2-3 % was in high oil quality, and 3-4% was in moderate oil quality. There were more than 4% which was grown in highly acidic soil could affect the oil quality for bio-diesel (B100). The Free Fatty Acid level in palm oil (or the acidity of palm oil) in normal plantations, where the pH level of soil was greater than 6 are recorded, and it was found that Univanich (UV), Tenera (DxP), and Deli Compact variety had an average acidity of 3.48, 3.66, and 3.50, respectively. In acidic soil where the pH level was greater than 6, it was found that the Univanich variety (UV) had a lowest level when compared with Tenera (DxP) and Deli Compact, which had an average acidity at 3.72 and 3.63, respectively. It was also found that the Univanich (UV) variety was the most productive one in both acidic and normal soil. It was clearly shown that the Univanich variety was the one that was able to grow in low acidic soil and gave a productive result as well as a desirable variety for oil distillery factories. (Figure 2 and Figure 3)

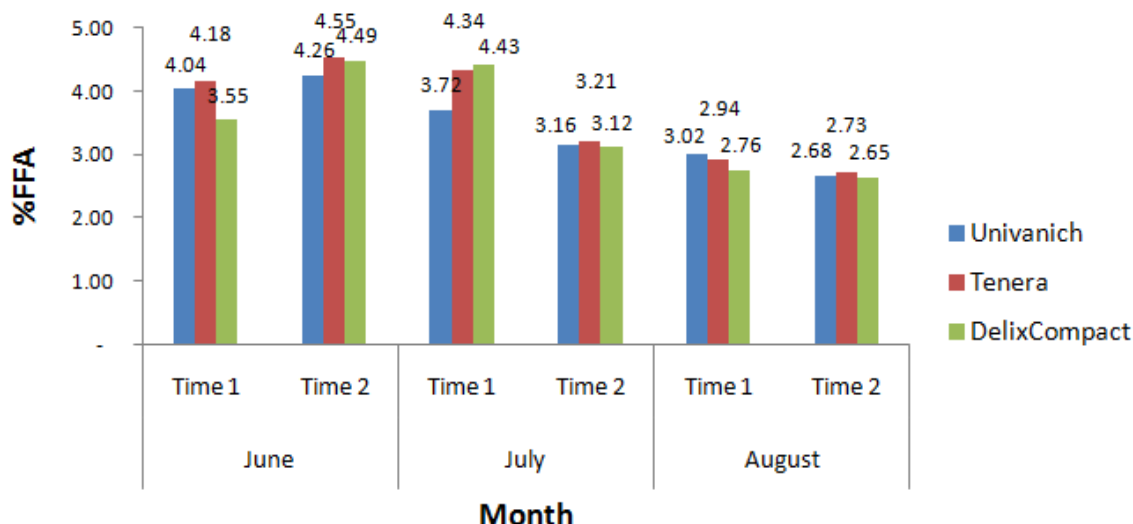


Figure 2. Showing a comparison of FFA detected in varieties Univanich, Tenera, and Deli x Compact grown in soil pH > 6 in Chachoengsao province.

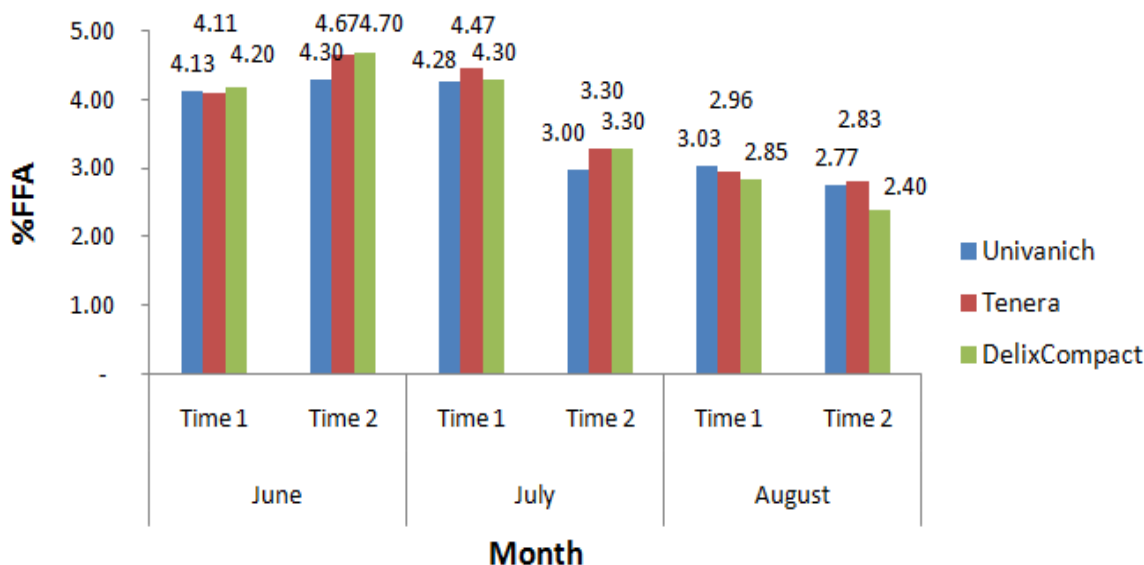


Figure 3. Showing a comparison of FFA detected in varieties Univanich, Tenera, and Deli x Compact grown in soil pH < 6 in Chachoengsao province.

4. Conclusion

The study revealed that the spreading of oil palm plantation in the eastern Thailand originated from the government policy of plantation area enlargement in promoting the substitute-energy policy. In regards to this policy, the promotion of exploitation in the waste areas was done. By this, infertile areas or non-irrigated areas were changed to be a palm oil plantation

for substitute energy. Incidentally, the private sectors like Suksomboon Palm Oil Company Ltd. and Eastern Palm Oil Company Ltd. played an important role for spreading the plantation area as well as being the market for the eastern Thailand. In Chachoengsao, the palm plantation area was totally 8,927 Rai. The six varieties of palm trees were Univanich for 8,036 Rai (92%), Tenera for 694 Rai (7.77%), Deli Lama for 60 Rai (0.67%), Surat Thani for 62 Rai (0.69%), Deli Compact for 75 Rai (0.84%), and Nong Ped for 30 Rai (0.33%). The variety Univanich (UV) was the most fruitful variety in the acidic area, which produced 632 kgs/Rai, Tenera produced 430 kgs/Rai, and Deli Compact 520 kgs/per Rai. The difference of fruitfulness quantity was resulted from their heredity. Therefore, the spreading of palm plantation should be considered for the suitable condition of plantation areas in order to secure both qualitative and quantitative productivity.

For the percentage of acidity or Free Fatty Acid (%FFA) of three varieties, i.e., Univanich, Tenera and Deli Compact, it was found that it was between 3-4 levels of crude palm oil (CPO). Also, it was explicit that the palm oil was in accordance with the standard of the biodiesel oil distillery factory of the Ministry of Energy and the Department of Internal Trade of Thailand after the oil extracting process (Energy Policy and Planning Office, 2011). Interestingly, the soil acidity did not affect the oil quality. The quality of Free Fatty Acid (FFA) of the variety Univanich, Deli Compact, and Tenera was 3.59, 3.65, and 3.72, respectively. The factors effecting the increase of FFA were the 15-20 day-pre-harvesting period (Nithedpattarapong *et al.*, 1996), lack of water in arid season, and bad effects from harvesting and transporting, etc. The Free Fatty Acid of three palm hybrids was not different in the acidic plantation area. Definitely, the suitable arrangement of palm plantation resulted in good harvesting and quality control, e.g. FFA quality. It was a way to add value and decrease the investment (capital) for bio-diesel.

Acknowledgments

The authors are very grateful for research grant from Office of the Higher Education Commission and financial support for publication from Rajabhat Rajanagarindra University Chacheongsoa province, Thailand. The authors also would like to extend a special thank to Professor Dr.Somsak Pantuwatana for his value advice and encourage for the publication of this paper.

References

- AOAC.1990. Official Methods and Recommended Practices of the American Oil Chemists Society. 4th Edn., American Oil Chemists Society, Champaign, California.
- Chareonchamratcheap, C., Kanchanathanaset, K. And Sirivong, M.1997. Management of Acid Soils in Thailand. Land Development Department, Ministry of Agriculture and Cooperatives, Thailand.
- Energy Policy and Planning Office.2011. EPPO Annual Report. Bangkok, Thailand.
- Haryati T, Che Man YB, Asbi A, Ghazali HM, Buana L.1997. Determination of iodine value of palm oil by differential scanning calorimetry. J. Am. Oil. Chem. Soc. 74(8): 939-942.
- Janiyom, T. 2011. Thung Rangsit Palm Paradise. The Plant magazine 5: 64-69.
- Kritchevsky D, Tepper SA, Kuksis A, Wright S, Czarnecki SK. 2000. Cholesterol vehicle in experimental atherosclerosis. 22. Refined, bleached, deodorized (RBD) palm oil, randomized palm oil and red palm oil. Nutr. Res. 20(6): 887-892.
- Nithedpattarapong, S., Srikul, S, and Chai Korawis, C.1996. Application of empty fruit bunch of oil palm as a source of plant nutrients in oil palm plantation by Department of Agriculture, Bangkok, Thailand (May-Aug), (in Thai).
- Ping BTY, May CY, Lian GEC, Hock GS .2002. Geometrical isomers of the major provitamin a palm carotenes, α - and β -carotenes in the mesocarp oil of fresh and sterilized palm fruits, crude palm oil and palm carotene-based products: red palm oil and carotene concentrates. J. Oil Palm Res. 13(2): 23-32.
- Saad B, Ling CW, Jab MS, Lim BP, Ali ASM, Wai WT, Saleh MI .2007. Determination of free fatty acids in palm oil samples using non-aqueous flow injection titrimetric method. Food Chem. 102: 1407-1414.
- Sundram K, Thiaharajan T, Gapor A, Basiron Y. Palm tocotrienols. 2002. New antioxidants for the new millennium. Inform 13: 634-641.
- Therapong Janiyom. 2011. Thung Rangsit Palm Paradise. The Plant magazine 5 : 64-69.
- Wattanapenpaiboon, N., Wahlqvist, M. W. 2003. Phytonutrient deficiency: the place of palm fruit. Asia Pacific journal of clinical nutrition 12(3):363-8.

The Integrated Development of the Community Learning Center of Philosophy of Economic Sufficiency: A Case study at Dong Kra Tong Yam Sub-district, Si Maha Phot District, Prachin Buri Province

Linda Nakpoi

Rajabhat Rajanagarindra University, Thailand

0209

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This study was aimed to determine the effectiveness of rural development tactics in rural and agricultural areas of Thailand. The Participatory action research was conducted at Dong Kra Tong Yam Sub-district, Prachin Buri Province, Thailand. The key informants were community's leaders, local government officers and the local scholars. The data were collected by qualitative method consisted of field studies, In-depth interviews, focus groups, and analyzed by using content analysis. The activity was opened to promote the philosophy of self-sufficiency, in-line with Thai Royal policy. However, the action was not fully successful. The community needed government and private support, career education, a decrease in local municipal and personal debt, expansion of the Community Learning Center, and a network of local sustainable community developments.

Keywords: Community learning center, philosophy of economic sufficiency, community's economic sufficiency learning network

Introduction

Dong Kra Tong Yam is one of ten sub-districts of Sri Maha Phot district in Prachin Buri Province. There are seven villages in Dong Kra Tong Yam sub-district. The majority of residence are Thai Puan. Thai-puan or laos-puen is the ethnic group living in Central Thailand and Laos. The Thai puan are famous for hand-weaving textiles. They have their own culture and language. (Pho Samlamjiak, 2003)

The main career of the population in this sub-district is farmers, whereas some of them also have minor jobs during the post-harvesting seasons, i.e., handcrafting, weaving, and wicker working. It is considered that most of the people are poor, and have encountered with debt problems. These aforementioned problems are the main causes of a big migration of the workforce to cities in order to find jobs, and those left-behind are children and older adults.

According to the current problems, it is interesting to find out how to develop the community as a learning center for the Philosophy of Economic Sufficiency (PES) of HM The King Bhumibol Adulyadej for all to learn and share information about their products and product developments. (Chaiyawat Wibulswasdi,2009)

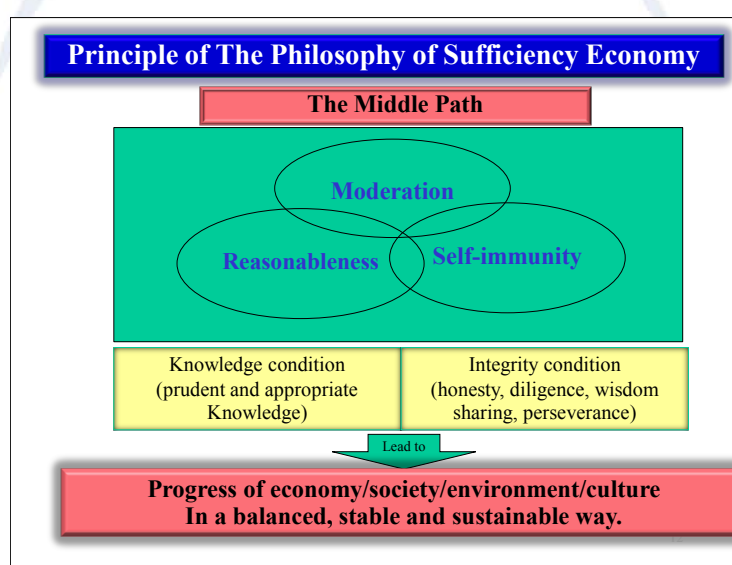


Figure 1. Principle of The Philosophy of Sufficiency Economy

The middle path as an overriding principle for appropriate conduct by Thai people at all levels, from family to community to country. It calls for national development and administration to modernize in line with the forces of globalization. “Sufficiency” means moderation, reasonableness, and the need of self-immunity for sufficient protection from impact arising from internal and external changes. To achieve this, the application of knowledge with due consideration and prudence is essential. (Charas Suwanwela, 2009)

In particular, great care is needed at every step in the utilization of theories and methodologies for planning and implementation. At the same time, it is necessary to strengthen the moral fiber of the nation, so that everyone particularly public officials, academics, and businessman, adhere first and foremost to the principle of honesty and integrity. (Mongsawad, Prasopchoke , 2007)

In addition, a way of life based on patience, perseverance, diligence, wisdom and prudence is indispensable to create balance and be able to cope appropriately with critical challenges, arising from extensive and rapid socioeconomic, environmental, and cultural changes in the world.

The center can also be the center for exchanging experiences between communities such as students, scholars, and so on. This will widen learning networks in their community, and strengthen the cooperation between public and private sectors as well.

This study was aimed to develop the Community Learning Center (CLC), which was based on the Philosophy of Sufficiency Economy in Dong Kra Tong Yam sub-district, Sri Maha Phot District, Prachinburi Province, learning networks for exchanging experiences, and serve as the base for developing community prototype under the Philosophy of Sufficiency Economy.

The **scope of the study** was focused on the development of the CLC under The Philosophy of Sufficiency Economy, which targeted participants were the leaders groups of the community, the members of local administration, occupational groups, and residents of Dong Kra Tong Yam sub-district.

The expected outcomes resulting from the development of the CLC will stimulate the awareness of the people to become realize that they have a valuable and meaningful CLC for learning and develop their own skills, improve their quality of life and their living under the PES, have community networks for exchanging knowledge within their community both in public and private sectors. Stakeholders are aware of the important of participation in building and developing their community according to The Philosophy of Sufficiency Economy, and people share their love and pride of their own community.

Methodology

This participatory action research (PAR) employed both qualitative approaches for collecting data. All data obtained from documents, field study, in-depth interview, focus group, were analyzed by using content analysis technique. The main focus of this study was people participation, training, workshops, and exploring and using databases within both scholars and the community.

Knowledge transferring plan

1. The researchers participated in the meeting with community for planning and conducting activities.
2. The meeting in the CLC would set up for all activities related to CLC.
3. Inviting guest speakers to deliver the principle of The Philosophy of Sufficiency Economy.
4. Setting up workshop for planning and develop the plans for community development. At this stage all clear directions, guidelines, and strategies for problem solving of the villages should be made available.
5. Searching for existing local wisdom within the community, and learning how to make use of knowledge for adding value to their community. At this stage, participants

should take notes; classify all information, assigning activities for transferring that wisdom, and then applying it to the community activities.

6. Analyzed and summarized the study results activities and documents

7. Presenting the study results to stakeholders so that they could apply them for enhancing participation in the community, which might be for social investigation, educating people, trainings, occupational visiting, building a body of knowledge, or even understanding phenomenon in their community. At this stage, it was important to make the community to be a learning center.

Results and Discussion

There were two centers that had been developed according to The Philosophy of Sufficiency Economy, namely Thai Puan Museum, which was located in Wat Ban Mai, and The Community Learning Center in Wat Raj Niyom.



Figure 2. Thai Puan Museum



Figure 3 . The Community Learning Center

As a result of having the centers, there were some noticeable points to consider in which career alertness and awareness was the first agenda. We could see that there were many groups of professions developed. Then the products of these groups were distributed to the center at Wat Raj Niyom (located in Ban Thai Dong) for sale. All representatives from the community were available at the center committees to manage, give advices, and solve problems. It was observed that there were many ongoing projects operating under the cooperation between temples, villages, and schools. Some examples of the ongoing projects were occupation training educating people, and teaching Dharma to children in Dong Kra

Tong Yam Schools by the local scholars and monks. The most important thing was that the local people knew, become aware of, and be able to apply the Philosophy of Sufficiency Economy for the way of living in their daily life. They make their own organic fertilizer instead of buying the chemical ones. They also manage their household income by deducting their wasteful payments; join the occupational groups, and grow kitchen gardens to increase their income, and so on. By doing this it helps make people's quality of life better.



Figure 4. Products of Community Learning Center

Guidelines for implementation and further study

Guidelines for tourism development

This area has a very long history and has its own culture and traditions. The most valuable one is Thai Puan's, which is remarkable to be promoted to be the local learning center to the world. Campaigns such as home staying, advertising on TV, websites, or even on the radios will make it more well known, and attract visitors to come. This will finally result in increasing community income.

Guidelines for product development

Occupational groups or local producers and distributors should register for product development trainings at any levels since it is the best way to increase community income dramatically. Furthermore, marketing by introducing community activities and products on media, i.e., Internet, radios, and TV are also making them well known for buyers.

Guidelines for social development

At the present time, authentic cultures, which have been passed from generation to generation, has changed because of the openness to foreign cultures. This can also change community cultures and identities as well. In order to maintain and conserve their own cultures and identities, children and young generations of the community need to be taught to inherit traditional values, such as wearing local or traditional outfits, and weaving or traditional massage.

Guidelines for capital development

To develop community capital, groups of profession such as a savings group, occupational groups and other community funds should be formed with the objectives to help people improve their products, their occupation, or even for increasing quality of life through education, trainings, visiting, seeking for local resources, and others. The most important thing is that the groups must be operated and managed by themselves via committees.

Guidelines for management development

The management is crucial for the community potentials so committees or even members of each group must be trained on how to run their activities and manage their community for ultimate results.

Acknowledgement

The authors appreciate the financial support from Rajabhat Rajanagarindra University.

References

- Chaiyawat Wibulswasdi Priyanut Piboolsravut; Kobsak Pootrakool (2009) Published by Sufficiency Economy Research Project Bureau of The Crown Property Bangkok, Thailand Website: <http://www.sufficiencyeconomy.org>.
- Charas Suwanwela, (2009). 'Sufficiency Economy Philosophy as an Approach for Sustainable Production & Consumption', presented at the 2nd ASEAN+3 Leadership Programme on Sustainable Production & Consumption, Sirindhorn International Environmental Park, Cha-am, Petchburi, Thailand, 8 August
- Mongsawad, Prasopchoke (2007). The philosophy of sufficiency economy and economic management. *NIDA Development Journal*, No.1/2550, pp. 159-180. (in Thai)
- Pho Samlamjiak, (2003) Thai Puan Legend: Narration of Old Stories. Kor Polpim Printing Co.Ltd. (in Thai)

*Rates of Sediment Deposition in Lam Phra Phloeng Dam , Nakorn Ratchasima
Province, Thailand, Using ²¹⁰Pb as a Geochronometer*

Kanitha Srisuksawad*¹, Sasimonton Moungrsrijun*², Tuangrak Nantawisarakul*³,
Kosit Lorsirirat*⁴

*¹Thailand Institute of Nuclear Technology, Thailand, *²Kasetsart University,
Thailand, *³King Mongkut's Institute of Technology Thonburi, Thailand, *⁴ Ministry
of Agricultural and Cooperation, Thailand

0216

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Lam Phra Phloeng dam, Nakhon Ratchasima Province, is one of the most seriously affected by soil erosion related sedimentation dam in Thailand. Deforestation and rapid land use change, from forest to agricultural land, has led to increase sediment load in rivers draining into the dam. The dominant crops in the upper catchment are sugar-cane and cassava. After the crop has been harvested the land is tilled and becomes sensitive to sheet erosion. As a direct result the dam has become very shallow and its storage capacity was reduced rapidly. In this study, the constant initial concentration (CIC) of unsupported ²¹⁰Pb model was successfully used to assess sedimentation rate from ²¹⁰Pb profile data of eight sediment cores from Lam Phra Phloeng dam. The ²¹⁰Pb based apparent sediment accumulation rates ranged from 0.21 to 1.02 g/cm²/yr with the average of 0.51 g/cm²/yr compatible to the total sediment loaded to the river of 5.491×10⁴ metric ton/yr and corresponding to the erosion rate of 2.27 mm/yr. Most of the sediment, more than 50%, was deposited at the distance of 3-5 km from the head of the reservoir. Such sediment distribution behavior was described based on the direction and velocity of the stream current. This study thus demonstrated the potential use of nuclear technique for water resource and erosion control management.

Key words: Lam Phra Phlong dam, sediment accumulation, ²¹⁰Pb

INTRODUCTION

One of the main problems of the water resource development program in Thailand is the sediment accumulation, which reduces the useful capacity of the reservoir. The expected economic and social benefits of the dam will be lower than expected at the planning stage because of the rapidly silt up sedimentation in the water body. The water resources development plan cannot be successful unless the upland soil erosion and reservoir sedimentation are prevented and controlled.

The above problems could be mitigated if the factors generating transportation and deposition are known and the prediction model can be developed. Most of the sediment deposition in the reservoir is generated by surface erosion at the upstream of the reservoir. Its amount and transportation depends on the degree of on-site erosion, which is the consequence of rainfall energy and land use changes. Environmental radiotracers which use natural and artificial radionuclides, for instances, ^{210}Pb , ^{137}Cs , ^{238}Pu , ^{239}Pu , ^{240}Pu and ^7Be have been used to identify and model important particle transport processes in diverse systems including great lake, small water bodies, wetlands and coastal marine environments. Rates of particle deposition and/or transport often can be determined using particle-associated radionuclides because of their built-in clock. These radiotracers have been utilized for dating purpose on time scales spreading from some years to several decades (Oldsfield and Appleby, 1984; Wasson et al., 1987; Olley et al., 2001; Bonotto and Lima, 2006)

The principles of ^{210}Pb dating were extensively outlined by Appleby and Oldsfield (1992). The isotope ^{210}Pb occurs as part of the radioactive decay chain of ^{238}U , which presents in small quantities in the materials of the Earth's crust. ^{238}U decays through a series of non-volatile intermediates to ^{226}Ra , a solid with a half-life of 1622 years, which decays to ^{222}Rn , an inert gas with a half-life of 3.825 days. ^{222}Rn decays via a series of short-lived daughters to ^{210}Pb , a solid with a half-life of 22.26 years. The lead becomes attached to the aerosols and reached the Earth's surface either by dry fallout or by being washed out of the atmosphere in precipitation. The aerosols ^{210}Pb which settles into lake waters is absorbed by suspended sediment and subsequently incorporated in the lake sediment and is referred to as unsupported or excess ^{210}Pb or in other words; it is not in equilibrium with its parent ^{226}Ra . ^{210}Pb is also formed in situ from the decay of ^{226}Ra eroded into the basin from the catchment or the decay of ^{238}U within rocks, soils minerals and sediments. The activities of this supported ^{210}Pb thus will not decrease with time resulted from continuous supply of ^{210}Pb from uranium and its daughters. While as the unsupported ^{210}Pb radioactivity in the sediments decreases by a factor of 2 every 22.26 years half-life. The rate of change of unsupported ^{210}Pb activity down a sequence may thus be used to establish the sedimentation rate.

Lam Phra Phloeng dam (Fig.1) is one of the most seriously affected by soil erosion related sedimentation dam in Thailand. Deforestation in the upper land area has reduced the forest area from 531 km² in 1974 to 160.25 km² in 1985 or about 70% reduction within 11 years. These have led to increase sediment load in rivers draining into the dam. The dominant crops in the upper catchment are sugar-cane and cassava. After the crop has been harvested the land is tilled and becomes sensitive to sheet erosion. As a direct result the dam has become very shallow and its storage capacity was reduced rapidly. In this study the sediment accumulation rates in Lam Phra Phloeng dam was estimated using the measurement of ^{210}Pb radioactivity profile in the sediment cores. Sediment accumulation rates were assessed using the constant initial concentration (CIC) of unsupported/excess ^{210}Pb model developed by Brugam (1978).

RESEARCH METHODOLOGY

General features of the study area

Lam Phra Phloeng dam (Fig. 1) is located in Nakhon Ratchasima Province, northeastern Thailand between the latitude of $14^{\circ} 30' - 14^{\circ} 36'N$ and longitude of $101^{\circ} 47' - 101^{\circ} 50'E$. The dam was constructed in 1963 and started operation in 1967. It is located at the upper part of Lam Phra Phloeng River in a small catchment area of 820 km^2 , which includes 10.78 km^2 as the water reservoir and 809.3 km^2 as the catchment. The catchment is a sub-basin of Moon river basin, which mostly occupied by flood plains. The foot hills located about 300-500 mean sea level (m.s.l.). The major stream flows into the reservoir is Lam Phra Phloeng River. The river flow direction is from west to east and the length of the river is about 60 km. The average annual water inflow is $241.93 \text{ million m}^3$. The ecology along the west and the east of the river is still a natural forest.

Rainfall is usually concentrated in the rainy season from May to October. Average annual precipitation varies from 1,270 to 2,000 mm/yr. The average annual rainfall ranged from 925 to 1,491 and averaged 1,140 mm/yr over a period of ten years from 1990 to 2000.

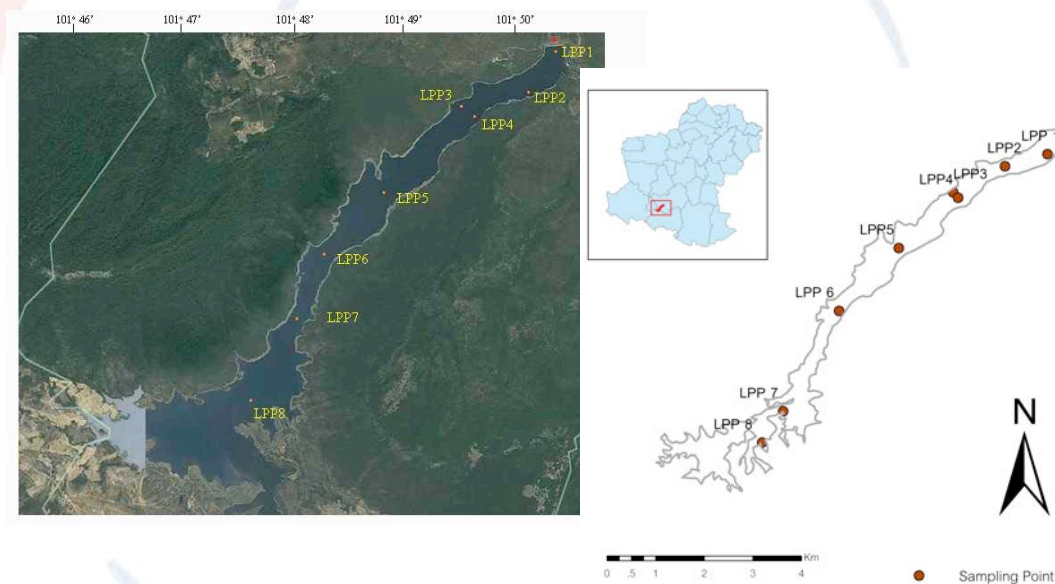


Fig. 1 A simplified map of the location of Nakhon Ratchasima Province and a portion of Lam Phra Phloeng dam, studied in this investigation. The monitoring stations are shown.

Sampling points

The study portion is in the crest dam covers the length of 11 km and the depth of 15-25 m (Fig.1). Eight sediment cores were sampled. The locations of all core sites were recorded by calibrated GPS. Horizontal position was recorded in the Universe Transverse Mercator (UTM) system based on the North American Datum of 1983 (NAD83) (Table 1). One core from each sampling site was collected using a gravity corer (Soft Cores Sediment Technologies) with a 10 kg weighing. The core is made of 75 cm acrylic tubes with inner and outer diameter of 5.4 and 6.2 cm, respectively. The sediment cores were sliced into segments of 1 cm thick by hydraulically extrusion on board ship. The sediment rim of each slice was removed and discarded to avoid contamination. The samples were put in plastic bags,

stored at 4°C. They were transported in an ice box to laboratory where all samples were stored at -30°C until determination.

Analytical method

The water content of each section was determined after drying at 60°C for the organic matter preservation and minimal loss of volatile compounds. The samples were dried for about 24 hrs or when the sample weights were constant. The dried sediments were disaggregated in a centrifugal ball mill and sieved through grain size <125 mm for removal of plants parts (roots, leaves, etc).

The particle size fraction <125 mm was analyzed based on optical laser diffraction method (Malvern Microsizer Laser Particle Sizing Analyzer). The sample to be analyzed was placed in the rotary auto-preparation station already equipped with the instrument. The samples were then diluted to the required obscuration of 10% (Pape, 1996; Buurman et al., 1997) and then automatically dispersed into the instrument. Most of the samples were analyzed twice for reproducibility of the result.

Total organic matter (TOM) of the sediment was measured by loss on ignition (LOI) (Dean, 1974). Principally about 0.5 g of dry sample was ignited in a muffle furnace for 4 hrs at 550°C, cool, and reweighed. The percent weight lost is the TOM in percent.

The particle density was determined using pycnometry (Ultrapycnometer 1000, Quantachrome) (Huang et al., 1995). Helium and nitrogen gas used were of 99.99% purity. The sediment bulk density was determined based on oven-dry and weight basis. The porosity was calculated based on particle density and bulk density data.

Mineralogy was determined using X-ray diffractometer (D8 ADVANCE, Bruker). About 50 g of sediment was grounded in agate mortar and irradiated in $\text{CuK}_{\alpha 1}$ (1.54 Å for Cu) radiation. The lattice parameters and atomic position were analyzed using FULL PROF SUITE-2000 software. The X-ray tube was operated at 30 kV, 25 mA and the sample was continuously scanned in the 2θ ranged of 20°-80° with scanning speed of 0.02 degree per second. The X-ray diffraction data were then analyzed by comparison data with the Joint Committee on Powder Diffraction Standards (JCPDS) database.

^{210}Pb activities were determined following a modification of the procedure of Robbins and Edgington (1975) and Carpenter et al. (1981, 1982). Sample digestion involved acid treatment of dried 2-3 g sediment samples spiked with a ^{209}Po tracer for chemical yield measurement. In the wet digestion, conc. HNO_3 , HClO_4 , and HCl in different proportion were employed sequentially. The final wet-digestion step was the dissolution of the residue in 0.3M HCl , followed by spontaneous plating on a silver disc. The ascorbic acid was added to prevent the metal iron from deposition on silver disc by reduction of Fe^{+3} to Fe^{+2} . ^{210}Po and ^{209}Po activity were finally recorded by high resolution alpha spectrometry system using 450 mm² surface barrier silicon detectors for a minimum of 24 hrs or the total count of the main peak was up to 1000 counts. This means that the counting error determined was less than 3%. The procedure was standardized and calibrated using the IAEA reference material, IAEA-SRM 300 and IAEA-SRM 368. Replicate analysis of the sample confirmed good agreement of ^{210}Pb isotope activities with certified value (% relative accuracy ~ 107.19) which is in the acceptable range (%RPD < 10).

To obtain information about the parent-supported (in-situ produced) ^{210}Pb , measurements of ^{226}Ra were performed on the same homogeneous portions of dried samples from each core used for ^{210}Po analysis. Aliquots of about 2 g were submitted to gamma ray spectrometry in a well type germanium detector (GWL-120230 ORTEC Instrument). Samples were put in a glass ampoule (10mm×30mm),

sealed, weighed and stored for 3 weeks waiting for ^{222}Rn to reach secular equilibrium with ^{226}Ra . The gamma spectrometer was calibrated for energy and efficiency through radionuclides (^{133}Ba , ^{152}Eu , ^{137}Cs and ^{60}Co) in the same geometry. The procedure was standardized and calibrated using the IAEA reference materials, IAEA-SRM-326 and IAEA-SRM-327.

RESULTS AND DISCUSSION

Table 1 reports the results obtained for all sediment analyzed. Physical properties such as the bulk density, porosity and organic matter, of soils and sediments influence their specific surface (area per mass, expressed in m^2/g), as 1% of organic matter in porous matrices may cause increase of the specific surface of about 7 m^2 (Kiehl, 1977 referred in Sabaris and Bonotto, 2011). Therefore, it is important to analyze such physical properties in order to evaluate their contributing to the adsorption of radionuclides here analyzed. The analyses revealed the sediments were mostly silt (60-94%), sand (up to 30%) and finally clay (2-8%). The moisture contents ranged from 33 to 75%, organic matters ranged from 7.12-13.53%, porosities ranged from 0.51-0.90, bulk densities ranged from 0.25-0.74 g/cm^3 , and particle densities ranged from 2.96-3.02 g/cm^3 . Fig.2 shows areal distributions of organic matters, sand, silt, and clay and mass and linear accumulation rates of sediment in Lam Phra Phloeng dam,

Table 1 Location, core length, particle density, porosity, surface mixed layer (SML), supported 210Pb, unsupported 210Pb activity and sedimentation rate of sediment cores of Lam Phra Phloeng Dam

Description	Site of cores							
	LPP1	LPP2	LPP3	LPP4	LPP5	LPP6	LPP7	LPP8
Location (UTM)	806596E 1615252N	805720E 1615002N	804651E 1614465N	804755E 1614352N	803532E 1613312N	802303E 1612011N	801151E 1609948N	800719E 1609300N
Core length (cm)	36	31	43	50	47	51	24	15
Particle density	3.01	3.01	2.96	3.02	3.01	2.96	3.01	2.96
porosity	0.82-0.90	0.61-0.90	0.70-0.90	0.75-0.88	0.72-0.90	0.71-0.89	0.64-0.89	0.51-0.72
Surface Mixed Layer	0	5	7	7	14	14	4	6
Supported 210Pb	7.02±1.16	9.10±1.38	5.05±0.67	5.23±0.71	4.96±0.76	8.04±1.05	7.01±0.94	7.23±0.95
Unsupported 210Pb activity	59.67±11.8 6 to	59.29±13.3 5 to 33.83±7.97	61.98±12.8 1 to 26.64±6.34	66.12±13.26t o 26.83±6.62	51.62±10.19t o 27.00±5.69	55.27±11.90t o 28.92±7.34	57.15±11.9 6 to 21.15±5.11	36.37±8.68t o 15.79±4.49
Sedimentatio n rate (CIC) ($\text{g}/\text{cm}^2/\text{yr}$)	0.26±0.03	0.24±0.02	0.50±0.09	0.33±0.03	0.61±0.15 and 0.62±0.14	1.02±0.20	0.87±0.17	0.21±0.06

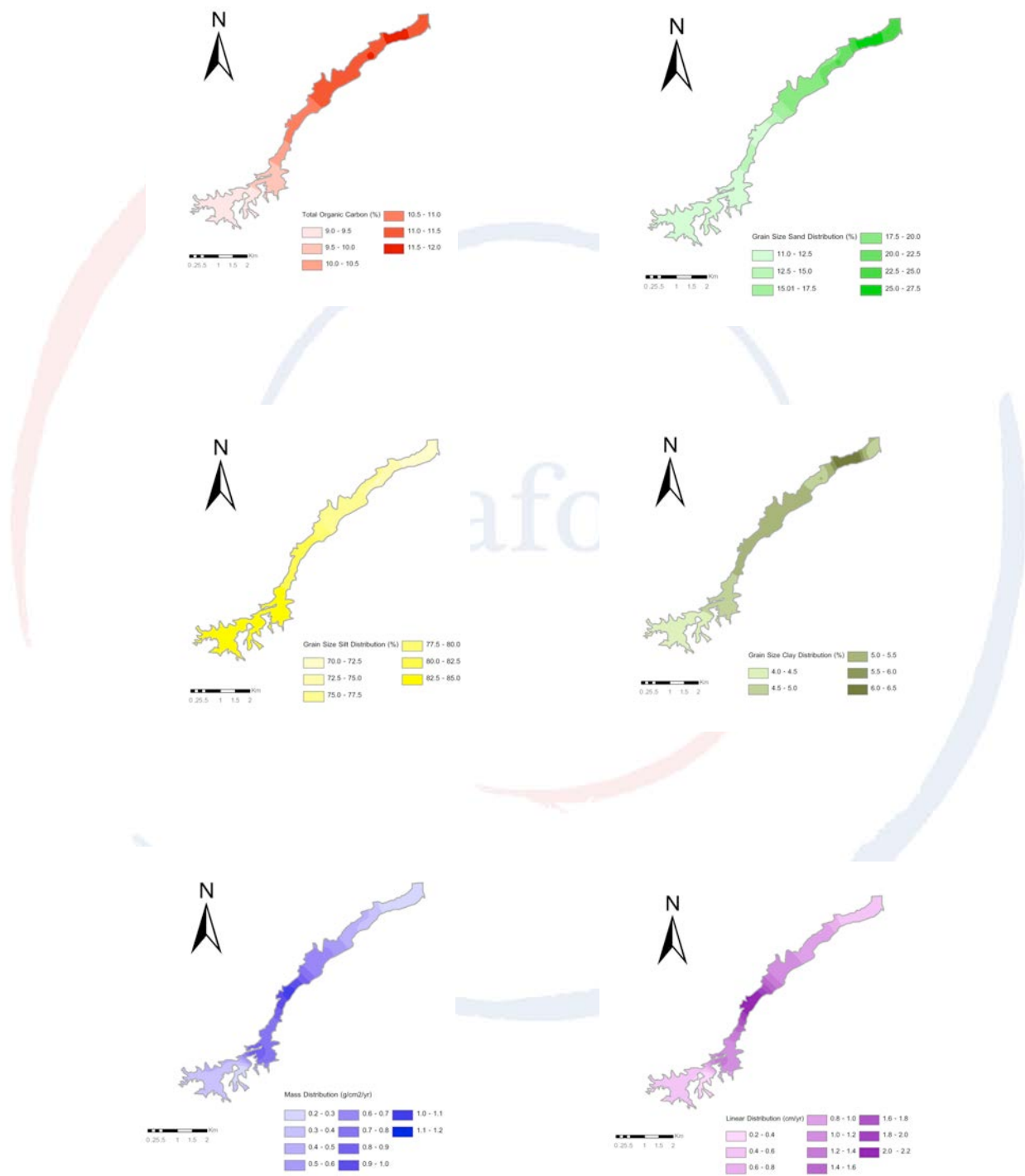


Fig. 2 Areal distribution of total organic carbon, sand, silt, and clay, mass and linear accumulation on a simplified map of the Lam Phra Phloeng Dam, Nakhon Ratchasima Province, Thailand. The highest mass accumulation rate corresponding to 1.02 g/cm²/yr was found at station LPP6, where the lowest accumulation rate corresponding to 0.21 g/cm²/yr was found at station LPP8.

XRD results showed the mineralogy included illite (KAl₂Si₃AlO₁₀(OH)₂), kaolinite (Al₂SiO₂O₅(OH)), covellite (CuS) and quartz (SiO₂) in all sample cores except LPP8 which its main mineralogy composed of just covellite and quartz. The composition of the sediment reflects the constituents of the rock in the study area that are dominated by minerals containing mainly Si and Al and minor amounts of K, S and Cu.

The total ²¹⁰Pb activities ranged from 23.02±4.49 to 71.35±13.26 Bq/kg. The supported ²¹⁰Pb analyzed by gamma-spectrometry ranged from 4.96±0.76 to 9.10±1.38 Bq/kg.

The sedimentation rate was evaluated by the CIC (Constant Initial Concentration) of unsupported ²¹⁰Pb model (Appleby and Oldsfield, 1978). Whereas the ln(unsupported ²¹⁰Pb) was plotted against the cumulative mass per unit area, the resulting ²¹⁰Pb profile will be linear with slope is $-\lambda_{210}/f$. λ_{210} is the radioactive constant for ²¹⁰Pb (0.0311 yr⁻¹). The sediment mass flux or deposition rate, f was determined from the mean slope of the profile using the least-square-fit procedure (Baskaran and Nandu, 1995).

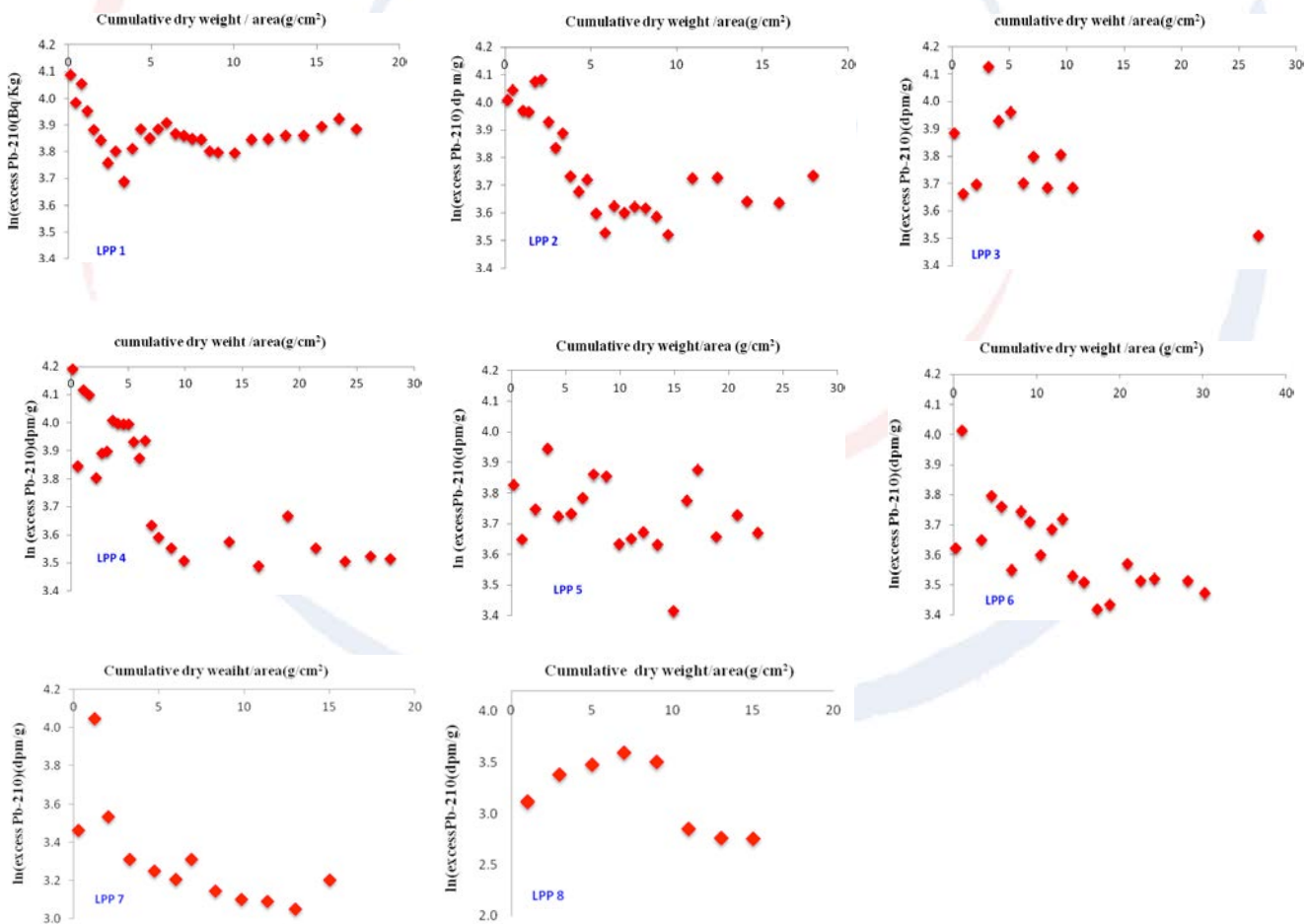


Fig. 3 Unsupported ²¹⁰Pb activities vs. cumulative dry mass relationships in the sediment cores collected at Lam Phra Phloeng crest dam basin, Nakhon Ratchasima Province, Thailand. The sediment mass accumulation rates allowed estimated linear

sedimentation rates; LPP1-0.55 cm/yr, LPP2-0.41 cm/yr, LPP3-0.79 cm/yr, LPP4-0.92 cm/yr, LPP5-1.03 cm/yr, LPP6-2.20 cm/yr, LPP7-1.27 cm/yr, LPP8-0.19 cm/yr.

In this study, the sediment mass fluxes were obtained by plotting the linear regression of natural log of unsupported ^{210}Pb activities against the cumulative dry weight per unit area for all individual cores (Fig. 3). The goodness of fit for all ages in determining the sedimentation rate was obtained from a least square regression lines. The least square best fit yield correlation coefficients statistically acceptable at $r^2 > 0.80$. The apparent sediment flux or deposition rate in Lam Phra Phloeng dam ranged from 0.21 to 1.02 g/cm²/yr.

The deposition time (in years) may be calculated by dividing the cumulative dry weight per unit area by the sediment mass accumulation rate. The average linear sedimentation rate (in cm/yr) can be evaluated by the division of the total thickness of the sediment cores by the deposition time at the deepest layer. The values estimated are: LPP1-0.55 cm/yr, LPP2-0.41 cm/yr, LPP3-0.79 cm/yr, LPP4-0.92 cm/yr, LPP5-1.03 cm/yr, LPP6-2.20 cm/yr, LPP7-1.27 cm/yr, and LPP8-0.19 cm/yr. They are relatively high when compare to our previous investigation at Bang Pakong and Chantaburi river estuary (0.46-0.69 cm/yr) (Cheevaporn and Mekkongpai, 1996), Lamtan and Sichang-Sriracha channel (0.14-0.21 cm/yr) (Srisuksawad and Rungsupa, 2002) and Pattani Bay (0.54-0.82 cm/yr) (Kaewtubtim, 2008) but comparable to 0.16-1.92 mm/yr in Atibaia River basin, Sao Paulo State, Brazil (Sabaris and Bonotto, 2011) and 0.87-3.10 mm/yr in Cordeaux reservoir, Sydney, Australia (Simms et al., 2008).

The major areas of sediment accumulating were LPP6 and LPP7 or about 3-5 km. far from the upper end of the dam. The high velocity water stream carried the sediments from the upper catchment into the dam. When it entered into the dam its velocity decreased gradually to the steady state and coarse sediment deposited. The water stream continued to lose its velocity and transport finer particles slowly and finally deposited it near the crest of the dam.

Table 2 Sediment accumulation per year calculated for sub-area of reservoir

Description	Area (X 10 ¹⁰ cm ²)	Sedimentation rate (g/cm ² /yr)	Average Bulk Density (g/cm ³)	Sediment accumulation (X10 ⁴ tons/yr)	Percent of total
LPP1	0.5	0.26	0.37	0.130	2.367
LPP2	0.8	0.24	0.42	0.192	3.497
LPP3	0.55	0.50	0.44	0.275	5.008
LPP4	0.57	0.33	0.41	0.188	3.424
LPP5	2.3	0.61	0.43	1.403	25.555
LPP6	1.3	1.02	0.44	1.326	24.149
LPP7	1.5	0.87	0.48	1.305	23.766
LPP8	3.2	0.21	0.65	0.672	12.238
Total	10.72			5.491	100

Lam Phra Phloeng dam has its water receiver area of $1.072 \times 10^{12} \text{ cm}^2$, if divided into 8 sub-areas according to the sampling point. The sediment deposition in each area can be calculated and showed in Table 2.

The total sediment deposition in the dam is 5.491×10^4 tons/year compatible to rate of erosion of 2.27 mm/year correlated with the result from previous investigation done by the Royal Irrigation Department. More than 80% of sediment was deposited in the area between LPP5-LPP8 and more than 50% was deposited in the area between LPP5-LPP6. The study results will be benefit for efficient dredging planning of the dam.

CONCLUSIONS

Eight sediment profiles were sampled at the Lam Phra Phloeng crest dam, in order to determine sedimentation rates by the ^{210}Pb method. Aliquots were separated from sections of each core for determining the mineralogy or crystal structure (by XRD), total organic matter (by ignition loss), particle size (by optical diffractometry method) and radionuclides. Alpha spectrometry was used to determine the ^{210}Pb activities (total ^{210}Pb) in each segment from the sediment profiles. The supported ^{210}Pb was evaluated by the equivalent uranium (^{226}Ra) through gamma spectrometry, whereas the excess ^{210}Pb was determined by the difference between total ^{210}Pb and supported ^{210}Pb activities. The results found in the sediment profiles revealed the sediments were mostly silt (60-94%), sand (up to 30%) and clay (2-8%). The moisture contents ranged from 33 to 75%, organic matters ranged from 7.12 to 13.53%, porosities ranged from 0.51 to 0.90, bulk densities ranged from 0.25 to 0.74 g/cm^3 , and particle densities ranged from 2.96 to 3.02 g/cm^3 . XRD results showed in all sample cores, except LPP8, the main mineralogy composed of illite, kaolinite, covellite and quartz whereas for LPP8 the main mineralogy was only covellite and quartz. This reflects Si and Al are the main constituents of the rock in the study area whereas K, S, and Cu are the minors. The sedimentation rates ranged from 0.21 to 1.02 $\text{mg/cm}^2/\text{yr}$ (0.19 to 2.20 cm/yr); the highest values were found within 3-5 km. radius from the upper end of the dam, whereas the lowest one were at the upper most and lower end or at the crest of the dam.

REFERENCES

- Appleby P.G., Oldsfield F. (1978) The calculation of dates assuming a constant rate of supply of unsupported ^{210}Pb to the sediment. *Catena* 5, pp. 1-8.
- Appleby P.G., Oldsfield F. (1992) Application of lead-210 to sedimentation studies. In: Ivanovich M and Harmon R.S. (eds) Uranium-series disequilibrium. Applications to Earth, Marine and Environmental Sciences, Oxford Science Publications, pp. 731-778.
- Baskaran M., Nandu A.S. (1995) ^{210}Pb -derived chronology and the fluxes of ^{210}Pb and ^{137}Cs isotopes into continental shelf sediments, East Chukchi Sea, Alaskan Artic. *Geochimica et Cosmochimica Acta* 59(21), pp. 4435-4448.
- Bonotto D.M., Lima J.L.N. (2006) ^{210}Pb -derived chronology in sediment cores evidencing the anthropogenic occupation history at Corumbatai River basin, Brazil. *Environmental Geology* 50(4), pp. 931-940.
- Brugam R.B. (1978) Pollen indicators of land-use change in Southern Connecticut. *Quaternary Research* 9, pp. 349-362.
- Buurman P., Pape Th., Muggler C.C. (1997) Laser grain-size determination in soil genetic studies 1: practical problems. *Soil Science* 162, pp. 211-218.
- Carpenter R., Bennett J.T., Peterson M.L. (1981) ^{210}Pb activities in and fluxes to sediments of the Washington continental shelf and slope. *Geochimica et Cosmochimica Acta* 45, pp. 1155-1172.

- Carpenter R., Peterson M.L., Bennett J.T. (1982) ^{210}Pb -derived sediment accumulation and mixing rates for the Washington continental slope, *Marine Geology* 48, pp. 135-164.
- Cheevaporn V., Mookongpai P. (1996) Pb-210 radiometric dating of estuarine sediments from the Eastern coast of Thailand. *Journal of Science Society of Thailand* 22, pp. 313-324.
- Dean W.E. (1974) Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: Comparison with other methods. *Journal of Sedimentary Research* 44, pp. 242-248.
- Huang C.C., Wang K., Bodily D.M., Hucka V.J. (1995) Density measurement of Argonne premium coal samples. *Energy Fuels* 9, pp. 20-24.
- Kaewtubtim P. (2008) Determination of recent sedimentation rates in Pattani Bay by Cs-137 dating techniques. In: *Proceeding of the Kasetsart University Annual Conference, January 29-February 1, Bangkok, Thailand*, pp. 201-207.
- Oldsfield F., Appleby P.G. (1984) The role of ^{210}Pb dating in sediment based erosion studies. In: *Drainage Basin Erosion and sedimentation –A conference on Erosion, Transportation and Sedimentation in Australian Drainage Basins, May, Newcastle, NSW*, pp. 175-182.
- Olley J.M., Caitcheon G.G., Hancock G., Wallbrink P.J. (2001) *Tracing and Dating for Sediment and Associated Substances*, CSIRO Land and Water, Canberra.
- Pape Th. (1996) Sample preparation for grain-size determination by laser diffraction In: Buurman P, Van Lagen B., Velthorst E.J. (eds) *Manual for soil and water analysis*, Backhuys Publishers(Leiden), pp. 287-290.
- Robbins J.A., Edgington D.N. (1975) Determination of recent sedimentation rates in Lake Michigan using Pb-210 and Cs-137. *Geochimica Cosmochimica Acta* 39, pp. 285-304.
- Sabaris T.P.P., Bonotto D.M. (2011) Sedimentation rates in Atibaia River basin, Sao Paulo State, Brazil, using ^{210}Pb as a geochronometer. *Applied Radiation and Isotopes* 69, pp. 275-288.
- Simms A.D., Woodroffe C., Jones B.G., Heijnis H., Mann R.A., Harrison J. (2008) Use of ^{210}Pb and ^{137}Cs to simultaneously constrain ages and source of post-dam sediments in the Cordeaux, Sydney, Australia. *Journal of Environmental Radioactivity* 90, pp. 1111-1120.
- Srisuksawad K., Rungsupa S. (2002) Sedimentation rates and cyst studies in sediment cores from the Eastern coast of Thailand In: *Proceeding of the IAEA/RCA Regional Technical Workshop on Radiometric Dating/Cysts Analysis Techniques and Receptor Binding Assay for Harmful Algal Blooms Management, January 7-10, Chonburi, Thailand*, pp. 95-107.
- Wasson R.J., Clark R.L., Nanniga P.M., Waters J. (1987) ^{210}Pb as a chronometer and tracer, Burrinjuck Reservoir, Australia. *Earth Surface Processes and Landforms* 12(4), pp. 399-414.

Green Architecture and Environmental Design using Rapid-Prototyping Social-Networking Sandbox Tools, followed by Professional Architectural Software

Joseph Thomas Wunderlich, Joseph John Wunderlich

Elizabethtown College, USA

0223

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

In 2012 the United Nations UN-Habitat's Sustainable Urban Development Network partnered with sandbox-game developers of the social-networking block-by-block building software Minecraft to upgrade 300 public spaces worldwide by 2016 by joining professional designers with local inhabitants in virtual-world simulations. This work is similar to the authors' research since early 2011 where a Minecraft server and concurrent database server were configured for peaceful architectural development by players worldwide, and in five college engineering and architectural courses. Students build green homes, plant gardens, and raise livestock in green villages, or on a virtual college campus within environments containing simulated weather, terrains, biomes, and AI-enhanced animals. Student avatars interact to design. Social-media scrolls across the screen so everybody can be heard. Student homes have active & passive solar, thermal mass, natural daylighting, mitigation of cold northern winds, and an overall architectural esthetic. Students create gardens, livestock areas, piazza's, markets, parks, and a wellness center with indoor pool and activity rooms. Credit is given for using the software's electrical, mechanical, and logic design features. Selected students are invited to develop professional architectural drawings. LEED (Leadership in Energy and Environmental Design) concepts are incorporated throughout. Future goals included implementing these methods in new architectural studio courses and at universities abroad; helping extend the UN/Minecraft concept to developed countries; and merging this research with the author's research in robotics & machine intelligence including interactive environmental maps communicating with real-time robots. Long-term goals include on-line virtual-reality classrooms and laboratories with real-time language translation and lifelike avatars.

I. Introduction

The conceptual design phase of architectural and urban design projects should be rapid, with minimal constraints. Only main concepts and architectural elements should be explored so that a maximum number of design variations and decisions can be made. Figure 1 (and YouTube video: <http://www.youtube.com/watch?v=6IuSOSjbJEE&feature=plcp>) show a rendition of Frank Lloyd Wright’s Robie House created in a few hours by Joseph John Wunderlich in 2011. Only simple images of the existing building [1] were viewed before the rendition was made using Minecraft, a sandbox game for building with the block primitives shown in figure 2 [2] (some of the original primitives, many more have been added). As of January 22, 2013, over 20 million copies of Minecraft have been sold across all platforms [3]. The United Nations began using Minecraft in 2012 for sustainable design of 300 sites worldwide; The U.N., architects, and planners use this multi-user, social-networking tool to allow the inhabitants of each site to become part of the design process [4].



Figure 1. Rendition of Frank Lloyd Wright’s Robie House by Joseph John Wunderlich in 2011 (created in a few hours).



Figure 2. Minecraft block primitives [2].

II. Minecraft vs. Traditional Foam-Board Conceptual Design

The use of Minecraft for conceptual design can be much faster than traditional foam-board as shown in figures 3, 4, and 5 (including Minecraft models by Joseph John Wunderlich in 2013).



Figure 3. Structure before new architecture (*digging started in Photo #2*), and foam-board model (2000).



Figure 4. Foam-board models for the Wunderlich residence renovation (several weeks of work).



Figure 4. Built architecture, and rapidly-created virtual models (façade created in minutes in 2013).

III. Rapid Prototyping of Cities

The speed of designing and building in Minecraft can enhance the relationships between buildings, plaza's, landmarks, pathways, and districts while improving the adherence to a common design style. The images in figure 5 show some of the 30+ buildings and gathering spaces built off-line by Joseph John Wunderlich in his “Joseph’s Kingdom” in 2011.

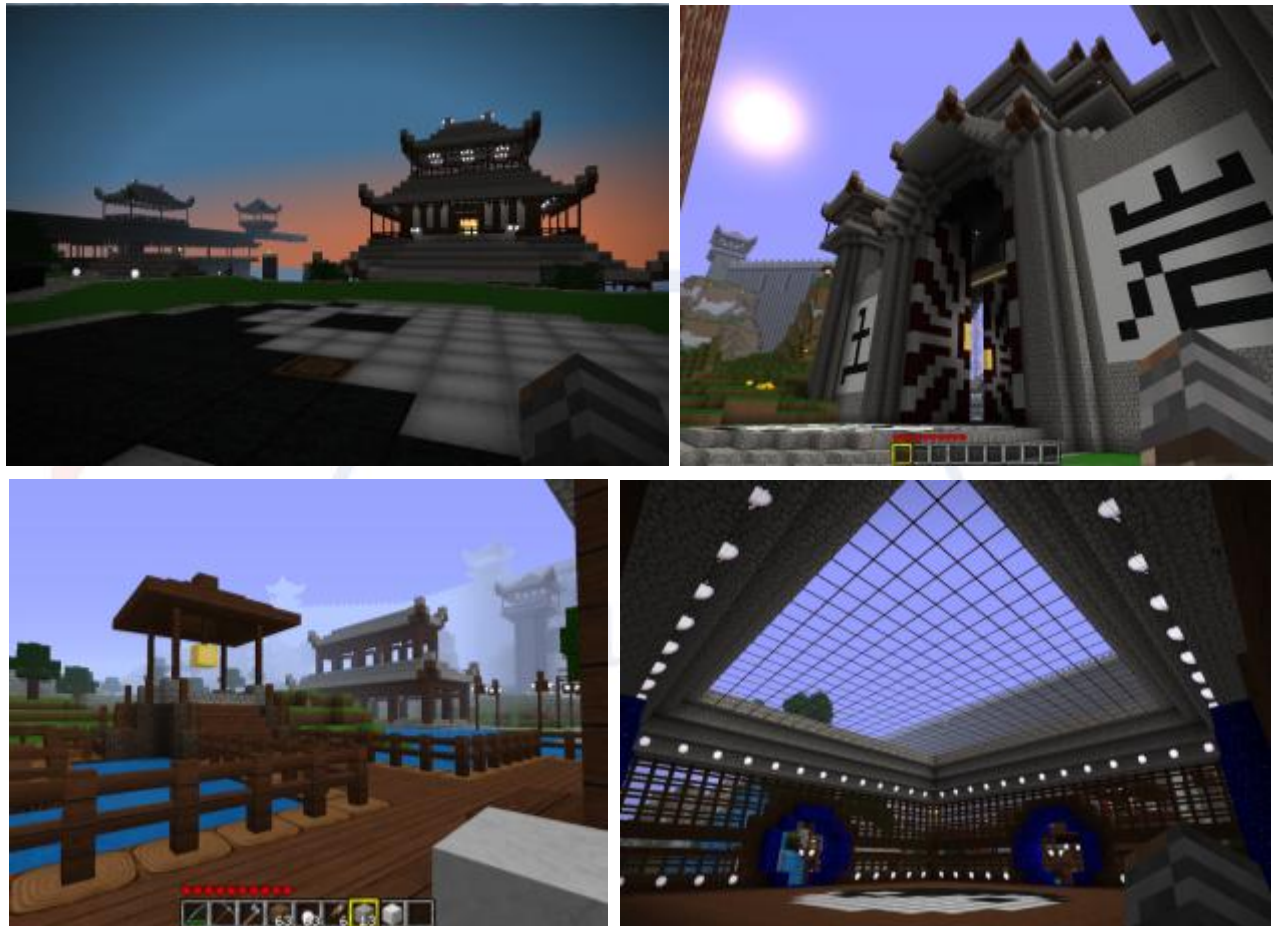


Figure 5. Rapidly-prototyped 30+ buildings in “Joseph’s Kingdom” (created in a few weeks in 2011)

IV. Rapid Prototyping of Networked International Communities

Minecraft can also allow participants from around the world to create virtual civilizations; with governments, monetary systems, socio-economic hierarchies, and laws. The images in figures 6, 7 and 8 show some of the first (of hundreds) of buildings and gathering spaces built by Joseph John Wunderlich in 2011 in “Tsojin,” our multi-world multiuser Minecraft server developed for players from around the world to create architecture, urban design, and civilizations in a peaceful setting. See YouTube Video: <http://www.youtube.com/watch?v=Y1r1dL007YA>



Figure 6. Town-center of our “Tsojin” server.

The original server organized a few of the most dedicated young designers from, who had worked together on less peaceful servers, to help administrate Tsojin: Joseph (USA), Eve (Canada), and Cameron (England). Dr. Wunderlich hosted the server on one of his computers and Joseph John designed a player-ranking system to allow incremental use of more powerful commands as players gain skills and trust. Dr. Wunderlich also configured a concurrently running database server to log all activity and allow administrators to undo damage by players (as shown in figure 7). He also implemented foul - language censorship, and disabled features such as fire-spread, placing lava, and TNT. Figure 9 shows part of the new Tsojin to be released in 2013.



Figure 7. A concurrent database server allows rollback of “griefing” so architecture and civilizations can be created in a peaceful setting.



Figure 8. Several hundred buildings have been created by Joseph John Wunderlich (avatar shown) in Tsojin and on other servers between 2011 and 2013. VIDEO: <http://www.youtube.com/watch?v=Y1r1dL007YA>



Figure 9. New Tsojin server to be released in 2013

To create a more powerful server, a third-party “Bukkit” server mod “CRAFTBUKKIT” [5] is used to allow the following features:

- 1) Player ranking; Ours was designed by Joseph John Wunderlich in 2011 with six ranks: *Guest, Builder, Architect, Master, Admin, and Grandmaster* -- each having many accumulated commands. Bukkit plug-ins “ESSENTIALS,” “PERMISSIONS,” “CHAT,” and “GROUPMANAGER” were configured.
- 2) Concurrently running SQL database server [6] and plug-in “LOGBLOCK” configured with many tables for logging player activity to allow rolling-back of “griefing” (destruction or construction by un-invited or misbehaving players). The initial release of Tsojin was public with no restrictions on who could play. Unfortunately, due to griefing (including organized griefing teams) Tsojin was made private (with a “whitelist” of users vetted by us and trusted high-ranking players).
- 3) Multi-world plug-in to allow running many concurrent worlds (and teleportation & gateways between them). Tsojin has six worlds: the main world, two private worlds, “DigitalDesignWorld” (shown in Figure 10), “FYSworld” for College freshman to build Green towns, and a survival world where all materials (and food) must be hunted or gathered (including mining) and tools and other materials are crafted as shown in figure 11.
- 4) Many other plug-ins (foul-language censorship, establishing monetary systems, allowing aircraft and vehicles to move, locking tool chests, sign-posting, etc.).

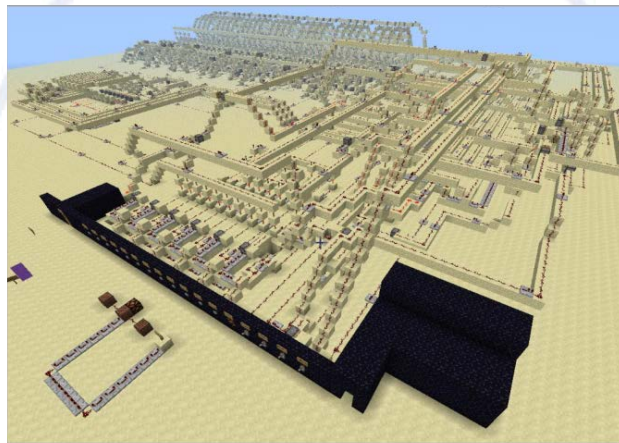


Figure 10. Tsojin “DigitalDesignWorld”– combination lock by student Tom Gorko

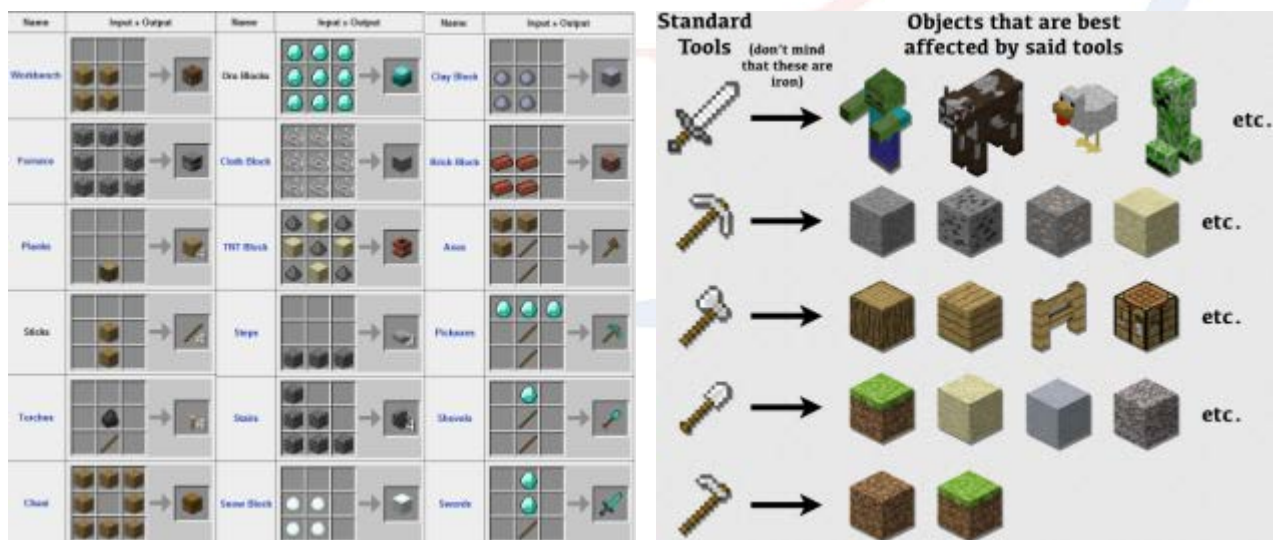


Figure 11. In Tsojin server “survival world” all materials (and food) must be hunted or gathered (including mining); and tools and other materials are crafted (*initial hunting and gathering is with no tools*).

V. Rapid Prototyping of College Campus Architecture

Minecraft can be used as an educational tool in Colleges and Universities. In 2012, classes of college students performed school assignments on Tsojin and on a sister-server hosted by Ricky Sturz, an EGR280 Engineering Research student of Dr. Wunderlich. The first initiative was to have 16 freshmen construct a facsimile of the Elizabethton College Hackman Apartments on the Sturz server running on a third-party secure computer in New York City, with added capacity to handle 40 players simultaneously (funded by Dr. Wunderlich). Four designated team leaders, who had developed skills on Tsojin during the summer before their Freshman year, set standards for the team-build, They also toured the actual buildings before the event. EGR280 Engineering Research student Ricky Sturz defined the footprint of the buildings. The results of this small-scale crowdsourcing activity can be seen in figure 12 and in the following YouTube video: <http://www.youtube.com/watch?v=CNzKo3etfSU&feature=plcp> -- plus more on Dr. Wunderlich's YouTube channel: http://www.youtube.com/channel/UC_kM_k93zrelu40CVwuHQzg?feature=watch

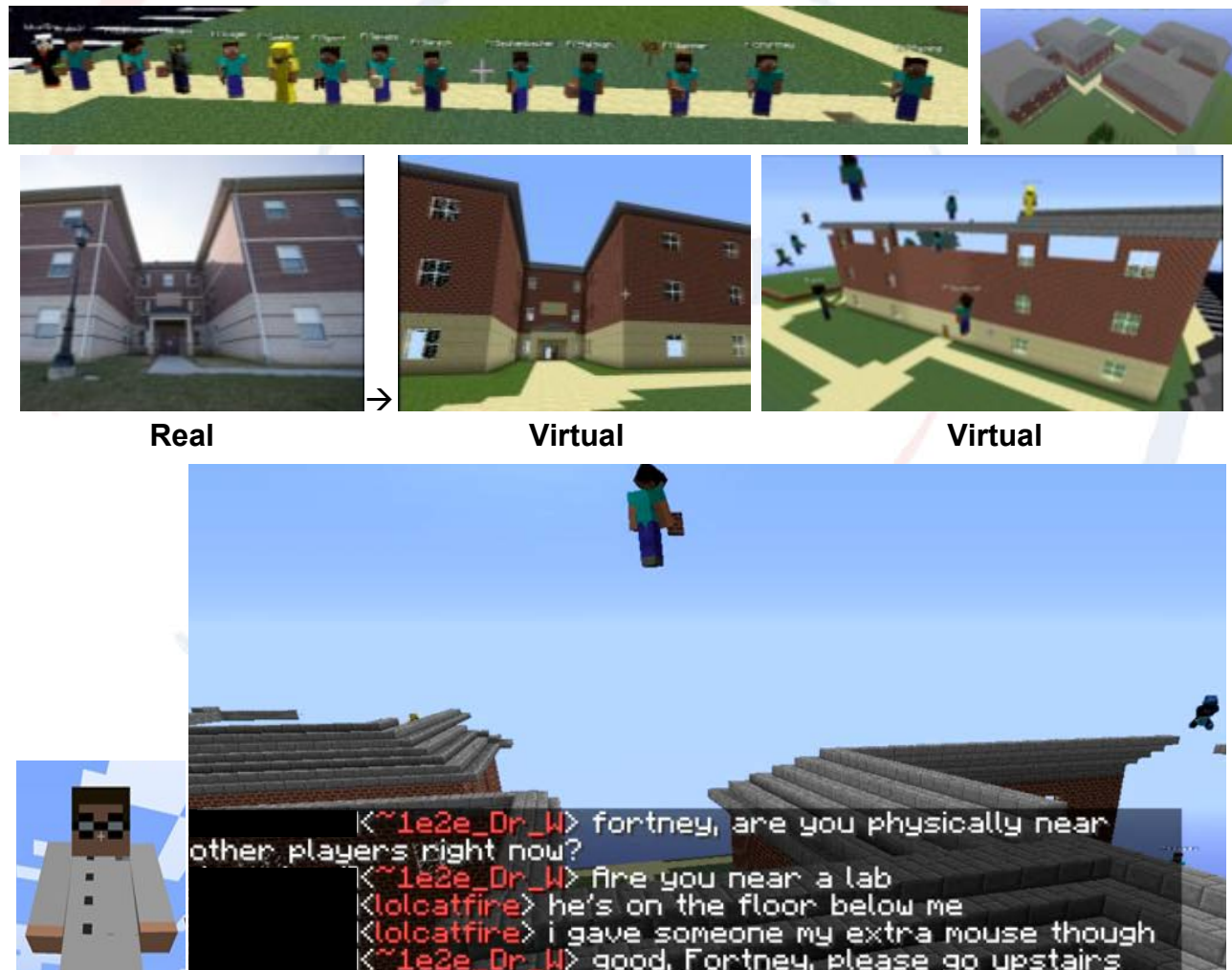


Figure 12. Model of Elizabethton College Hackman apartments built BLOCK by BLOCK in two hours by Dr. Wunderlich's 16 students in course "Scientific Modeling for Sport" demonstrates emerging student research in small-scale crowdsourcing. **VIDEO:** <http://www.youtube.com/watch?v=CNzKo3etfSU&feature=plcp>
(Dr. Wunderlich's avatar shown on left)

Another college project was a team-build of Elizabethtown College's Masters Center for Science, Math, and Engineering; with participation from students in five courses (and results shown in figure 13):

Dr. Wunderlich's [EGR280 Engineering Research](#) student Ricky Sturz

Dr. Michael Silberstein's Cognitive Science Course (12 students)

Dr. Wunderlich's First Year Seminar [Scientific Modeling for Sport](#) (16 students, 2 TA's)

Dr. Wunderlich's [EGR332 Computer Organization & Architecture](#) course (16 students)

Dr. Wunderlich's [EGR343 Green Architectural Engineering](#) course (7 students)



Figure 13. Elizabethtown College's Masters Center built BLOCK by BLOCK in 3 hours by students from five courses (footprint and partial facade established in advance by student Ricky Sturz).

VI. Rapid Prototyping of Green Communities

The semester project in 2012 [Scientific Moderling for Sport course](#) was: *“Individual Green Home Architectural Builds, and Community-Development Environmental-Planning”*

This assignment (with selected results shown in figures 14, 15, and 16) was defined as:

Build a Green home in Tsojin FYSworld in your designated village (one of four Green towns). Assume you're in a southeastern Pennsylvania climate. Your grade will be based on:

PASSIVE SOLAR: Without use of electrical or mechanical devices, let light into house to warm it in winter, but not overheat it in summer. Remember that the sun rises in the East, sets in the West, tracks across the sky at high angles during hot months, and at low angles during cold months. Since Minecraft doesn't yet have variable sun paths, just be aware of which direction is South – figure it out from the trajectory of the sun. Create overhangs on roofs to strategically shade windows (estimate dimensions), and note that too many west-facing windows may cause overheating. Also, have sun shine on interior thermal mass's to absorb heat during the day and release it at night. Assume thick masonry works very well, and water works even better but may be more difficult to implement (and maintain).

ACTIVE SOLAR: Simulate solar panels using a black material and place them on your house and around your site to maximize energy generation while not disrupting movement of people & animals. Creatively angle them towards the sun.

NATURAL DAYLIGHTING: Maximize entrance of sunlight into your house while not overheating the house in summer.

MITIGATE COLD NORTHERN WIND: Through site selection, placing of dirt & grass, and design of your building's northern elevation (including wall thickness and materials chosen), shield the house from cold Northern winds; but consider letting some light in for natural daylighting and preserving views.

COMMUNITY GARDEN: Help create a large community garden of eatable plants -- till/hoe ground; place water (in adjacent trenches) with water bucket. Plant carrots, potatoes, seeds, etc, and fertilize everything with bone meal.

COMMUNITY LIVESTOCK: Help create animal pens & shelters; and spawn many animals for meat and producing milk.

OVERALL ARCHITECTURAL ESTHETIC: House should not only be the ultimate sustainable habitat, but also must be livable and have a high-quality architectural esthetic on the interior and exterior -- so balance all criteria above while creating beautiful architecture. Your architecture should also be complimentary to all else in your village.

URBAN DESIGN and CITY PLANNING: Help create common-areas including piazza's, a central market, a central park, etc., -- and designate a large lot to be used by visiting high-school students to build a Wellness Center in your town (with indoor pool, large activity room, and lockers).

EXTRA CREDIT: Make something electromechanical, and operate it with circuits and logic gates.

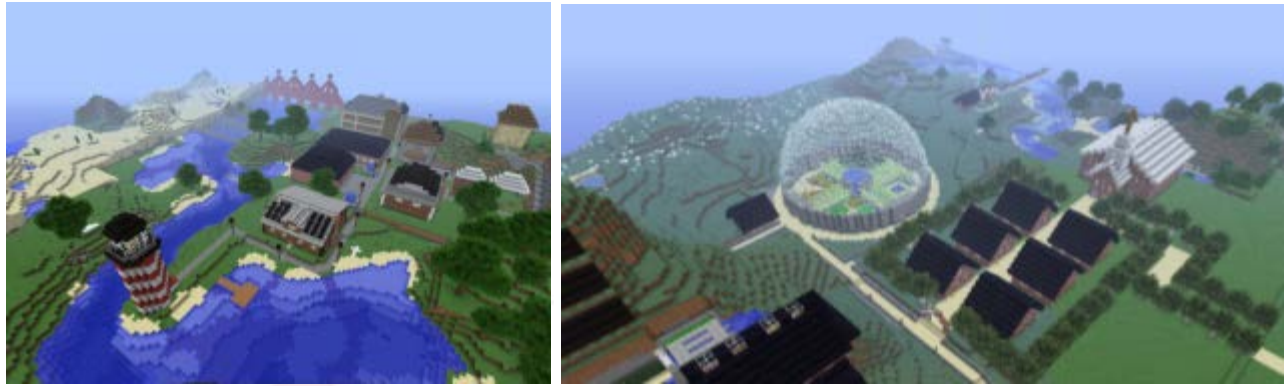


Figure 14. Two of the four Green towns in Tsojin FYSworld, including one with a bio-dome.

VIDEO: <http://www.youtube.com/watch?v=HdCfW0tkWkc> and <http://www.youtube.com/watch?v=NDOyiYJHpm>



Figure 15. Community gardens and livestock required in all Green towns.

VIDEO: <http://www.youtube.com/watch?v=HdCfW0tkWkc>, <http://www.youtube.com/watch?v=NDOyiYJHpm> and <http://www.youtube.com/watch?v=Zh456JQxFJO>



Figure 16. Active & passive solar, maximum natural daylighting, and thermal mass in Green towns

VIDEO: <http://www.youtube.com/watch?v=HdCfW0tkWkc>

VII. Rapid Architectural Prototyping for Recruiting College Students

In 2012 Dr. Wunderlich organized a recruiting event as part of the college's Engineering & Physics Department-Day. Twenty-four visiting high school students built in Green towns in Tsojin FYSworld. In only one hour, each team of four built a Wellness Center in a town – with pool, activity room, and locker rooms. Figure 17 shows the winning designs judged from entries by all six competing teams.

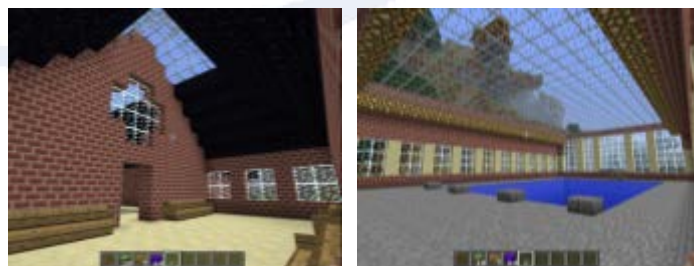


Figure 17. Best activity room and pools built in one hour by competing visiting high school student teams.

VIII. Professional Architectural Software after Rapid-Prototyping

The complexity and effort needed to create “Working Drawings” and detailed construction specifications to build a building requires professional architectural software after the initial conceptual design phase is completed using rapid prototyping. In 2006, student Bryan Kuppe in one of Dr. Wunderlich’s [EGR280 Engineering Research](#) courses developed with “Rhinceros” and “Flamingo” software detailed renderings for the new Elizabethtown College Steinman Building Lobby Renovations as shown in figure 18, and in 2008, in another Wunderlich [EGR280](#), developed renderings for the Robotics and Machine Intelligence Lab shown in figure 19. These drawings helped both these spaces become a reality. In 2012 and 2013 Revit software is being used by students in Wunderlich’s [EGR280](#)’s and [EGR343 Green Architectural Engineering](#) courses as shown in figure’s 20 and 21 with the accomplishments of students Emily Vogel and Kaylee Werner.



Figure 18. 2006 student Bryan Kuppe used “Rhinceros” and “Flamingo” software for Elizabethtown College Steinman Building Lobby Renovations.



Figure 19. 2008 student Bryan Kuppe used “Rhinceros” and “Flamingo” software for Elizabethtown College’s new Robotics and Machine Intelligence Lab.



Figure 20. 2012 student Emily Vogel used Revit software for LEED redevelopment of her family’s New Jersey shore vacation property destroyed in 2012 by hurricane Sandy.



Figure 21. 2013 student Kaylee Werner used Revit software for proposed Engineering & Physics department shop extension (“Fabrication Lab”)

IX. Prototyping to Promote Building New Field-House/Wellness-Center

In only one semester in 2012 Dr. Wunderlich's [EGR280 Engineering Research](#) student Ricky Sturz modeled the entire Elizabethtown College campus using Minecraft, then proposed a Field-House/Wellness-Center; Ricky has now begun using the professional architectural software Revit to continue this work. Images for some of these buildings are shown in Figure 22 and on YouTube: <http://www.youtube.com/watch?v=YS38Cki7hck&feature=plcp>. Previously, in 2009, student Bryan Kuppe in one of Dr. Wunderlich's [EGR280 Engineering Research](#) courses developed with "RhinoCeros" and "Flamingo" software proposed enhancements to the present Elizabethtown College athletic facilities as shown in figure 23. This work, although much more detailed than if done in Minecraft, required the entire semester to complete. Both the 2009 and 2012 prototyping initiatives hopefully contributed to the recent decision by the Elizabethtown College trustees to vote yes on spending many millions of dollars to build a large Field-House/Wellness-Center.

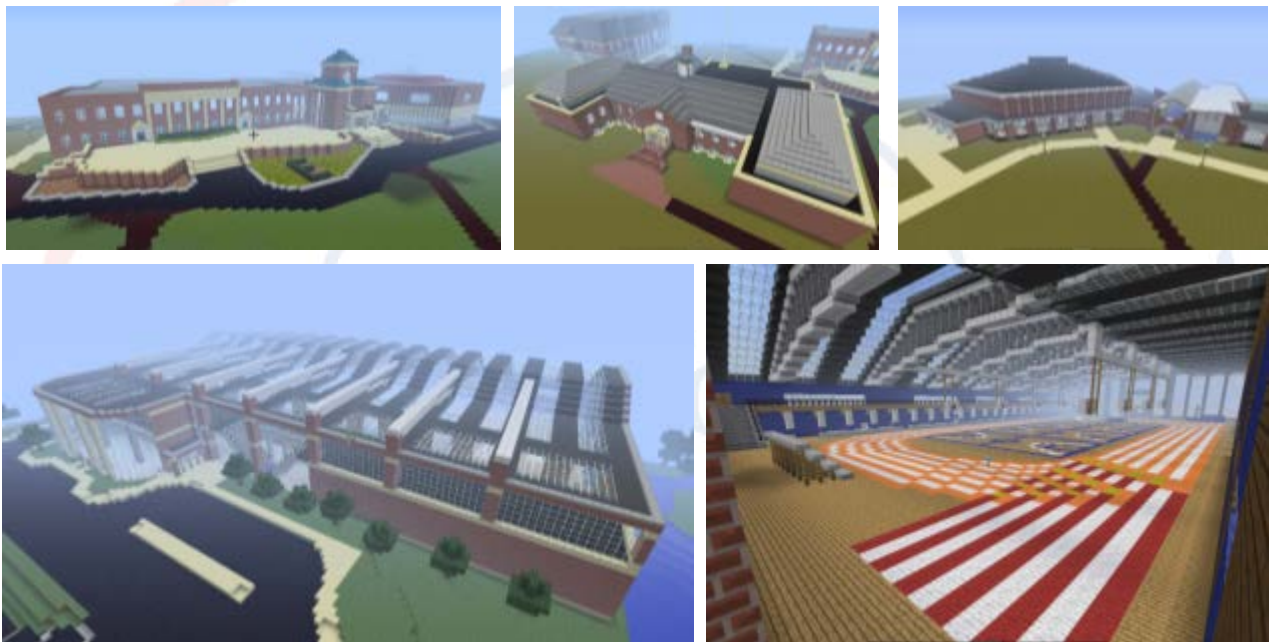


Figure 22. 2012 student Ricky Sturz modeled entire campus in only one semester using Minecraft, including his proposed Field-House/Wellness-Center that he's now using Revit software on.

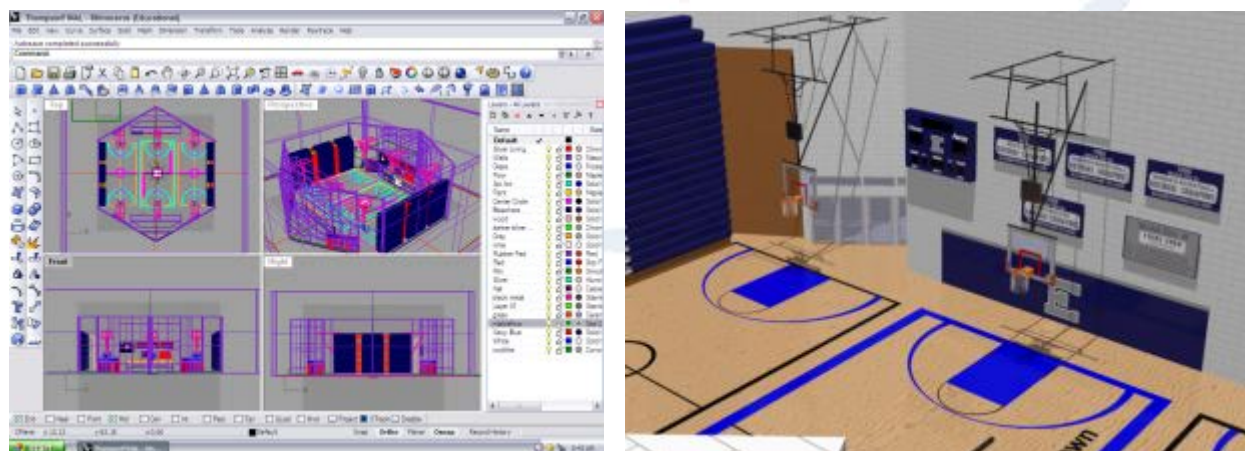


Figure 23. In 2009 student Bryan Kuppe used "RhinoCeros" and "Flamingo" software for proposed enhancements to the present athletic facilities. This work required the entire semester to complete.

X. Green Standards for Architecture and Environmental Design

Although many countries have federal laws for maintaining very high green standards in architecture and environmental design throughout their country, the United States has a spectrum of laws that vary by state, county, township, city, and changing political tides; however the LEED standard (Leadership in Energy and Environmental Design) is becoming increasingly accepted throughout the U.S., and is followed on an increasing number of international projects. The project shown in figure 24 was designed to LEED standards by student Vaclav Hasik in Dr. Wunderlich's [Green Architectural Engineering course](#). Figure 25 and 26 shows LEED analysis of the Wunderlich project "*WUNDERessin EAST*" which will likely soon become a new laboratory for students.

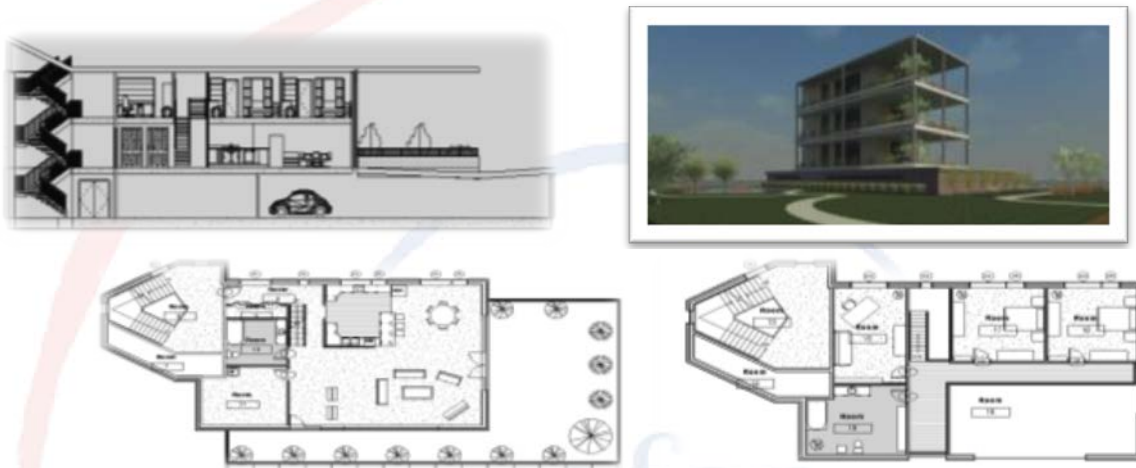


Figure 24. 2012 student Vaclav Hasik used Revit software for LEED redevelopment of a Philadelphia, Pennsylvania city block.

XI. Future Work

Future goals include implementing these methods in new architectural studio courses required for the new Architectural Studies Minor and possibly at two universities in Italy; helping extend the UN/Minecraft concept to developed countries; merging this research with the author's research in robotics & machine intelligence including interactive environmental maps communicating with real-time robots; and possibly expanding research into an additional lab at *WUNDERessin EAST* shown in figure 25. The College's varied related initiatives shown in the appendix could lead to many new collaborations. Long-term goals include teaching a related Massive Open Online Course (MOOC), and creating on-line full-immersion virtual-reality classrooms and laboratories with real-time language translation and lifelike avatars.



Figure 25. Wunderlich project *WUNDERessin EAST* barn likely to become lab space for students.

LEED-NC v3.0 (2009) Preliminary Project Checklist				16-Oct-12
"WUNDERessin EAST" (J. Wunderlich Residence/Farmette, possible future Bed & Breakfast)				Preliminary Review Only - Subject to Change
Near Elizabethtown College, Pennsylvania				
Yes ?	No			
11		Sustainable Sites	26 Points	
Y		Prereq 1 Construction Activity Pollution Prevention	Required	
1		Credit 1 Site Selection	1	UNOBSTRUCTED SOUTHERN EXPOSURE, SHIELDED NORTHRN, A+ VIEWS
5		Credit 2 Development Density & Community Connectivity	5	COMPLIMENTS/PRESERVES FARM COMMUNITY ESTHETIC AND CULTURE
	N	Credit 3 Brownfield Redevelopment	1	not applicable, BUT RESTORATION OF 150-YEAR OLD STRUCTURES
	N	Credit 4 Alternative Transportation, Public Transportation Access	6	not applicable IN FARMING COMMUNITY
1		Credit 4 Alternative Transportation, Bicycle Storage & Changing Rooms	1	BIKES FOR EVERY FAMILY MEMBER
	N	Credit 4 Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicle	3	NOT YET -- PLANNING HYBRID VEHICLE PURCHASE
	N	Credit 4 Alternative Transportation, Parking Capacity	2	not applicable IN FARMING COMMUNITY
1		Credit 5 Site Development, Protect or Restore Habitat	1	212 TREES PLANTED, FENCED-IN WILDLIFE, BIRD SANCTUARY CREATED
1		Credit 5 Site Development, Maximize Open Space	1	EXTENSIVE -- 3-1/2 Acres
1		Credit 6 Stormwater Design, Quantity Control	1	FRENCH DRAINS AROUND NEW CONSTRUCTION
	N	Credit 6 Stormwater Design, Quality Control	1	GREY-WATER SYSTEM BEING CONSIDERED
	N	Credit 7 Heat Island Effect, Non-Roof	1	not applicable IN FARMING COMMUNITY
	N	Credit 7 Heat Island Effect, Roof	1	not applicable IN FARMING COMMUNITY
1		Credit 8 Light Pollution Reduction	1	RECYCLE ALL PLASTIC AND PAPER, DONATE CLOTHES, ETC. TO POOR
3		Water Efficiency	10 Points	Notes
Y		Prereq 1 Water Use Reduction, 20% Reduction	Required	
1		Credit 1 Water Efficient Landscaping	2 to 4	MINIMAL IRRIGATION FOR TREES AND 3 TO 4 GARDENS PER YEAR
1		Credit 2 Innovative Wastewater Technologies	2	NEW DRAINFIELD
1		Credit 3 Water Use Reduction	2 to 4	LOW-PRESSURE WELL; DISHES: HAND-WASH + ENERGY-EFF DISHWSHR
7		Energy & Atmosphere	35 Points	Notes
Y		Prereq 1 Fundamental Commissioning of the Building Energy Systems	Required	
Y		Prereq 2 Minimum Energy Performance	Required	
Y		Prereq 3 Fundamental Refrigerant Management	Required	
6		Credit 1 Optimize Energy Performance	1 to 19	OIL + ELECTRIC ZONES WITH ARTIFICIAL INTELLIGENCE COMING
1		Credit 2 On-Site Renewable Energy	1 to 7	ACTIVE SOLAR, GROUND WATER LOOP, & WIND BEING CONSIDERED
	N	Credit 3 Enhanced Commissioning	2	not yet
	N	Credit 4 Enhanced Refrigerant Management	2	not yet
	N	Credit 5 Measurement & Verification	3	not yet
	N	Credit 6 Green Power	2	not yet
11		Materials & Resources		Notes
Y		Prereq 1 Storage & Collection of Recyclables	Required	
3		Credit 1 Building Reuse, Maintain Existing Walls, Floors & Roof	1 to 3	EXTENSIVE -- PRESERVATION OF 95% OF EXISTING STRUCTURES
1		Credit 1 Building Reuse, Maintain 50% of Interior Non-Structural Elements	1	EXTENSIVE - 90% MAINTAINED
2		Credit 2 Construction Waste Management	1 to 2	EXTENSIVE -- PRECISE MATERIAL ESTIMATES, NO DUMPSTERS
2		Credit 3 Materials Reuse	1 to 2	EXTENSIVE -- ALL POST & BEAMS, AND SIDING, AND STONES
?		Credit 4 Recycled Content	1 to 2	SOME, BUT UNCERTAIN PERCENTAGE
2		Credit 5 Regional Materials	1 to 2	85% LOCAL BUILDING SUPPLIER w/in 10 miles, REUSE OF WOOD & STONE
1		Credit 6 Rapidly Renewable Materials	1	90% WOOD CONSTRUCTION
?		Credit 7 Certified Wood	1	POSSIBLY SOME -- NEED TO CHECK RECORDS
11		Indoor Environmental Quality	15 Points	Notes
Y		Prereq 1 Minimum IAQ Performance	Required	
Y		Prereq 2 Environmental Tobacco Smoke (ETS) Control	Required	
	N	Credit 1 Outdoor Air Delivery Monitoring	1	
1		Credit 2 Increased Ventilation	1	ATTIC TEMP-CONTROLLED FANS, PLENUMS FOR OPTIMAL AIR-FLOW
1		Credit 3 Construction IAQ Management Plan, During Construction	1	MASKS, NEGVE-PRESS CONTAINMENT, AND VENTILATION/FANS ALWAYS
1		Credit 3 Construction IAQ Management Plan, Before Occupancy	1	CONTAINMENT AND VENTILATION
1		Credit 4 Low-Emitting Materials, Adhesives & Sealants	1	WATER-BASED WHEN POSSIBLE
1		Credit 4 Low-Emitting Materials, Paints & Coatings	1	LOW-VOC'S (Volatile Organic Compounds), PAINTS WATER-BASED
1		Credit 4 Low-Emitting Materials, Flooring Systems	1	ALL-WOOD, MINIMAL VOC'S
?		Credit 4 Low-Emitting Materials, Composite Wood & Agrifiber Products	1	ALWAYS ATTEMPTED MINIMAL VOC'S -- NEED TO CHECK RECORDS
1		Credit 5 Indoor Chemical & Pollutant Source Control	1	RADON TESTED, CO2 MONITORED, INCREASED VENTILATION
	N	Credit 6 Controllability of Systems, Lighting	1	NOT YET, BUT DAILY FAMILY LIGHTING-MINIMIZATION PLAN
1		Credit 6 Controllability of Systems, Thermal Comfort	1	SEVERAL PROGRAMMED ZONES (ARTIFICIAL INTELLIGENCE PLANNED)
1		Credit 7 Thermal Comfort, Design	1	PROGRAMMED ZONES, DEHUMIDIFICATION
	N	Credit 7 Thermal Comfort, Verification	1	NOT YET
1		Credit 8 Daylight & Views, Daylight 75% of Spaces	1	EXTENSIVELY OPTIMIZED
1		Credit 8 Daylight & Views, Views for 90% of Spaces	1	EXTENSIVELY OPTIMIZED
5		Innovation & Design Process	6 Points	Notes
1		Credit 1 Innovation in Design: Provide Specific Title	1	EXTRA INSULATION, Vapor & Moisture BARRIERS, Northern BUFFER SPACES
1		Credit 1 Innovation in Design: Provide Specific Title	1	OVERALL BUILDING HAS LOW SURFACE-AREA TO VOLUME RATIO
1		Credit 1 Innovation in Design: Provide Specific Title	1	STRUCTURAL REINFORCING OF OLD HOUSE WITH NEW FOUNDATIONS
1		Credit 1 Innovation in Design: Provide Specific Title	1	99% CONSTRUCT BY OWNER W/ HAND-TOOLS, 70 YARDS DIRT W/ SHOVEL
1		Credit 1 Innovation in Design: Provide Specific Title	1	212 NEW TREES: PASSIVE-SOLAR, WINDBLOCK, NOISE-CONTROL, BIRDS
	N	Credit 2 LEED [®] Accredited Professional	1	OWNER PREPARING TO TAKE LEED GA EXAM
2		Regional Priority	4 Points	Notes
1		Credit 1 Regional Priority: Provide Specific Title	1	PRESERVING EXISTING FARMHOUSES AND BARN
1		Credit 1 Regional Priority: Provide Specific Title	1	3 TO 4 WORKING GARDENS PER YEAR -- AGRICULTURAL ZONING
		Credit 1 Regional Priority: Provide Specific Title	1	
		Credit 1 Regional Priority: Provide Specific Title	1	
50		Project Totals (pre-certification estimates)	110 Points	ADD 15 POINTS WHEN SOLAR, WIND, & AI ZONES DONE
Yes ?	No	Certified 40-49 points Silver 50-59 points Gold 60-79 points Platinum 80-110 points		

Figure 26. 2012 academic LEED assessment of Wunderlich project "WUNDERessin EAST."

XII. Conclusions

The United Nations is using Minecraft to include the inhabitants of 300 international sites in the design process [4]. This work is closely related to the work in this paper. College projects include green homes, green villages, and a virtual college campus in virtual worlds containing simulated weather, terrains, biomes, and AI-enhanced animals that can bring a new level of realism to the design process. Player avatars interact to collectively design and build (or in “survival mode,” hunt, gather, and make tools). This group problem solving can be considered small-scale crowdsourcing or even an on-going charette. The social-media streaming dialog enhances collaboration. Student homes have passive solar, active solar, natural daylighting, mitigation of cold northern winds, and an overall architectural esthetic; each student contributes to a community garden, community livestock (barns and corrals), and overall urban design and city planning including piazza’s, a central market, parks, and a wellness center with an indoor pool and large activity room. Credit is given for using digital logic circuit design and electromechanical devices. Selected students are invited to develop professional architectural construction drawings (“working drawings”) and detailed specifications. LEED (Leadership in Energy and Environmental Design) architectural sustainability concepts are incorporated throughout. This educational methodology has enhanced interdisciplinary collegiality; with not only engineering and architectural student interest, but also interest from students in computer science, cognitive science, the arts, and the humanities; some of this can likely be attributed to the development of not only the built environment, but also the creation of virtual civilizations -- with governments, monetary systems, and laws. The youngest generation of students entering college are particularly interested. As of January 22, 2013, over 20 million copies of Minecraft have been sold [3]. Many in-coming college freshmen have been engaged by our Minecraft server Tsojin, and have perhaps been drawn into new possibilities for their academic and professional careers. The combining of rapid prototyping conceptual design with conventional professional architectural software is helping strengthen the college’s relationships with outside organizations and architectural design firms. Recent student projects using standard professional architectural software have helped facilitate building renovations, a new robotics and machine intelligence lab, and an engineering shop extension. The proposed methodology of combining rapid-prototyping with professional tools for a new campus Field-House/Wellness-Center should help facilitate this large project. Future work includes extending this research to software developers, international universities, and the United Nations. An important aspect of the proposed methodology is the social dynamic of participants mentoring each other as shown in Figure 27, and the possibilities of having people of all ages, races, and beliefs collaborate from around the world regardless of design skills. This could have a positive impact on civilization; and our younger generations have already accepted the intense connectivity of our rapidly changing world.



Figure 26. 2012 students mentoring each other.

References

- [1] Robie house image: <http://thefabweb.com/86381/24-best-architecture-pictures-of-the-month-march-16th-to-april-14th-2013/attachment/86391/>
- [2] Minecraft building blocks image: http://www.minecraftwiki.net/wiki/Minecraft_Wiki
- [3] Nunneley, Stephany, "Minecraft sales hit 20 million mark for all platforms". *VG247*. Retrieved January 30, 2013.
- [4] "Minecraft to aid UN regeneration projects" *BBC News on Technology*, Nov 26, 2012. [available at: <http://www.bbc.co.uk/news/technology-20492908>]
- [5] Minecraft "Bukkit" server-mod and plugins: <http://forums.bukkit.org/pages/about-us/>
- [6] SQL Database server "Wampserver" <http://www.wampserver.com/en/>
- [7] Minecraft tools: <http://www.planetminecraft.com/blog/-dingos-tools-of-the-trade--1373080/>
- [8] Minecraft crafting-formulas: <http://www.planetminecraft.com/blog/notch-should-add-crafting-428794/>

Author Bio's:

Dr. Joseph Thomas Wunderlich has designed two neurocomputers and part of an IBM supercomputer operating system. His Ph.D. (U. Delaware) and M.Eng. (Penn State) are in Electrical and Computer Engineering. He's conducted robotics research and taught a Ph.D. course at the University of Trento in Italy. He's taught 31 courses including eight new ones. He also has a BS in Architectural Engineering (U. Texas) and an almost-completed 2nd BS in Urban-Planning/Environmental-Design (UCSD). He has Project Director experience for ~\$70Milliion USD of architectural projects in Texas, California, and Pennsylvania; experience as a San Diego County Environmental Planner and as a San Francisco Engineering Consultant (including EPA certifications). Recently he created the Elizabethtown College Sustainable Design Engineering program and the Architectural Studies Minor.

Mr. Joseph John Wunderlich is the designer of several hundred buildings throughout many virtual worlds in Minecraft, and has presented his work on several occasions in Dr. Wunderlich's courses.

Appendix

2nd ANNUAL ELIZABETHTOWN COLLEGE SYMPOSIUM ON SUSTAINABILITY

Tuesday, April 23, 2013 Gibble Auditorium 9:30am to 12:30pm (Posters at 1:15pm in Lobby)

-----Session I-----



#1 9:30 AM "High-end Phoenix Contact Technologies for International Green Initiatives" by James Kelly

#2 9:40 AM "Reflections from 16 Months of Interdisciplinary/Multicultural Collaboration on a West African Social Business Start-Up"

by Jillian Casey, Jennifer Hughes, Eleanor McCarthy, Joshua Rowlands, Emily Vogel, Julia Ward, and Nicholas Young

#3 10:00 AM "Next Steps in Continuing Work Toward West African Social Business Start-Ups – New Product Development"

by Anthony Fraccica, Joshua Frey, and Courtney Warlick

#4 10:15 AM "Family EcoRise"

by Vaclav Hasik

#5 10:30 AM "Proposed Design to Replace a New Jersey Vacation Home Destroyed by Hurricane Sandy"

by Emily Vogel

-----Session 2-----



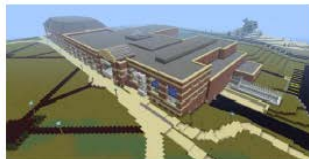
#6 11:00 AM “SWOT Analysis of a Sustainable Entrepreneurial Ecosystem in Costa Rica”
by Kyle McNulty and Derek Zmcic



#7 11:15 AM “Computer Controlled Hydroponic Gardens”
by Sean Flannigan and Andrew Khela



#8 11:30 AM “Analyzing the Hydrological Impacts of a Proposed Sports/Recreation/Fitness Center at Elizabethtown College”
by Deborah Bartyczak, Josh Rowlands, Emily Vogel, and Nick Young



#9 11:45 AM “FEAST(Future Energies and Sustainable Technologies) Club Activities”
by James Annab, Jack Hess, Matt Klempa, and Anthony Fraccica

#10 12:00 PM “Social-networking, Crowd-sourcing Teamwork to Rapidly-Prototype Green Architecture and Communities”
by Ricky Sturz



#11 12:15PM “Solar Decathlon Charette” *by Vaclav Hasik*

-----Posters-----

(1:15PM in Lobby): “LEED (Leadership in Energy and Environmental Design) Architectural Design”
by Shane Weller, Kyle Wilt, Meghan Donahue, Emily Vogel, and Vaclav Hasik

*Sense of Place as Community Empowerment in Bioregional Planning Process: A
Proposed Model*

Muhammad Farid Azizul*¹, Stephen Knight-Lenihan*², Marjorie van-Roon *²

*¹University Technology Malaysia, Malaysia, *²The University of Auckland,
Auckland, New Zealand

0230

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org

1. Introduction

Landscape change, has increasingly been recognized within interdisciplinary perspectives to be a process that is inherently influenced by an interacting social-ecological system. This process is not deemed to be static, but rather it is a dynamic process of transaction between human values and functions that have evolved as a consequence of past resource use, policy and social response. The process of landscape creation as a human territorial region is described by Mumford (1938, p.367) as “a complex of geographic, economic and cultural elements. Not found as a finished product in nature, not solely the creations of human will... the region... is a collective work of art”. A human territorial region or a “place” is the sum of all interactions between human activity and preference, and biophysical resources, whereby a bioregion indicates a similar pattern of land use and ecosystem (Brunckhorst 2001; Slocombe, 1993) creating the social identity of that physical context (Shannon, 1998). Planning frameworks should embrace more pragmatic approaches towards the inclusion of values and meanings because planning decisions involve the negotiation of human habitation which can trigger uncertain future actions regarding land use. Stedman (2005) asserts that place attachment can be a catalyst determining the choice and activities in land use outcomes. In other words, negotiating the meaning of place by various social actors inevitably implies a different direction for future actions. Although it is indicated in some studies that while an attachment to a place substantially expresses a strong support to maintain the setting (e.g., Cheng et al., 2003), an understanding of the way in which the place should be perceived by various actors, may imply a different course of action that further determines the future of the spatial pattern (Stedman, 2005). The repositioning of our sense of place through bioregional thinking therefore is imperative, underlining its importance to nurture and empower human culture towards a positive landscape change.

Land use planning, resource and biodiversity conservation under these circumstances suggest that these activities not only manage biophysical components, but also the negotiation of human territorial regions, which are composed of complex values, interactions and meanings. The literature in land use change commonly developed a spatially explicit model to assess a range of human drivers for change, for example environmental aspects (e.g., Wu et al., 2008), economic (e.g., Irwin & Geoghegan, 2001), political and institutional influences (e.g., Clement et al., 2006), in addition to attitudinal considerations (e.g., Karali et al., 2011). While most of these factors recognized largely as involving definitive and measurable indicators, the less perceptible gauge of human well-being or satisfaction, the attachment to place, has received little attention. This type of value system is seen as less defensible as it is regarded as far more difficult to measure, with an “unseen” physical impact in managing sustainable land use practices. Simply, “it is easier to oppose land uses when there is hard evidence that these practices will have tangible, measurable, objective and widespread impacts” (Stedman, 2005, p.121). The focus of this paper is that the exploration of sense of place should be an imperative to better understand how humans reorganize their response to environmental impacts.

In this context, a question is posed- how are land use decisions rendered by the negotiation of the actors values, which then in turn shape the land use patterns and ecosystem services that will further be enjoyed by the communities at large? Landscape that embodies a multitude of values from amongst the social actors

predicts a different action outcome for land use decisions that subsequently shape future spatial patterning, influencing ecological functioning. In a study by Stedman (2005) these differences were observed whereby the impact of shoreline development on sense of place between two groups of property owners was assessed. The end result revealed that the degree of lakeshore development significantly influenced the resident's considerations about their lake. While the property owners on lightly developed lake shores associated their sense of place with that of a pristine, natural-based setting that is peaceful, this view for the residents on highly developed lake shores was held to a far lesser extent. The residents of highly developed lakes shores were more likely to consider their place as residential-suburbia, packed with related urban services and recreational opportunities with consequential pollution problems. The discrepancies between the different residents' beliefs assert that human cognitions have a pivotal and measurable impact on future land use pattern. In a similar manner, a study by Lerner (2005) examined how attachment to a place empowered a community for a positive change against a local contamination issue. The study concluded how sense of place defines us and the environment through the process of the creation of 'change maker', a person that is empowered to make positive changes in regards to local land use issues through active participation.

2. Bioregional Planning: Re-envisioning Humanities Role in Social-Ecological Systems

The fundamental rethinking of natural resource management, conservation and reconciling human needs in land use planning has led to a paradigm shift from a rational planning approach towards alternative integrated planning approaches (Scrase & Sheate, 2002). In this age of complexity where the patterns of nature and society are interwoven into an interconnected web of domains and processes, many planning approaches struggle to frame the uncertainties of the future as a result of our actions today. Current advances in ecosystem sciences, sustainability sciences and other related disciplines acknowledge that socio-ecological systems are interlinked, creating an intertwined linkage of systems that are influenced by each other. Different approaches have been debated on how best to protect public interests. The failure of a traditional top-down planning approach has increasingly been noted by advocates in planning and environmental management fields (see for example; Blair, 1996; Scott, 1998). In particular, it has been critiqued as being overly relied on in regards to the aspect of growth projection (Loveridge, 1972), the inability of local government to solve trans-boundary environmental problems associated with urban sprawl (Godschalk et al., 1977) and disempowerment of local communities in decision-making (Harris, 1994).

More importantly, Diffenderfer & Birch (1997) claimed that these responses are rather symptomatic of the core issue of a centralized command and control approach, highlighting an inability to counteract against a utilitarian view of specific actors in satisfying their needs. Furthermore, public dissatisfaction with government, has led to mistrust in science as a base for political decision-making (see for example; Gauchat, 2012; Reynolds, 1969) which often does not reflect the concerns, values and needs of the communities (Moote & McClaran, 1997). Consequently this has necessitated a social restructuring of planning in order to manage effectively competing land use interests between various social actors (Frame et al., 2004). In the context of regional planning and conservation, bioregionalism offers an alternative approach for governance that involves both social and political restructuring. Birkeland (2008) and

Diffenderfer & Birch (1997) assert that the subsequent transformation of governance implies the need for a multi-faceted platform designed to achieve ecological conservation, which in turn facilitates social, ecological and economic sustainability.

A more overt approach for the inclusion of sense of place in planning and conservation through bioregional planning is needed as a means of addressing these concerns. While bioregions, as defined earlier, are patterns of land use and biophysical similarities, they also emphasize the “terrain of consciousness” – a place where the inhabitants are aware and have their own ideas regarding their existence or thoughts concerning how to live in that place (Relph, 1976; Tuan, 1977). This in turn distinguishes bioregionalism from the ecoregional approach that is to a greater extent directed towards biodiversity conservation. Relevantly, while earlier fragmented research and planning field’s isolated society from resource use, bioregionalism under these conditions expresses the self-reliant characteristics of several multi-faceted components in the planning system. Sale (1993) noted that the core foundation of bioregionalism is the in-depth understanding of a region’s resources and geography, in which dynamic social and economic development operates within the ecological carrying capacity. This philosophy underlines the importance of an ecological-planning approach so as to be responsive to people who inhabit the place (Thayer, 2003) and to enable community-empowerment in decision making (Harris, 1994) in order to facilitate and achieve long-term ecosystem conservation.

The bioregional planning approach that is conveyed in this article aims to provide an integrated framework that will relate ecological imperatives alongside the social systems. While discussion on bioregional planning as a framework for land use planning, conservation and social reorganization (see discussion in Brunckhorst (2002) and Miller (1996)) is beyond the scope of this paper, we acknowledge that the framework shares a common ground among the various definitions, that is, bioregional planning recognizes both the natural environment and human societies as dynamic components of the landscape. Subsequently, the implication for bioregional planning is as an integrated ecosystem management system, where plans for conservation and maintenance of ecological integrity depend on sustaining human processes and vice-versa through co-operative decision-making (Berkes & Folke, 1998; Bunch et al., 2011; Cumming, 2011).

The foundation of bioregional theory amalgamates human and ecological needs as applied in the ecological land use planning paradigm (McHarg, 1995). However, bioregions are also perceived as a place, acknowledging the influence of collective public vision in the development of place and accordingly desire to maintain the ecosystem (Brunckhorst, 2001). This paper proposes to elaborate further on the association between a sense of place as a social process and how this process influences social actions of conservation and development policies. The two main thematic notions of bioregions as a transformation of place, and environmental stewardship which empowers communities will be deconstructed and a conceptual model will be proposed that illustrates the role of people-place collaboration in achieving social and ecological sustainability within the context of bioregionalism.

3. Grounding a Sense of Place in Bioregional Planning

A bioregional planning approach explicitly addresses the need for conservation planning in maintaining ecological processes and functions. Scientific knowledge of

landscape ecology underlines the set of principles used in modifying the spatial organization of the landscape when achieving balanced performance-based ecosystem outcomes. This may differ from the socio-cultural context, within which opinions, perceptions and values that are attached to particular landscapes are contingent on changes of the biophysical components. This dual perspective of conceptualizing the environment is crucial, as the scientific view of organizing the landscape is coupled with real community involvement in the planning process. In reality social opinion is not always aligned with the intended outcomes of conservation planning. Therefore, this poses a challenge for planners when considering the dualistic realm of an environmental model such as that described by Rappaport cited in Ndubisi (2002, pp. 111-112):

“Two models of the environment are significant in ecological studies; the operational and cognitive. The operational model is that which the anthropologist (scientist, planner, designer) constructs through observation and measurement of ecological entities, events and material relationship. He takes this model to present analytical purposes, the physical world of the group he is studying.... The cognized model is the model of environment conceived by people who act in it...The important question concerning the cognized model, since it serves as guide to action, is not the extent to which it conforms to reality (is identical to operational model) but the extent to which it elicits behaviour that is appropriate to the material situation of the actors, and it is against this function and adaptive criterion that we may assess it”

Humans enter into the ecological system by being incorporated as another set of values or determinants (Cosens, 2013; Uy & Shaw, 2013). The cognitive model reflects on how people conceptualize and participate in the landscape by creating a specific meaning or value associated with the idea of ‘ecosystem’. Within the context of this study, this phenomenon is underpinned by the “transactional concept” and the “interactionism perspective”. Zube (1987) coined the idea “transactional concept” in order to explain human-landscape relationships by suggesting the notion that “both the human and the landscape change as a function of the transactions” (p.38). He suggested that active social participation and exploration in nature, creates an experience that contributes to the attribution of value towards nature. From the discipline of sociology, Greider & Garkovich (1994, p. 1) argue that landscape is the process of social construction in nature and:

“Are the symbolic environments created by human acts of conferring meaning to nature and the environment, of giving the environment definition and form from a particular angle of vision and through a special filter of values and beliefs”

These theories conceptualize human-nature interaction where the human is an active participant in seeking, processing and making judgments about the landscape that generates affinity or attachment to a particular place manifested by a unique set of cultural, belief or norms.

Translating this interaction of human and nature within bioregionalism, these theories imply that societal outcomes when managing ecosystems are not dictated by the biophysical process, but rather are guided by the spatial organization of the landscape built upon ecosystem sciences in such a way that it fulfills both social and biophysical objectives. As a result of this developmental process, “sense of place” emerges as an overarching concept that encapsulates values and meanings that explain the intricate relationship between land and people. Planning considered as a process “founded on the need to deliver human experience” underlines the complexity of negotiating public values and meanings (Knopf, 1983, p. 229). The implications of ignoring this experience may include influencing the way people react or behave, either positively or negatively in that place setting. As bioregionalism stresses the notion of people knowing the “place” in which they live, it is crucial to understand the process of how a place is developed from the human interaction with biophysical components.

4. Sense of Place

The subject of place as an experiential place or ‘sense of place’ has been explored from various disciplinary perspectives bounded by their own epistemological foundation in conceptual understanding. Early development in geography indicated *place* as a *locale* of physical properties in a geographical context (Lew, 2008). Since then, humanistic geography studies have enriched the concept by suggesting that place is not merely a physical entity but it is composed of complex experiential and psychological dimensions attached to a particular physical continuum. This particular discourse is endowed by humanistic geographers such as Relph (1996) asserting that place is not just a mere connection to physical properties of the natural environment but rather “tightly interconnected assemblages of buildings, landscapes, communities, activities, and meanings which are constituted in diverse experiences of their inhabitants and visitors” (p. 907-8). Drawing upon this phenomenological experience, he further suggests that development of place not only evolves from individual-meaning, but is presented as a collective form of intersubjective, shared values communicated between inhabitants (Relph, 1996). Such complexity in conceiving and establishing clear development of place has been highlighted by Butz & Eyles (1997) as “rooted in theories of social organization and society, and as being variably and contingently ecologically emplaced” (p.1).

Considering these circumstances, ‘a sense of place’ is therefore associated with the idea of experience that turns the ecosystem space into a place. Tuan (1977) in his seminal work pointed out that space turns into place “as we get to know it better and endow it with value” (p. 6). In a similar manner, Relph (1996) suggests ‘a sense of place’ is an awareness of the “inherent and unique qualities of somewhere” (p. 909). Implicitly, this understanding imposes a dimension of awareness or sense that qualities (environment or social) can be achieved and maintained (Tuan, 1980). In other words, ‘sense of place’ is composed of “personal memory, community history, physical landscape appearance, and emotional attachment” (Galliano & Loeffler, 1999 p. 2). Places therefore, in addition to a physical setting, are an amalgamation of meanings and values, (Sampson & Goodrich, 2009) and socio-psychological processes (Gieryn, 2000; Stedman, 2002). Consequently, clarifying the qualities that can be classified as subjective to the meaning of anything – culture, own identity, imagination or memory and so physical or social properties when describing one’s ‘sense of place’ and therefore presents certain challenges.

Despite the complexity of theory and practice in place-related research, the theoretical construct of 'sense of place' has been divided into two main lines of inquiry. The first approach conceptualizes three components of 'sense of place', constructed as place dependence, place identity and place attachment that overlap each other in one instance and subsequently override each other in another (Proshansky et al., 1983; Vaske & Kobrin, 2001; Williams & Roggenbuck, 1989). Alternatively, others have viewed 'sense of place' as a tripartite of three multidimensional constructs, with each construct representing the component of cognitive, emotive and conative of human consciousness (Stedman, 2002; Jorgensen & Stedman, 2006). Organizing these constructs in alignment with human consciousness, place identity can be conceptualized as the cognitive component while place dependence is associated with the conative component and place attachment as the emotive component of sense of place. Place identity according to Proshansky (1978) refers to an intersection of personal values, beliefs and goals within the physical setting, and hence an idea of how a physical setting becomes purposeful and meaningful to life. While place dependence is a functional relationship illustrated when a place is instrumental in fulfilling certain needs of the individual (Stedman, 2002), place attachment on the other hand reflects the emotive part of awareness, thus positive bonding develops between the individual and their natural world (Altman & Low, 1992).

Environmental psychologists have used place attachment as the denominator for a sense of place in their theory development and practice and their approach presents a stark contrast to epistemological and research approaches (Graham et al., 2009, p.15). Their primary focus has been on investigating the psychological process of mental cognition/development of an individual's connection within the physical context. This range of researchers has emerged concurrently with the objective to inform the behavioural process in planning. Altman & Low (1992) define place attachment as "the symbolic relationship formed by people giving culturally shared emotional/affective meanings to a particular space or piece of land that provides the basis for the individual's and group's understanding of and relation to the environment" (p. 165). A symbolic relationship is experienced at the scale of individual, group or culture inculcation, through "interplay of affect and emotions, knowledge and beliefs, and behaviours and actions in reference to a place" (Altman & Low, 1992, p.4). However, the study of place attachment in environmental psychology has been criticized for its sole emphasis on the psychological process of development of place (Sime, 1995). In contrast, humanistic geography emphasizes the phenomenological experiences of how people understand places and shape the role places play in their life, while research into environmental psychology has tended to separate the composite experiential of place into discrete elements that are measured in a positivist approach.

Nonetheless, the contribution of place attachment and identity in environmental psychology has been widely accepted in planning practice due to its ability to conceptualize the emotive bonds between people and place- a subject that many planning realms strive hard to manage. Regardless of various disciplinary orientations in understanding place, they are underpinned by the core principle of human beings embedded in a particular environmental context that involves interaction of experience and physical components. Therefore it is intended that this article will employ 'sense of place' as a broad concept that is assumed to capture the tripartite construct of place attachment, place identity and place dependence rather than

articulating the constructs into distinct individual elements (e.g., Rollero & De Piccoli, 2010). Sense of place therefore refers to the people-place connection manifested via collective memories, values and history of culture as reflected by, and influencing, the physical context.

5. Bioregional Planning: Sense of Place Nurturing and Empowering Positive Landscape Change

Environmental stewardship is a one of the core principles of community planning articulated in bioregionalism as people who live in a specific place, consciously developing their own idea and way of living in relation to that particular place. As outlined earlier, disintegration of people and place in the rational planning approaches disempowers community members from their civic role and responsibility towards the protection of their living environment. In contrast it is apparent that developing the competency of community-based-decision-making is founded on residential understanding of local resources availability. Bioregionalism under these circumstances becomes a decentralized planning exercise, underscoring the importance of economic and politic decision-making to be delegated at a local level, which inherently gives rise to personal and community empowerment (Harris, 1994). Moreover, community empowerment is translated into active participation in decision-making that fosters a shared learning process – a quality legitimated by the interaction between experiential and technical knowledge (Aberley, 1993; Diffenderfer & Birch, 1997).

Such mobilization of empowerment is determined importantly by understanding the connection of humans with their natural world and stewardship of the land. The emphasis on consideration of human connection and values in planning potentially can be the turning point for more directive actions towards a resilient social-ecological system. Concurring with bioregional thinking, it advocates the re-envisioning of people-place relationship translated into “repairing...the damage done to natural systems, and recreating human cultures capable of flourishing in an ecologically sustainable manner through time” (Plant & Plant cited in DePrez, 1997, p. 43). Human culture in this sense is parallel to the land ethics that Aldo Leopold espouses, which works toward intensifying the sense of care, commitment and concern of how the place should be. He eloquently suggests that in developing a land ethic, the role of humanity is transformed from conqueror of ecological system to an egalitarian view that a human is “just plain member and citizen of it” (Leopold, 1949, p.240). He further asserts that culture which then drives societal action can be assessed in relation to one’s connection or association to the natural world:

“A thing is right when it tends to maintain the integrity, stability, and beauty of biotic community, it is wrong when it tends otherwise”
(Leopold, 1949, p. 266).

One of his supporters, Worrell & Appleby (2000) suggest that environmental stewardship is a form of land ethic, defining it as a deeply held moral obligation interpreted into actions of “responsible use (including conservation) of natural resources in a way that takes full and balanced account of the interests of society (and) future generations ... as well as private needs, and accepts significant answerability to society” (p. 269). Considering that society must confront multifaceted issues related to land management, a compelling question arises. In what

way are social actions directed towards achieving social, economic and ecological sustainability? It has been suggested that the land ethic should provide a conceptual foundation for environmental stewardship that can guide the action and response of society towards the threat of ecosystem degradation and resources depletion (Knight, 1996). This segment will articulate and characterize certain qualities promoted by ethical social action that would qualify as environmental stewardship, which is initiated from planning and conservation decisions.

The majority of research into planning, resource management, environment and behaviour have made connections between place-based values and stewardship, although in each case it has been explored within its own paradigm. Studies in landscape and urban planning for example, have explored the role of local resident attachment to rural and urban landscapes in determining their motivation for stewardship and land protection (Lokocz et al., 2011; Walker & Ryan, 2008). These studies have found strong connections between place attachment and stewardship engagement. This quality is manifested through several forms of supportive attitude towards conservation strategies that promote ecological stability. Inasmuch, this presents evidence that residents are more concerned about their connection to place by sustaining the local economic and landscape character. Studies have shown that social actions through several mechanisms in development planning directly contribute to social embeddedness in a physical context. Cantrill (1998) indicates that 'sense of place' constitutes a major role in influencing individual capacity and involvement in environmental advocacy for sustainable resource policies. Their ability to practice attitudes which heighten the protection of ecosystems is underlined by awareness of place-based knowledge. Kruger & Shannon (2000) assert that citizens who developed awareness of their local context seem to "grasp the opportunity to create knowledge, benefits, and new opportunities for social action" (p. 475).

Drawing on literature in environmental psychology and behaviour, volunteer motivation for engaging in stewardship programs have been demonstrated to depend on whether they can view it as a process of social learning, care-taking of the environment, as well as developing sense of belonging to that place, or not (Bramston et al., 2010). Over and above people-place relationship theory, other studies have explored this concept through the lens of community attachment – how socially based attachment determines attitudes about local environmental issues (Brehm et al, 2006; Stewart et al., 2004). This line of research distinguishes between socially based bonding relating to physical attachment, and the emphasis placed on community-level attachment on environmental concerns.

As the people-place connection is inextricably embedded in the ecosystem context, previous studies suggest emotional bonding with the place can mediate the way people respond and react to ecosystem change through several mechanisms. For example, people who exhibit a strong sense of place demonstrate more commitment to problem solving and are more likely to react to environmental issues. This is a predictor of a resilient characteristic of dynamic landscape change (Burley et al., 2007; Kaltenborn & Bjerke, 2002; Lai & Kreuter, 2012). These studies have suggested that the role of communities within themselves can participate and make clear how the policy should be oriented towards their needs. Pertinent to that, resident acceptance of proposed landscape changes are inclined to legitimize and enhance their meaning of place in the planning process (Stewart et al., 2004). This finding for

example, was underlined by Steadman (2002) where place-based values are incorporated into the decision-making process, where it creates a protective behaviour that seeks to maintain and enhance values attributed to place – actions that reveal the importance of the place. Similarly, Vaske & Kobkrin (2001) found that local attachment to natural resources could be a valuable mechanism to predict whether an individual acts in an environmentally responsible manner (or not). These studies, when applied within various fields related to environmental policy-making, have demonstrated that the people-place connection and community attachment have played a significant role in guiding specific social actor behavioural responses, either positively or negatively, to environmental decision-making.

6. Summary & Operationalization

Figure 1 proposes a conceptual model linking sense of place with social and ecological sustainability. This model illustrates sense of place as a concept of a social process that helps make conservation and development policies viable by acknowledging the values and meanings of humans. It captures the idea that ecosystem functioning evolves as a result of human understanding of the place across social structure and institutions; specifically, it is manifested in an amalgamation of social attitudes and behaviours in influencing land use outcomes. This article argues that individual and community empowerment is developed from the connection to the place within which they are embedded, and this serves as a basis for developing an ethical and moral responsibility for actions mobilized by stewardship to the land.

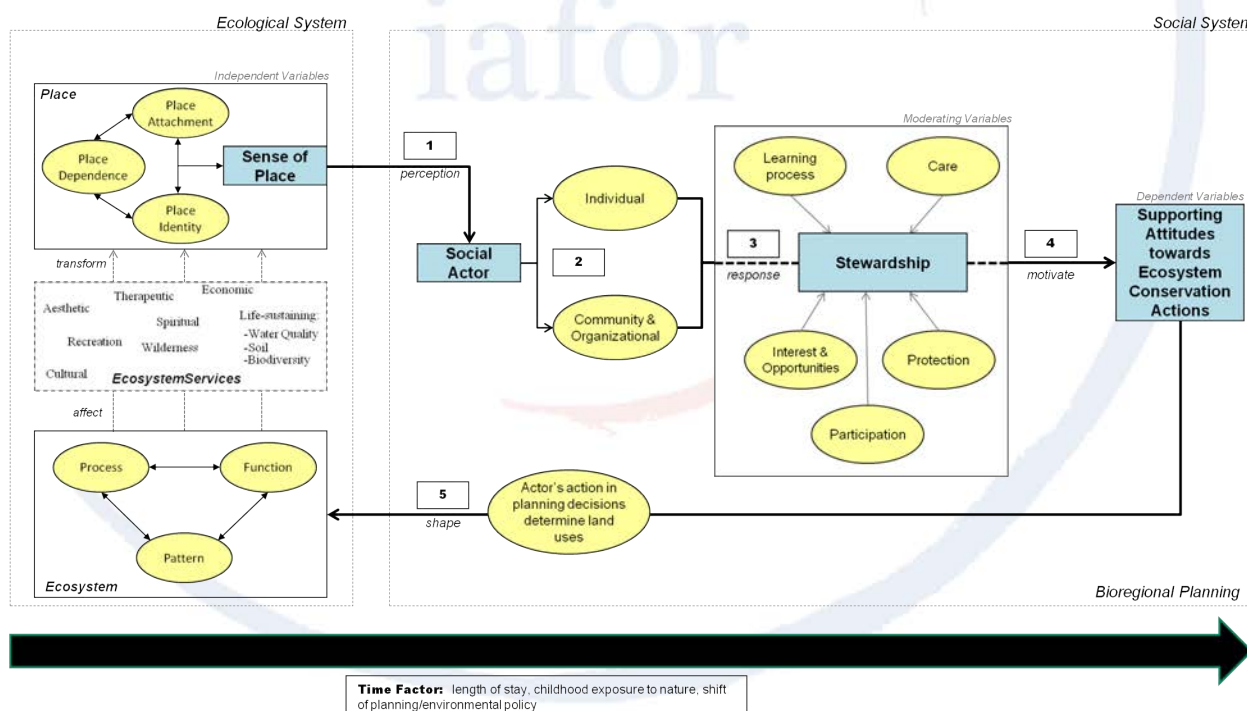


Figure 1: Conceptual model linking the core premise that the people-place relationship fulfils an important role in achieving social and ecological sustainability. An experience of a place might be developed over a given time period and changes of environmental.

Drawing upon this conceptual model, several compelling questions arise for further study; (1) How do individuals and communities develop a sense of place? (2) Is there any variance in the strength of sense of place among social actors, e.g., individuals,

professionals and other stakeholders in land management? (3) How do variations in the sense of place influence the effect of environmental stewardship? (4) How does environmental stewardship empower communities in their actions and attitudes towards environmental protection policies? (5) How do these responses feed back into the ecological system, through behavioural actions that determine the land use outcomes shaping the ecosystem functioning? As stressed in this article, bioregional planning envisions the place of people-place relationship in its core foundation to characterize specific emergence of social behavior in planning decisions. This repositions the human dimension in integrated ecosystem management, suggesting an alternative path to the sustainability of socio-ecological systems especially in dealing with the uncertain future of our plans today. The evolution of an ecosystem is partly but crucially determined by what we identify as important for the next generation to enjoy including the ecosystem services that we are experiencing now. In conclusion, a sense of place is a concept that people use to conceptualize themselves into the ecological system and plays a powerful role in influencing and distinguishing actions across social actors in land management.

7. Acknowledgement

The authors would like to acknowledge that this paper has substantial content in common with a similar paper published previously in the 50th International Federation of Landscape Architects 2013 proceedings. The authors would like to acknowledge the funding support of the Ministry of Higher Education Malaysia, University Technology Malaysia and The University of Auckland. This article forms part of the first author's doctoral thesis at The University of Auckland, New Zealand.

8. References

- Aberley, D. (1993). *Boundaries of home: mapping for local empowerment* / edited by Doug Aberley: Gabriola Island, B.C.: New Society Publishers, c1993.
- Altman, I., & Low, S. (1992). *Place Attachment*. New York: Plenum Press.
- Berkes, F., & Folke, C. (1998). Linking social and ecological system for resilience and sustainability. In Fikret Berkes, C. Folke, & with the editorial assistance of J. Colding. (Eds.), *Linking Social and Ecological Systems : Management Practices and Social Mechanisms for Building Resilience*. Cambridge, U.K. ; New York, USA: Cambridge University Press.
- Birkeland, J. (2008). *Positive Development: From Vicious Circles to Virtuous Cycles through Built Environment Design*. London: Taylor & Francis.
- Blair, H. W. (1996). Democracy, equity and common property resource management in the Indian subcontinent. *Development and Change*, 27, 475–499.
- Bramston, P., Pretty, G., & Zammit, C. (2010). Assessing Environmental Stewardship Motivation. *Environment And Behaviour*, 43(6), 776–788. doi:10.1177/0013916510382875
- Brehm, J. M., Eisenhauer, B. W., & Krannich, R. S. (2006). Community Attachments as Predictors of Local Environmental Concern: The Case for Multiple Dimensions of Attachment. *American Behavioural Scientist*, 50(2), 142–165. doi:10.1177/0002764206290630
- Brunckhorst, D. J. (2002). *Bioregional Planning: Resource Management Beyond the New Millennium*. London; New York: Routledge.
- Brunckhorst, D. J. (2001). Building capital through bioregional planning and biosphere reserves. *Ethics in Science and Environmental Politics*, 2001(1), 19–

32. Retrieved May 20, 2013, from <http://www.int-res.com/articles/esep/2001/article2.pdf>
- Bunch, M. J., Morrison, K. E., Parkes, M. W., & Venema, H. D. (2011). Promoting Health and Well-Being by Managing for Social – Ecological Resilience: the Potential of Integrating Ecohealth and Water Resources. *Ecology And Society*, 16(1). Retrieved July 6, 2013, from <http://www.ecologyandsociety.org/vol16/iss1/art6/ES-2010-3803.pdf>
- Burgess, J., & Gold, J. (1982). On the Significance of Valued Environments. In J. A. Gold, J. R., Burgess (Ed.), *Valued Environments* (pp. 1–9). London: George Allen & Unwin.
- Burley, D., Jenkins, P., Laska, S., & Davis, T. (2007). Place Attachment and Environmental Change in Coastal Louisiana. *Organization Environment*, 20(3), 347–366. doi:10.1177/10860266070305739
- Butz, D., & Eyles, J. (1997). Reconceptualizing Senses of Place: Social Relations, Ideology and Ecology. *Geografiska Annaler: Series B, Human Geography*, 79(1), 1-25. doi: 10.1111/j.0435-3684.1997.00002.x
- Cantrill, J. G. (1998). The environmental self and a sense of place: Communication foundations for regional ecosystem management. *Journal of Applied Communication Research*, 26(3), 301-318. doi: 10.1080/00909889809365509
- Cheng, A. S., Kruger, L. E., & Daniels, S. E. (2003). “Place” as an Integrating Concept in Natural Resource Politics: Propositions for a Social Science Research Agenda. *Society Natural Resources*, 16(March 2002), 87–104. doi:10.1080/08941920390174229
- Clement, F., Amezaga, J. M., Orange, D., Toan, T. D., Large, A. R. G., & Calder, I. R. (2006). Reforestation Policies and Upland Allocation in Northern Vietnam: An institutional approach for understanding farmer strategies and land use change. *International Symposium Towards Sustainable Livelihoods And Ecosystems In Mountainous Regions*. Retrieved July 5, 2013, from <http://www.iascp.org/bali/papers.html>
- Cosens, B. A. (2013). Legitimacy, Adaptation, and Resilience in Ecosystem Management. *Ecology and Society*, 18(1). doi:10.5751/ES-05093-180103
- Cumming, G. S. (2011). Spatial resilience: integrating landscape ecology, resilience, and sustainability. *Landscape Ecology*, 26(7), 899–909. doi:10.1007/s10980-011-9623-1
- DePrez, V. (1997). Bioregionalism : a state of mind, place, and heart. In C. Warwick (Ed.), *Proceedings Fifteenth North American Prairie Conference* (pp. 42–43). Natural Areas Association. Retrieved February 2, 2013, from <http://digital.library.wisc.edu/1711.dl/EcoNatRes.NAPC15>.
- Diffenderfer, M., & Birch, D. (1997). Bioregionalism: A comparative study of the Adirondacks and the Sierra Nevada. *Society Natural Resources*, 10(1), 3–16. doi:10.1080/08941929709381006
- Frame, T. M., Gunton, T., & Day, J. C. (2004). The role of collaboration in environmental management: an evaluation of land and resource planning in British Columbia. *Journal of Environmental Planning and Management*, 47(1), 59-82. doi: 10.1080/0964056042000189808
- Galliano, S. J., & Loeffler, G. M. (1999). *Place assessment: how people define ecosystems*. Portland, Or: U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Research Station.

- Gauchat, G. (2012). Politicization of Science in the Public Sphere: A Study of Public Trust in the United States, 1974 to 2010. *American Sociological Review*, 77(2), 167–187. doi:10.1177/0003122412438225
- Gieryn, T. F. (2000). A Space for Place in Sociology. (Anonymous, Ed.) *Annual Review of Sociology*, 26(1), 463–496. doi:10.1146/annurev.soc.26.1.463
- Godschalk, D. R., Brower, D. J., McBennett, L. D., & Vestal, B. (1977). *Constitutional issues of growth management*. Chicago, NC: ASPO Press.
- Graham, H., Mason, R. & Newman, A. (2009). *Literature Review: Historic Environment, Sense of Place, and Social Capital*. Newcastle Upon Tyne: Newcastle University Commissioned for English Heritage. Retrieved February 20, 2013, from http://www.englishheritage.org.uk/hc/upload/pdf/sense_of_place_lit_review_web.pdf?1257932683
- Greider, T., & Garkovich, L. (1994). Landscapes: The Social Construction of Nature and the Environment. *Rural Sociology*, 59(1), 1–24. doi:10.1177/S0038038599000280
- Harris, G. (1994). The Adirondack Mountains: Wilderness preservation or bioregional vision? *Trumpeter*, 11(3), 117–120.
- Irwin, E. G., & Geoghegan, J. (2001). Theory, data, methods: developing spatially explicit economic models of land use change. *Agriculture, Ecosystems & Environment*, 85(1-3), 7–24. doi:10.1016/S0167-8809(01)00200-6
- Jorgensen, B. S., & Stedman, R. C. (2006). A comparative analysis of predictors of sense of place dimensions: attachment to, dependence on, and identification with lakeshore properties. *Journal of Environmental Management*, 79(3), 316–327. Retrieved May 3, 2013, from <http://www.ncbi.nlm.nih.gov/pubmed/16288828>
- Karali, E., Rounsevell, M. D. A., & Doherty, R. (2011). Integrating the diversity of farmers' decisions into studies of rural land-use change. *Procedia Environmental Sciences*, 6, 136–145. doi:10.1016/j.proenv.2011.05.014
- Kaltenborn, B. P., & Bjerke, T. (2002). Associations between environmental value orientations and landscape preferences. *Landscape and Urban Planning*, 59(1), 1-11. doi: 10.1016/s0169-2046(01)00243-2
- Knight, R. L. (1996). Aldo Leopold, the land ethic, and ecosystem management. *Journal of Wildlife Management*, 60(3), 471–474. Retrieved February 15, 2013, from <http://www.jstor.org/stable/3802064>
- Knopf, R. C. (1983). Recreational needs and behavior in natural settings. In I. Altman & J. F. Wohlwill (Eds.), *Behavior and the Natural Environment* (pp. 205–240). New York: Plenum Press.
- Kruger, L. E. & Shannon, M. A. (2000). Getting to know ourselves and our places through participation in civic social assessment. *Society & Natural Resources*, 13, 461–478.
- Lai, P-H., & Kreuter, U. P. (2012). Examining the direct and indirect effects of environmental change and place attachment on land management decisions in the Hill Country of Texas, USA. *Landscape and Urban Planning*, 104(3–4), 320–328. doi: 10.1016/j.landurbplan.2011.11.007
- Leopold, A. (1949). *A Sand County Almanac*. London; New York: Oxford Press.
- Lerner, J. M. (2005). *Stand in the Place Where You Live: Sense of Place, Values and Perceptions about Land Use in Tiverton, Rhode Island*. Brown University.
- Lew, A. A. (2008). What is geography? *Geography: USA*. Retrieved July 6, 2013, from <http://www.geog.nau.edu/courses/alew/gsp220/text/chapters/ch1.html>

- Lokocz, E., Ryan, R. L., & Sadler, A. J. (2011). Motivations for land protection and stewardship: Exploring place attachment and rural landscape character in Massachusetts. *Landscape and Urban Planning*, 99(2), 65-76. doi: 10.1016/j.landurbplan.2010.08.015
- Loveridge, R. O. (1972). The environment: New priorities and old politics. In H. Hahn (Ed.), *People and politics in urban society* (pp. 499–529). Beverly Hills, CA: Sage Publications.
- McHarg, I. L. (1995). *Design With Nature*: San Val, Incorporated.
- Miller, K. (1996). *Balancing the scales: guidelines for increasing biodiversity's chances through bioregional management*. Washington, DC: World Resources Institute.
- Moote, M. A., & McClaran, M. P. (1997). Viewpoint: Implications of participatory democracy for public land planning. *Journal Of Range Management*, 50(5), 473–481. Retrieved February 15, 2013, from <http://www.scopus.com/inward/record.url?eid=2-s2.0-0030854294&partnerID=40&md5=a02a0f2e088fc434c93443ee923d33b6>
- Mumford, L. (1938). *The Culture of Cities*. London: Seeker & Warburg.
- Ndubisi, F. (2002). *Ecological planning: a historical and comparative synthesis*. *Center books on contemporary landscape design* (p. 287). Johns Hopkins University Press. Retrieved January 12, 2013, from <http://books.google.com/books?id=VzzSulgl4qQC&pgis=1>.
- Proshansky, H. M., Fabian, A. K., & Kaminoff, R. (1983). Place-identity: physical world socialization of the self. *Journal of Environmental Psychology*, 3(1), 57–83. Retrieved February 20, 2013, from <http://psycnet.apa.org/psycinfo/1983-30076-001>
- Proshansky, H. M. (1978). The City and Self-Identity. *Environment And Behavior*, 10(2), 147–169. doi:10.1177/0013916578102002
- Relph, E. C. (1996). Place. In I. Douglass, R. Huggett, & M. Robinson (Eds.), *Companion Encyclopedia of Geography: the environment and humankind* (pp. 906–922). London: Routledge.
- Relph, E. C. (1976). *Place and placelessness*. London: Pion Press.
- Reynolds, J. P. (1969). Public participation in planning. *Town Plan. Rev*, 40, 131–148.
- Rollero, C., & De Piccoli, N. (2010). Place attachment, identification and environment perception: An empirical study. *Journal of Environmental Psychology*, 30(2), 198–205. doi:10.1016/j.jenvp.2009.12.003
- Sale, K. (1993). *The Green Revolution. The Environmental Movement 1962-1992*. New York: Hill & Wang.
- Sampson, K., & Goodrich, C. (2009). Making Place: Identity Construction and Community Formation through “Sense of Place” in Westland, New Zealand. *Society Natural Resources*, 22(10), 901–915. doi:10.1080/08941920802178172
- Scott, J. C. (1998). Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed. (J. C. Scott, Ed.) *Yale agrarian studies* (Vol. 1, p. xiv, 445 p.). Yale University Press. doi:10.1177/146499340100100213
- Scrase, J. I., & Sheate, W. R. (2002). Integration and integrated approaches to assessment: what do they mean for the environment? *Journal of Environmental Policy and Planning*, 4(4), 275–294. Retrieved July 6, 2013, from <http://dx.doi.org/10.1002/jcpp.117>
- Shannon, M. A. (1998). Understanding social organizations and institutions. In R. J. Naiman & R. E. Bilby (Eds.), *River ecology and management : lessons from the*

- Pacific coastal ecoregion* (pp. 529–551). New York: Springer. Retrieved June 20, 2013, from <http://books.google.com/books?id=yQeM-OUrLDUC&pgis=1>
- Sime, J. D. (1995). Creating places or designing spaces? In L. Groat (Ed.), *Giving Places Meaning. Readings in Environmental Psychology* (pp. 27–41). London: Academic Press.
- Slocombe, D. S. (1993). Implementing Ecosystem-Based Management. *Bioscience*, 43(9), 612-622.
- Stedman, R. C. (2005). Sense of place as an integrated framework for understanding human impacts of land use change. In S. J. Goetz, J. S. Shortle, & J. C. Bergstrom (Eds.), *Land use problems and conflicts : causes, consequences and solutions* (pp. 121–131). London; New York: Routledge. Retrieved June 25, 2013, from <http://www.loc.gov/catdir/enhancements/fy0651/2004050983-d.html>
- Stedman, R. C. (2002). Toward a Social Psychology of Place. *Environment and Behavior*, 34(5), 561-581. doi: 10.1177/0013916502034005001
- Stewart, W. P., Liebert, D., & Larkin, K. W. (2004). Community identities as visions for landscape change. *Landscape and Urban Planning*, 69(2-3), 315–334. doi:10.1016/j.landurbplan.2003.07.005
- Thayer, R. L. (2003). *LifePlace: Bioregional Thought and Practice*. Ewing, NJ: University of California Press.
- Tuan, Y.-f. (1980). Rootedness versus Sense of Place. *Landscape: A Magazine of Human Geography*, 24(1).
- Tuan, Y.-F. (1977). *Space and place: The perspective of experience*. London: Arnold.
- Uy, N., & Shaw, R. (2013). Ecosystem resilience and community values: Implications to ecosystem-based adaptation. *Journal of Disaster Research*, 8(1), 201–202. Retrieved July 6, 2013, from <http://www.scopus.com/inward/record.url?eid=2-s2.0-84873436509&partnerID=40&md5=8df950b0d8fdd623ba390d61b44adeb2>
- Vaske, J. J., & Kobrin, K. C. (2001). Place Attachment and Environmentally Responsible Behavior. *The Journal of Environmental Education*, 32(4), 16-21. doi: 10.1080/00958960109598658
- Walker, A. J., & Ryan, R. L. (2008). Place attachment and landscape preservation in rural New England: A Maine case study. *Landscape and Urban Planning*, 86(2), 141-152. doi: 10.1016/j.landurbplan.2008.02.001
- Williams, D. R., & Roggenbuck, J. W. (1989). Measuring Place Attachment: Some Preliminary Results. *Session on Outdoor Planning and Management* (p. 7). Retrieved March 3, 2013, from <http://www.fs.fed.us/rm/value/docs/nrpa89.pdf>.
- Worrell, R., & Appleby, M. C. (2000). Stewardship of natural resources: Definition, ethical and practical aspects. *Journal of Agricultural and Environmental Ethics*, 12(3), 263–277. doi:10.1023/a:1009534214698
- Wu, X., Shen, Z., Liu, R., & Ding, X. (2008). Land Use/Cover Dynamics in Response to Changes in Environmental and Socio-Political Forces in the Upper Reaches of Yangtze River, China. *Sensors (Peterborough)*, 8(12), 8104–8122. doi:10.3390/s8128104
- Zube, E. H. (1987). Perceived land use patterns and landscape values. *Landscape Ecology*, 1(1), 37–45. doi:10.1007/BF02275264

*Implications of Spatial Sustainability on the Territorial Planning Framework in a
Transition Country*

Alexandru-Ionuț Petrișor, Vasile Meiță

NR&DI URBAN-INCERC, Romania

0234

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Sustainable development involves a synergic integration of social, economic, environmental, and cultural issues to a multi-scale hierarchy of territorial systems. This sentence underlines the importance of the territorial dimension of sustainability, in addition to the need for a systemic approach, and has special implications over spatial planning, accounting for the entire process related to landscapes, urban or rural settlements, including the design of sustainable constructions. The paper addresses environmental aspects of the planning process, using the Romanian planning system as a case study to look at the change of the general framework, moving from a sectoral approach to a holistic one, consistent with the recent developments of systemic ecology. In more detail, we propose a replacement of the traditional description of 'environmental factors' – air, water, soil, fauna, and flora – with an analytical and quantitative model developed under a systemic framework. The model consists of examining the spatial levels of biodiversity (correlated to the levels of the hierarchy of territorial units) and its conservation through natural protected areas, and a transitional dynamics based analysis of changes of land cover and use to account for the impact of humans. This approach is illustrated by its application to several territorial and urban plans, carried out at different spatial scales during the recent years. The results of this process underline the importance of applying a scientific methodology, focused on the reproducibility of results, to the planning process, and suggest that an up-to-date scientific substantiation is preferable to a legalistic understanding of planning.

Key words: planning, holistic, global changes, land cover and use, diversity.

1. Introduction

Since its first definition given in the late 1860 by Ernest Haeckel, the science of ecology has evolved and diversified continuously, establishing trans-disciplinary links with other subjects (such as economy, engineering, sociology, or architecture, to name only few of them) in order to form approximately 30 branches (Petrișor, 2012c). During this process, some of its paradigms have shifted:

- The main object shifted from individuals (pinpointed by Haeckel's definition) to 'coupled socio-ecological complexes of systems' (Vădineanu, 2004). This process became particularly obvious in the 1980's when ecologists embraced the systemic conception, perceiving the environment as a hierarchy of organized and dynamic units with quantifiable structural and functional properties (Vădineanu, 1998). Nevertheless, during this process nothing was lost; autecology (study of the relationships between individual organisms and abiotic environment) and synecology (study of the relationships between individual organisms belonging to different species) are stages in the evolution of ecology, but also current areas of interest for ecologists.
- A consequence of this evolution, already mentioned, is the evolution in perceiving the global environment, from an anthropocentric perspective placing man (individual or society) in the center and considering that the environment is simply what surrounds man, to differentiating 'factors' or 'components' within the surrounding (water, air, soil, flora, and fauna) and finally the holistic model based on a hierarchy of systems discussed above (Vădineanu, 1998, 2004).
- The hierarchy of systems is connected with different spatial and temporal attributes associated with the dynamics of each level. In simple terms, larger systems need more time to change than the smaller ones (Petrișor, 2011). A direct consequence is that, if accounting for the inter-conditioned dynamics of systems situated at different levels, described by the theory of 'panarchy' or adaptive cycles (Holling, 2004), a system cannot be analyzed separately from its components and integrated system, which determines the need for a multi-scale analysis (Petrișor, 2013). It has to be stressed out here that 'panarchy' replaces the succession theory, even though community ecologists still find succession more relevant for their studies.
- In 1970, geographer Waldo Tobler phrased a principle situated at the core of spatial analyses, referred later as 'The First Law of Geography': "*everything is related to everything else, but near things are more related than distant things*" (Tobler, 1970). Ecologists embraced the first part, and "*everything is related to everything else*" became a guiding principle of ecology. One of the most recent illustrations is the concept of 'global change', designated to encompass all man-driven impacts on the environment: energy use, land cover and energy changes, and climate change (Dale *et al.*, 2011).
- Inter- and trans-disciplinary approaches describe in the best way the relationship between ecology and other sciences. Interdisciplinary approaches are an intermediate step where concepts and methods are exchanged by different disciplines, resulting in the final trans-disciplinary stages into the creation of new disciplines (Kötter and Balsiger, 1999), such as social ecology, urban ecology etc.

In parallel with these shifts, ecologists had a particular interest in exploring the relationship between man and environment, resulting into the concept of 'sustainability' defined by the Brundtland Report as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987). The concept evolved towards a self-standing trans-disciplinary science, placed at the intersection of natural and socio-economic sciences, even though technical sciences are included as well. Several paradigms of sustainability have evolved too:

- Shifting the focus of development from addressing some ignored issues (*e.g.*, environmental) to a better integration of the three traditional pillars: economic, social, and ecological (Bugge and Watters, 2003)

- Adding a fourth cultural pillar by acknowledging the market value of the cultural capital and its potential for development (United Cities and Local Governments, 2010)
- Adding a spatial dimension, including the concept of ‘sustainable communities’ coined by the 2005 Bristol Accord (Office of the Deputy Prime Minister, 2006), but also linking to core concepts of territorial development, such as polycentricity and cohesion (Colignon, 2009); in the last case, environmental cohesion is an important component of ‘cohesion’
- In practical terms, sustainability presumes an utilization of resources within the carrying capacity limits and active strategies for reducing the generation of waste and pollution (reclaiming the environmental impact assessment to determine whether stocks are affected and internalize environmental and social costs due to the degradation of the environment and effects on human health through pollution) and the restoration of degraded systems, and is compatible with conservation of biodiversity (through natural protected areas) (Petrișor, 2011).

An important concept introduced in ecology in close relationship with sustainability is biodiversity. The concept was introduced by the 1992 Rio de Janeiro United Nations Conference on the Environment and Development to encompass the diversity of man-dominated systems (including ethno-cultural diversity) in addition to the one of biological systems at different levels (from genetic to taxonomic and ecosystemic variability), and gradually expanded against its semantic roots to include in addition to the diversity of the biological realm abiotic systems. As a consequence, eco-diversity (diversity of ecosystems and complexes of ecosystems, including biotic and abiotic components) was seen as part of biodiversity, even though in reality ecosystems include biotic components; if perceived correctly, eco-diversity is the ecological synonym of geographical ‘geo-diversity’ and includes biodiversity, in addition to the diversity of abiotic components – geological, climatic diversity, intermediary components – soil diversity, and ethno-cultural diversity (Petrișor and Sârbu, 2010). Biodiversity has, similarly to sustainability, a spatial dimension; the spatial levels of biodiversity are:

- α – ecosystem, community, taxonomic or functional group or biocoenose,
- β – ecosystems within an ecological complex, habitats or gradients,
- γ – regional ecological complex, large areas,
- δ – higher rank, macro-regional ecological complexes
- ε – life environments (oceanic, terrestrial),
- ω – phylogenetic / taxonomical hierarchy.

2. Sustainability and planning

Since sustainability accounts for the development of society, placing human beings at its core (United Nations, 1992b), it is tightly related to the planning process. Furthermore, spatial planning is also connected to sustainable spatial development. The concept of ‘spatial planning’ can be understood in general terms, overlapped with the ‘territorial planning’, or in a particular way in countries where the planning system has two levels (such as France and Romania), one dealing with larger territories (spatial planning) in strategic terms (general guidelines and objectives), and another tackling concretely, in regulatory terms, with the spatial development of urban and rural areas – ‘urban planning’ (Petrișor, 2010). In methodological terms, Lacaze (1990) identifies strategic planning, urban composition, and participatory, management and communication urbanism to be the core methods of spatial planning.

Furthermore, in addition to these characteristics, planning tends to be everywhere a regulated process. This means that a planner does not always have the possibility of a scientist to explore new ideas or methods, but instead needs to observe specific guidelines. In many countries, plans have the power of laws; once approved, they become the reference document for issuing a building or demolition permit, make changes in a certain area, and even direct investments. For this reason,

after their elaboration plans are subject to approval by representatives of different sectors from the public administration.

2.1. Current Romanian urban and spatial planning framework

The elaboration of plans in Romania is subject to legally approved guidelines. According to Grigorovschi (2008), the three legal documents governing the elaboration of urban and spatial plans are:

- A 1991 order of the Ministry of Public Works and Spatial Planning discussing the forms, authorization procedure and contents of urban and spatial plans,
- A 2006 proposed contents elaborated by NRDI UBANPROIECT in 2006, and
- A proposal started (and never completed) in 2008 by the Ministry of Development, Public Works and Housing

In addition to them, other particular documents discuss specific chapters. For example, a 2000 methodology jointly proposed by the Ministry of Waters, Forests and Environmental Protection and the Ministry of Public Works and Spatial Planning describes the contents and methodology for elaborating the environmental analyses, part of urban and spatial plans (Grigorovschi, 2008).

As it can be seen, the approved instruments in place are outdated, and the proposed instruments not only lack the legal status, but are also ageing. Their contents no longer reflects the theoretical developments in ecology; it indicates an erroneous sectoral perception of the environment, using the outdated concept of 'environmental factors' (water, air, soil, flora, and fauna), and tend to introduce a merely descriptive rather than analytical methodology.

2.2. An emerging methodology

Attempting to develop a novel methodology, compliant with the progress of ecology, the core principle observed was that environmental protection is equivalent to the conservation of biodiversity, representing the 'ecological foundation' (Vădineanu, 2004). However, the 'Zero Growth Strategy' introduced a different view of conservation, as a strict preservation of ecological systems in an intact state (Meadows *et al.*, 1972). Sustainability changes the paradigm of conservation, perceiving it as a man-driven support for the self-maintenance of ecosystems within their carrying capacity limits (Petrișor, 2011). By doing it, conservation becomes compatible with development, as long as development aims for safeguarding a part of current biodiversity for future generation through an active management ensuring that the activities carried out within and around protected areas are designed for a long term.

From this perspective, understanding the environmental system representing the object of an urban or spatial plan needs to address several issues:

- Identify correctly and comprehensively all the components of biodiversity, accounting for the spatial variability of the systems
- Identify the main stressors that are likely to affect biodiversity and propose concrete strategies for the mitigation or reduction of their effects, unless complete elimination is possible
- Describe the actions aimed at conserving biodiversity, including the environmental impact assessment, ecological restoration, and natural protected areas

In order to accommodate these requirements, the plan should include:

- A general characterization of diversity, discussed in the next section, based on the ecological or biogeographical regions, relief units etc., types of ecosystems or habitats, as reflected by land cover and/or use, including changes across time, natural habitats, if known (*e.g.*, NATURA

2000 sites in Europe benefit upon an inventory of the habitats constituting a priority for conservation, in accordance with the Habitats Directive)

- Data on elevation, hydrography, climate (including predicted changes, as underlined by DIVA-GIS data), soils (if available), fauna and flora (including protected species from global and national Red Lists; in Europe, particular requirements are added by the Birds Directive)
- Natural protected areas of national/global designated in accordance with the International Union for the Conservation of Nature guidelines, and of regional or local importance
- Natural hazards: floods, landslides, earthquake (zoning)
- Possible impact of proposed modifications on the ecological systems
- Proposals based on the results of all analyses presented above, including mitigation or reduction of impacts

2.1.1. Identifying the components of biodiversity

It is very easy to list the components of biodiversity based on the text of the Convention on Biological Diversity (United Nations, 1992a):

- Diversity of terrestrial, marine and other aquatic ecological complexes
- Diversity of terrestrial, marine and other aquatic ecosystems
- Diversity between species (phylogenetic)
- Diversity within species (genetic)

However, reading between the lines, as shown in the previous section, several other components need to be explicated:

- Diversity of abiotic components
- Ethno-cultural diversity

The next question is asked from a practical perspective. Detailing and illustrating each component for all systems and sub-systems analyzed in a plan is impossible. Moreover, a simple list is not relevant to spatial planning. Therefore, for each spatial level diversity must be assessed correlated to its spatial level (dependent on the size of system), the size of administrative / territorial units (reflected in Europe by the Nomenclature of Territorial Units for Statistics – NUTS), and, for practical reasons, a certain classification able to produce reproducible results and a common understanding. Taking into account all these requirements, the proposed methodology utilizes, for different spatial levels, the correspondence presented in Table 1.

As it can be seen, the practical relevance is ensured by using globally or widely accepted classifications: the European Nature Information System (EUNIS) classification of habitats, the land cover and use classification systems (Anderson *et al.*, (1976) in the United States and CORINE in Europe), the World Wide Fund for Nature classification of ecological zones, used by the European Environment Agency as well, the European Environment Agency classification of biogeographical regions used in the European Union, and Pielou's (1979) classification of global biogeographical regions.

Table 1. Correspondence of the hierarchies of systems in ecology and spatial planning and spatial diversity

Ecological system	Classification	Spatial Planning (NUTS level)	Diversity
Structural and functional subunits of ecosystems	EUNIS habitats	-	α, ω
Ecosystem	Land cover and use (CORINE, Anderson)	NUTS V (LAU II)	α, ω
Regional ecological complex	Ecological regions (second level), relief units	NUTS III	β, γ, ω
Macro-regional ecological complex	Continental biogeographical regions, ecological regions (first level), relief units	NUTS II, NUTS I national territory, continent	$\gamma, \delta, \varepsilon, \omega$
Ecosphere	Global biogeographical regions	Globe	ω

2.1.2. Land cover and use and their changes as planning instruments

Jensen (2000) considers ‘*land cover*’ an indication of what lays on the ground surface from a biophysical viewpoint, while ‘*land use*’ shows its usage by human communities. The second definition is perfectly valid for land situated in man-dominated systems, where communities use it; in natural systems, ‘*land use*’ is simply a detailed classification (Petrișor *et al.*, 2010). Changes in land cover and use reflect transitional dynamics; some of them can pinpoint human impacts, and even persisting trends. Examining all trends based on long-term data (1990-2006) covering the entire territory, Petrișor (2012c) identified several underlying causes, presented below; most of them are not characteristic to Romania only, but specific to transition countries.

- Urbanization (including changes of agricultural or natural systems into urban areas, but also land use changes indicating the growth of urban areas within their limits: conversion of construction sites or urban green spaces into urban fabric, transformation of discontinuous urban fabric into continuous urban fabric)
- Two opposite phenomena affect agriculture: development and abandonment of agricultural land
- Other opposite phenomena affect forests: deforestation and their regeneration due to natural causes (reforestation) or induced by man (afforestation)
- To a very little extent, floods (both periods), dams, desertification, and drainage of waters (1990-2000 only)

3. Examples

Three examples have been chosen based on their scale to illustrate the approach:

1. A study carried out at the level of the Romanian regions of development (NUTS 2) to look at their environmental potential as a part of the substantiation study for the National Concept of Spatial Development (Petrișor, 2008), presented in Fig. 1,
2. A study carried out at the regional level of county (NUTS 3) to analyze the environmental issues of Vrancea County, displayed in Fig. 2, and
3. A local study looking at a small commune (NUTS 5 or LAU 2), Dobrun, situated in Olt County, showed in Fig. 3.

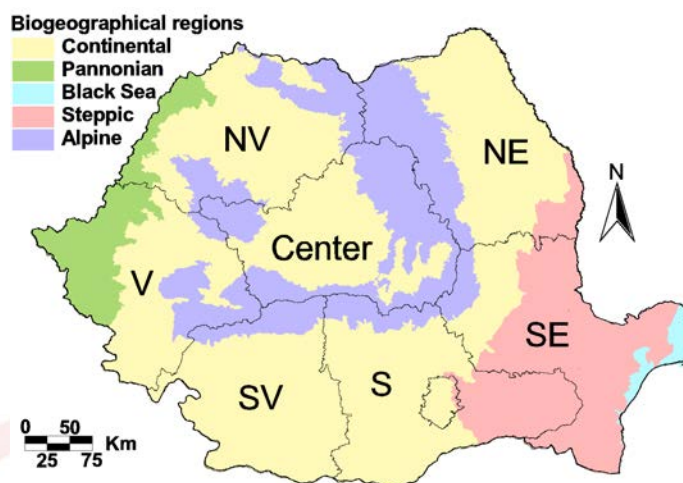


Fig. 1. Environmental status of the Romanian regions of development. The image displays the biogeographical regions, classified according to the European Environment Agency, overlapped with the administrative divisions.

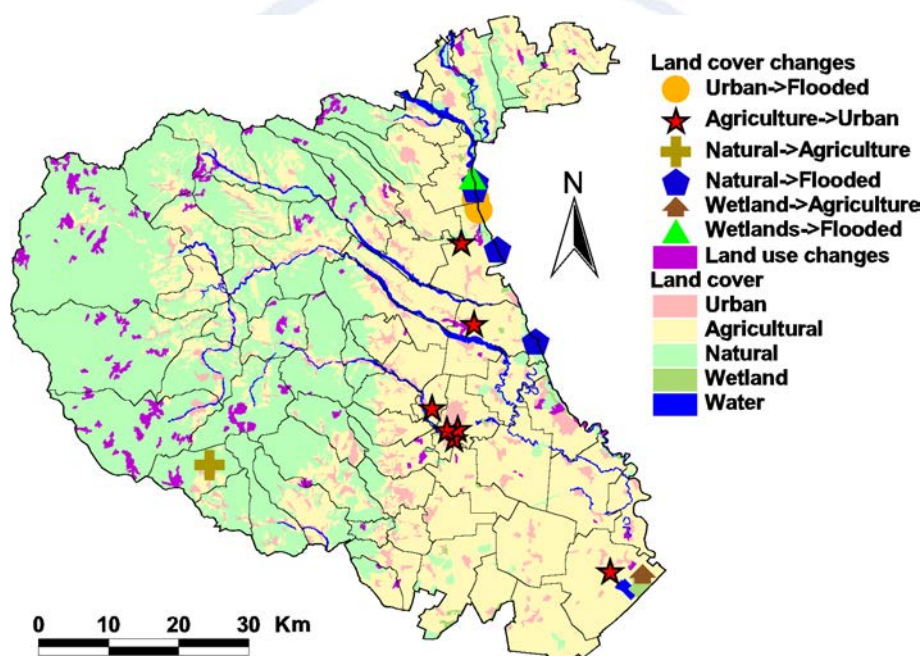


Fig. 2. Environmental status of Vrancea County, Romania. The image displays land cover overlapped with the administrative divisions (for precise location of issues) and land cover and use changes occurred during 1990-2000, using CORINE data from the European Environment Agency.

The three studies allowed for pinpointing specific environmental issues:

1. The first study presented in Fig. 1 underlines the natural diversity of Romania. The image itself does not speak for itself, but it has to be stressed out that there are 11 European biogeographical regions; large countries, such as Spain or Germany, have only two or three of them, while Romania, due to its geographical position, has five. Consequently, even small biogeographical regions have two or three biogeographical regions, equaling in diversity large countries.
2. The analysis of environmental issues of Vrancea County displayed in Fig. 2 looked separately at land cover and use changes. Land use changes are not covered in detailed typology, but are showing the extent of human interventions. Their density in the natural areas from the western part of the county pinpoints an important phenomenon, deforestation, occurred in Romania as a consequence of the restitution of forests as part of the goods confiscated from people by the communist regime. The economic decline, combined with no legislation establishing duties of owners, made most of the new owners cut down their new property for immediate gain. Land cover changes are more important in showing trends; some of them lie down over the eastern

border, represented by a river (Prut). They are consequences of the floods, determined most likely by the forest cuts mentioned before. Other changes are concentrated around a city (Focșani), the administrative center ('residence') of the county. Its economic strength determined an intense urbanization of adjacent areas, by converting former agricultural land into urban areas.

3. The study looking at Dobrun commune in Olt County, showed in Fig. 3, shows another interesting issue. The only land use change is due to the deforestation of a forest situated in the west of the area, transformed into a transitional shrub-woodland. However, the area affected by change is situated within an important Special Area of Conservation, part of Natura 2000 network. One would ask, 'How would it be possible without violating the restrictions?' The answer consists of the temporal dimension: CORINE data show changes occurred during 1990-2000, while the declaration of Natura 2000 sites was completed in 2008. Therefore, the deforestation occurred prior to the declaration of the area as a Natura 2000 site. Nevertheless, previous actions are likely to set their fingerprint over the structural and functional integrity of the site.

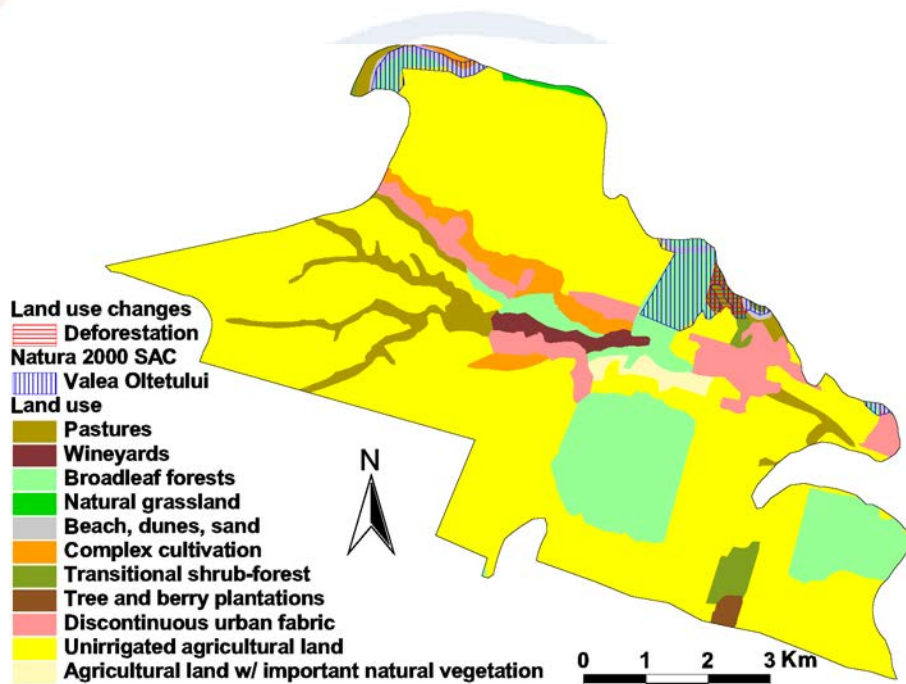


Fig. 3. Environmental status of Dobrun Commune in Olt County, Romania. The image displays land use overlapped with the most important natural protected areas and land use changes occurred during 1990-2000, using CORINE data from the European Environment Agency.

4. Architectural consequences

Since the need for a systemic approach has been underlined, in correlation with the spatial scale, a natural question relates to the next level: what are the consequences of spatial plans and associated environmental studies on the architectural design and constructive engineering details of buildings? To answer this question, several previous findings have to be reiterated:

- A study carried out over the Danube Delta Biosphere Reserve started with the spatial planning issues, moving down to the seismic and energy-use criteria, tackling also with the architectural constraints needed to preserve ethno-cultural diversity (including traditional architectural solutions) in addition to biodiversity; the result was a set of architectural constraints imposed to the new buildings (Meiță *et al.*, 2011)
- An analysis of exposure to natural hazards showed the need for spatial continuity in zoning the risk from regional mapping down to urban mapping and finally knowing exactly the buildings at risk in an urban or rural region; the design of new building, but also the consolidation of existing ones, needs to take into account these criteria (Georgescu *et al.*, 2012)

- Other particular examples include criteria for designing buildings in earthquake prone areas, in protected areas containing natural or heritage sites, or in vulnerable areas (already discussed in the detailed studies above), and buildings accommodating the mitigation of climate change effects (Petrișor, 2013)

5. Conclusion

The paper attempted to introduce a methodology based on the systemic theory used for elaborating the environmental studies representing a part of the urban and spatial plans. Several examples illustrated the analytical potential of the method. The results underline the importance of applying a scientific methodology focused on the reproducibility of results to planning, suggesting that an up-to-date scientific substantiation is preferable to a legally valid, but scientifically outdated approach.

References

- Anderson JR, Hardy EE, Roach JT, Witmer RE (1976), *A land use and cover classification system for use with remote sensor data*, US Geological Survey Professional Paper **964**, 28 pp.
- Brundtland GH (1987), *Our Common Future*, WCED, Oxford University Press, Oxford.
- Bugge HC, Watters L (2003), *A Perspective on Sustainable Development after Johannesburg on the Fifteenth Anniversary of Our Common Future: An Interview with Gro Harlem Brundtland*, Georgetown International Environmental Law Review **15**:359-366.
- Colignon P (2009), *Situation and challenges of the rural space: Heritage and landscape at the core of sustainable development objectives* [in French], European Spatial Planning and Landscape **88**:99-103.
- Dale VH, Efroymson RA, Kline KL (2011), *The land use–climate change–energy nexus*. Landscape Ecology **26**: 755-773.
- Georgescu ES, Meiță V, Petrișor AI, Simion-Melinte CP (2012), *Using GIS to manage and assess urban risks. A review comparing the experiences of Romania (in a European context) and the United States of America*, ACSEE 2012. The Asian Conference on Sustainability, Energy & the Environment Proceedings, The International Academic Forum, Japan, pp. 135-147
- Grigorovschi M (2008), *Strategic planning in trans-boundary spatial planning in a European context* [in Romanian], Alfa Press, Iași, Romania, 348 pp., ISBN 973-8953-72-3.
- Holling CS (2004), *From complex regions to complex worlds*, Ecology and Society **9**(1), <http://www.ecologyandsociety.org/vol9/iss1/art11/>
- Jensen JR (2000), *Remote Sensing of the Environment. An Earth Resource Perspective*, Prentice Hall, Upper Saddle River, New Jersey, 544 pp., ISBN 9780134897332.
- Kötter R, Balsiger PW (1999), *Interdisciplinarity and Transdisciplinarity: A Constant Challenge To The Sciences*, Issues in Integrative Studies **17**:87-120.
- Lacaze JP (1990), *Methods of urbanism. Second corrected edition* [in French], French University Press, Paris, France, 127 pp., ISBN 978-2130452140.
- Meadows DH, Meadows DL, Randers DL, Randers J, Behrens WWIII (1972), *The limits to growth: A report for the club of Rome's project on the predicament of mankind*, Potomac Associates Books, Earth Island, London, UK, 205 pp., ISBN 0856440086.
- Meiță V, Georgescu E-S, Petrișor AI (2011), *Sustainable spatial development in the Danube Delta Biosphere Reserve: Planning, architecture, seismic, construction and energy-related criteria*, ACSEE 2011. The Asian Conference on Sustainability, Energy & the Environment Proceedings, The International Academic Forum, Japan, pp. 53-70
- Office of the Deputy Prime Minister (2006), *A common approach to creating sustainable communities: "The Bristol Accord"*, in: UK Presidency. EU Ministerial Informal on Sustainable Communities. Policy Papers, ODPM Publications, London, Document 05 EUPMI 03656/A

- Petrișor AI (2008), *Levels of biological diversity: a spatial approach to assessment methods*, Romanian Review of Regional Studies **4(1)**:41-62.
- Petrișor AI (2010), *The Theory and Practice of Urban and Spatial Planning in Romania: Education, Laws, Actors, Procedures, Documents, Plans, and Spatial Organization. A Multiscale Analysis*, Serbian Architectural Journal **2(2)**:139-154.
- Petrișor AI (2011), *Systemic theory applied to ecology, geography and spatial planning*, Lambert Academic Publishing, Saarbrücken, Germany, 172 pp., ISBN 978-3-8465-0260-0.
- Petrișor AI (2012a), *Comparative critical analysis of systems studied by ecology, geography and spatial planning*, in: Posea G, Andrei MT, Zăvoianu I, Cruceru N, Benea I, Văduva I, Dumitrașcu C, *Landscapes: Perception, knowledge, awareness, and action. Proceedings of the FG-SHU International Symposium on Geography*, Addleton Academic Publishers, New York, NY, US, ISBN 978-1-935494-34-8, vol. 1, pp. 94-108.
- Petrișor AI (2012b), *Dynamics of the environmental transformation processes during 1990-2006 in Romania reflected by land cover and use changes*, Present Environment and Sustainable Development **6(1)**:353-365.
- Petrișor AI (2012c), *Editor's note*, IAFOR Journal of Sustainability, Energy and the Environment, <http://iafor.org/acseejournal.html>
- Petrișor AI (2013), *Multi-, trans- and inter-disciplinarity, essential conditions for the sustainable development of human habitat*, Urbanism. Architecture. Constructions **4(2)**:43-50.
- Petrișor AI, Ianoș I, Tălângă C (2010), *Land cover and use changes focused on the urbanization processes in Romania*, Environmental Engineering and Management Journal **9(6)**:765-771.
- Petrișor AI, Sârbu CN (2010), *Dynamics of geodiversity and eco-diversity in territorial systems*, Journal of Urban and Regional Analysis **2(1)**:61-70.
- Pielou EC (1979), *Biogeography*, Wiley Interscience, New York, NY, USA, 351 pp., ISBN 0471058459.
- Tobler W (1970), *A Computer Movie Simulating Urban Growth in the Detroit Region*, Economic Geography **46(2)**:234-240.
- United Cities and Local Governments (2010), *UCLG Policy Statement. Culture: Fourth Pillar of Sustainable Development*, 3rd World Congress of United Cities and Local Governments, http://agenda21culture.net/index.php?option=com_content&view=article&id=46&Itemid=63&lang=en
- United Nations (1992a), *Convention on Biological Diversity*, Rio de Janeiro, Brazil, <http://www.cbd.int/doc/legal/cbd-en.pdf>
- United Nations (1992b), *Report of the United Nations Conference on Environment and Development*, Rio de Janeiro, Brasil, document A/CONF.151/26, <http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm>
- Vădineanu A (2004), *Management of development: an ecosystemic approach* [in Romanian], Ars Docendi Press, Bucharest, Romania, 394 pp., ISBN 973-558-070-5.
- Vădineanu A. (1998), *Sustainable development, vol. 1. Theoretical foundations of sustainable development* [in Romanian], University of Bucharest Press, Bucharest, Romania, 248 pp., ISBN 973-975-256-5.

Total Sulfur Deposition over Forest in Tropical Climates, Thailand

Phuvasa Chanonmuang, Pojanie Khummongkol

King Mongkut's University of Technology Thonburi, Bangkok, Thailand (1), , ,

0239

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Sulfur (S) is the key component of atmospheric acid deposition on ecological system. This study, S components were collected by a four-stage filter pack over a tropical forest from June 2011 to May 2012 at Sakearat Environmental Research Station. The experiment was operated under conditional sampling technique or relaxed eddy accumulation (REA) method. This method was deployed to sample concentration of aerosol particulates and gases over the forest canopy. The REA system consisted of a 3D sonic anemometer, a flow controlling device, software for switching valve controller and a chemical collecting equipment. Concentration and continuous micrometeorological data were measured on a tower height of 36 meter. The S components were analyzed by an ion chromatography. Deposition fluxes of S components were computed by $F = \beta \sigma_w (\bar{C}_{up} - \bar{C}_{dn})$. The empirical coefficient value (β) for the REA equation was evaluated to be 0.50 ± 0.04 . The deposition flux of S over the forest canopy was determined to be 1.7 and $57.2 \text{ ng m}^{-2} \text{ s}^{-1}$, for the dry and the wet season, respectively. The annual mean value for the flux was determined to be $20 \text{ ng m}^{-2} \text{ s}^{-1}$. The deposition velocities were evaluated to be 0.7 and 1.0 cm s^{-1} , for the dry and the wet season, respectively. The annual mean deposition velocity of S was 0.9 cm s^{-1} .

Keyword: Relaxed eddy accumulation, deposition flux, deposition velocity, β empirical coefficient

1. INTRODUCTION

Acid atmospheric substances have been in focused in many areas of source emissions including industrial estate, city, agriculture, water surface and forest. The atmospheric deposition is the primary removal processes of atmospheric pollutants in gaseous and aerosol phases[1]. They deposit in both wet and dry forms. The wet deposition is characterized by the amount of acid substances dissolved in droplets of rain or dew and then precipitate to the ground. The dry deposition consists of gas and aerosol particles deposited on the earth surface at any time with no rain involved.

Total sulfur (TS) referred to sulfur constituents in both gaseous and aerosol forms. They are the key chemical species of the acid deposition. The main emission source of gaseous sulfur constituent (SO_2) is from fossil fuel combustion in the power plant. Other sources come from sea salt (sulfate), chemical production (H_2SO_4) and secondary photochemical reactions of primary acids (SO_2 , NO, etc.) that eventually become new sulfur constituents of SO_4^{2-} . To determine the amount of TS dry deposition requires an appropriate method to collect the air samples as well as to calculate their flux values. Currently, the relaxed eddy accumulation (REA) is a successful method for fluxes measurement of several chemical components, for example, volatile organic compounds (VOC), SO_2 , SO_4^{2-} [2, 3]. The REA method does not require a fast-response sensor or device to measure the chemical species.

The purpose of this study is to estimate the dry deposition flux and a global deposition velocity of total sulfur (TS) over the forest using the relaxed eddy accumulation method. The study also investigates some influences of meteorological parameters over the amount of deposition flux and hence, a global deposition velocity.

2. METHODOLOGY

2.1 Relaxed eddy accumulation

The eddy accumulation (EA) method was initiated by Desjardins 1977[1] to directly collect the atmospheric samples using two separate reservoirs for positive and negative vertical wind velocities. The relaxed eddy accumulation method (REA) is the work of Businger and Oncley 1990[4-6]. They combine the EA method with the flux-variance similarity. Their method becomes an indirect method. REA was utilized to estimate fluxes of atmospheric trace species both aerosol particles and gases phase. Moreover, the advance of the REA method can be applied to atmospheric monitoring for which fast response equipment is not available. The vertical mass flux is equal to the difference in the mean concentration of the trace gas of interest between the upward and downward moving eddies, multiplied by the standard deviation of the vertical wind velocity and an empirical coefficient. The flux of atmospheric can be determined by the following equation (1).

$$F = \beta \sigma_w (C_{\text{up}} - C_{\text{dn}}) \quad (1)$$

Where β is empirical coefficient, σ_w is the standard deviation of vertical wind velocity w and $C_{\text{up}} - C_{\text{dn}}$ are the average concentrations of chemical species in the updrafts and downdrafts, respectively[4, 7]. The value of β has to be estimated from the parameters that measure at a specific site or experimental area. The necessary parameters for β calculation were measured by a sonic anemometer such as vertical wind speed and standard deviation and fluctuation

temperature[8]. The β coefficient was computed with the REA method following equation equation (2).

$$\beta = F_H / \sigma_w (T_{up} - T_{dn}) \quad (2)$$

where F_H is the sensible heat flux ($w't'$) and T_{up} and T_{dn} are the average temperatures of the updraft and downdraft direction, respectively[9]. The β is constant value for flux estimation in equation (1), which is from the parameter measurement at a specific area.

The first suggested of β value is 0.6[4] or namely Businger constant (β). Gallagher et al. used a β value of 0.58 ± 0.13 for their experiment[2]. Other products are still closer to those obtained such as Hamotani et al. (1996), Baker et al. (1992), Pattey et al. (1993) and Woods (1997) have resulted of β value ranging 0.56-0.6[7, 10, 11].

2.2 Site description

The Sakaerat Environmental Research Station (SERS) was located at $14^\circ 30' 13.68''$ N, $101^\circ 57' 8.67''$ E in a height land (300 meters above sea level) in the northeast of Thailand (Fig. 1). The area was surrounded by mountain series of 200-272 m height. SERS covers an area of 78 km² by two major forest types: dry evergreen forest (DEF) and dry dipterocarp forest (DDF). Other tree species are bamboo, planted trees, and grasslands. The height of trees was varying between 20-27 m. A highway was situated on the eastern side about 1.5 km from the experimental site. The residential area was surrounded about 20-30 km in the northwest and the southwest direction.

2.3 Experimental system

The REA system consisted of two air samplers, a switching valve controller, a 3D-anemometer, a micrometeorological recorder and a concentration analyzer. The sampling system was designed to take the air through a single inlet at a constant flow of 10 Lmin⁻¹ into one of the three filter collectors functioning as updraft (+), mid-draft and downdraft (-) for later analysis of the mean concentration of SO₂. The direction of the air intake in to which filter controlled by a three-ways switching solenoid valve which received signal from the 3D ultrasonic anemometer (HD2003-HD2003.1 model) to indicate the wind direction (Fig. 2). The air collectors are inline filter pack type without particles size cut to avoid aerosol particle deposited on the tube surface. A dynamic velocity deadband was preset at 0.13 ms⁻¹. When the vertical wind velocity was below 0.13 ms⁻¹, the air sample would be directed to flow into the mid-draft filter and discarded.



Figure 1 Location of the SERS research site in the northern Thailand

This study considered a total sulfur deposition which included both gas and aerosol phases. The collection period for daytime was 6:00 – 18:00 hr and for nighttime was 18:00 – 6:00 hr. The air collectors and the ultrasonic anemometer were installed at the same level of 36 m on the tower. The collected samples were extracted and analyzed, following the Guidelines for Acid Deposition Monitoring in East Asia (EANET) and technical Document for Filter Pack Method in East Asia[12], using an ion chromatograph (IC).

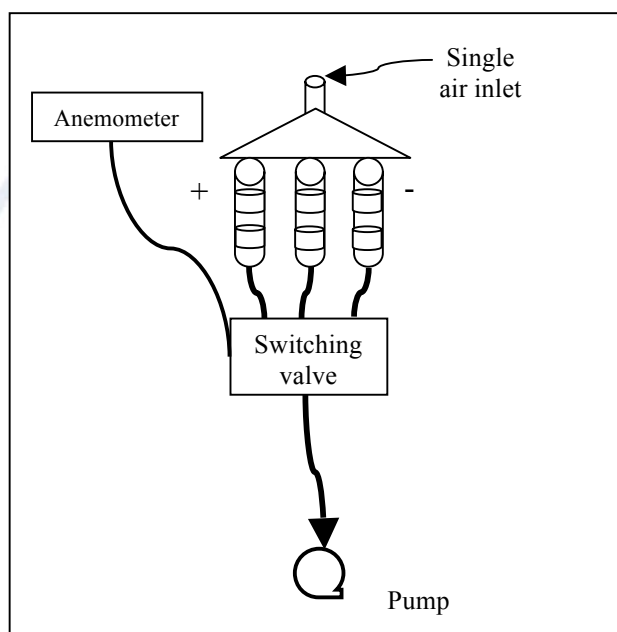


Figure 2 Schematic drawing of the relaxed eddy accumulation air sampling system.

3. RESULT AND DISCUSSION

3.1 Atmospheric conditions

The meteorological parameters in Fig. 3 show the averaged atmospheric condition at the study site during the experimental period (June 2011 – May 2012). The observed values of the wind speed (WS), temperature (T), rainfall (RF) and relative humidity (RH) were found in ranges of 0.19-0.43 m/s, 21.5-27.2 °C, 0-12 mm and 71.9-84.1%, respectively. The amounts of rainfall in (March-October) were measured to be 4.1-11.4 mm and no precipitation reported in November-February.

a

b

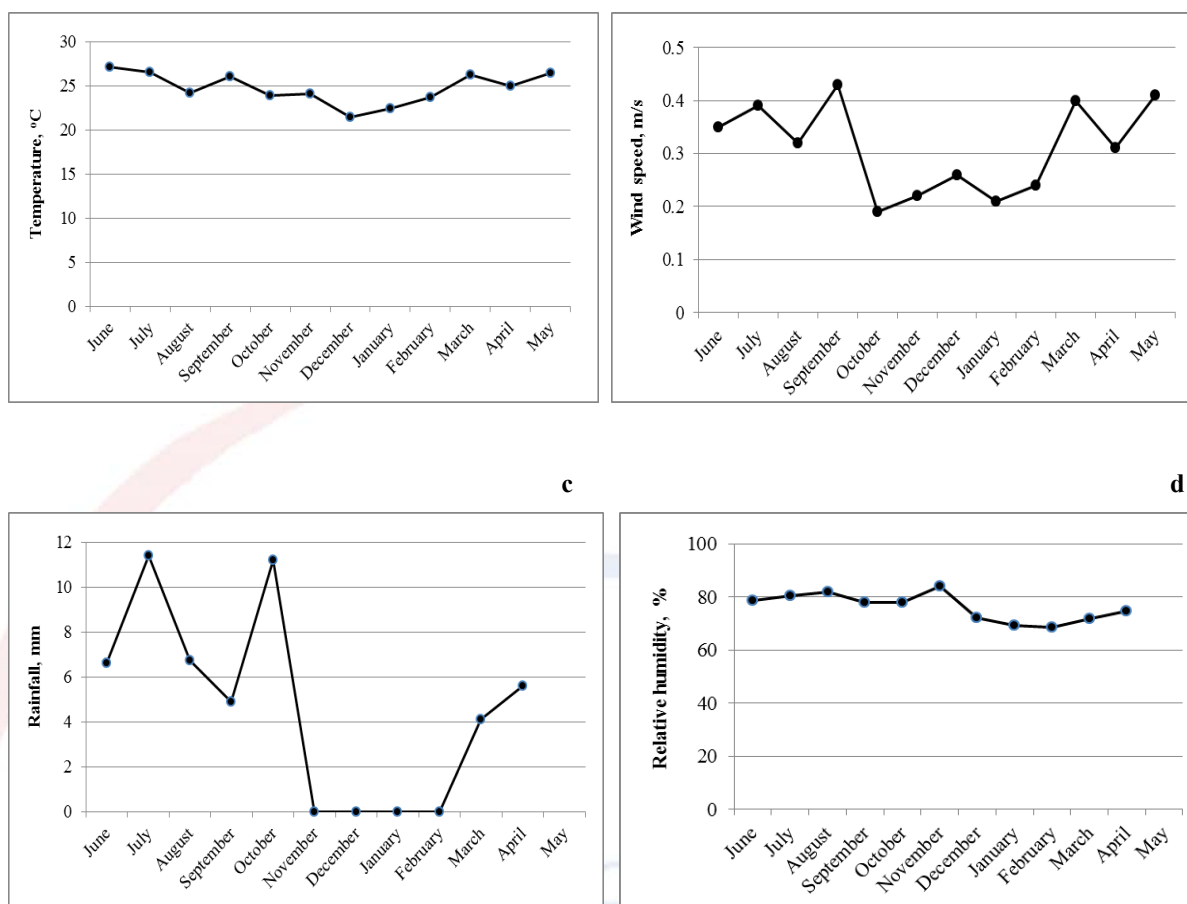


Figure 3 Meteorological parameters measured during June 2011 – May 2012.

3.2 Empirical coefficient (β)

In this experiment, the β value for flux estimation in Eq. 1 was determined by Eq. 2 and the average value for one year was 0.50 ± 0.04 . Fig. 4 shows a monthly variation of β coefficient that fell within a range of 0.42 – 0.60.

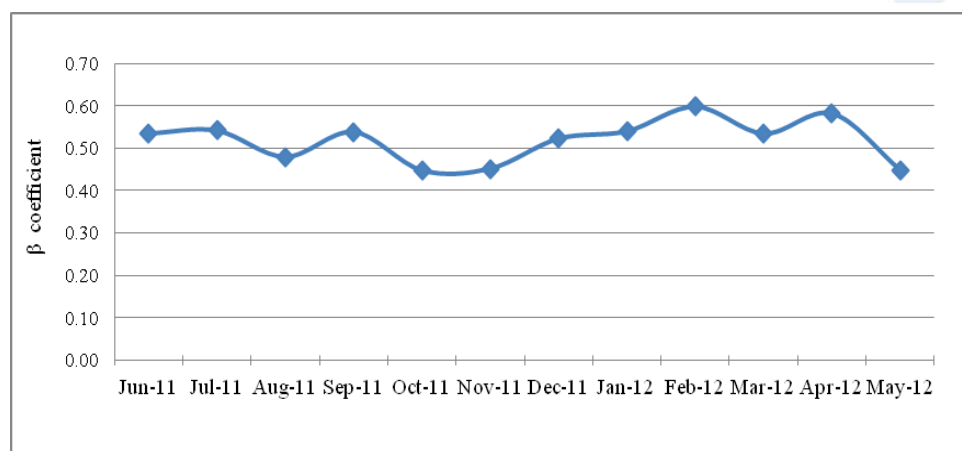


Figure 4 Evaluation of monthly Empirical coefficient (β)

3.3 Total sulfur concentration

Fig. 5 shows monthly average concentrations of SO_2 and SO_4^{-2} in the atmospheric layer over the forest. The concentrations were averaged from the updraft, the mid-draft and the downdraft samples collected by the filter packs. The measured concentrations of SO_4^{-2} and SO_2 were found in ranges of $0.25\text{-}1.4 \mu\text{g m}^{-3}$ and $0.1\text{-}0.6 \mu\text{g m}^{-3}$, respectively. It was observed that the concentration of SO_4^{-2} and SO_2 were in close ranges during the wet and humid seasons (June-October 2011 and March-May 2012). It is also noticeable that SO_4^{-2} existed in higher concentrations compared with SO_2 during the dry and low humidity conditions (November 2011-February 2012).

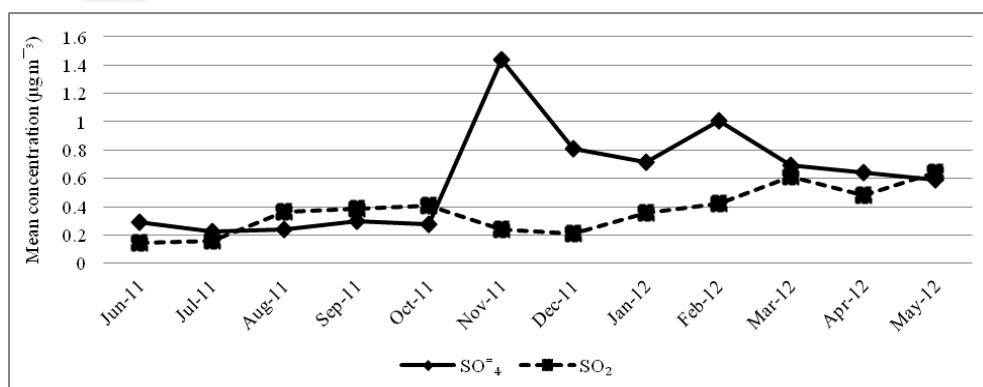


Figure 5 Average measured concentrations of SO_4^{-2} and SO_2 during June 2011 – May 2012.

Fig. 6 shows average concentrations of TS that derived from SO_4^{-2} and SO_2 . The concentration of SO_4^{-2} was observed to increase with the ambient humidity. In November 2012, the TS reached the maximum value of 600 ng m^{-3} when the relative humidity was also reached the maximum value of 84.1%. It is believed that SO_2 reacted with water vapor (H_2O) to form a particulate SO_4^{-2} and sulfuric acid mist [13, 14].

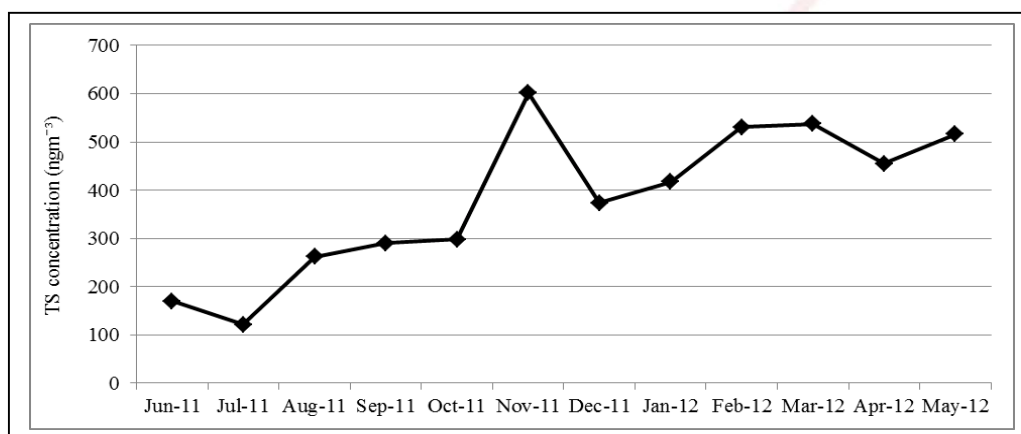


Figure 6 Average concentrations of TS during June 2011 – May 2012.

3.4 Deposition flux and global deposition velocity estimation

Fig. 7 shows the monthly variation of total sulfur (TS) deposition fluxes and global deposition velocities. The term global is referred to the combined deposition velocities of SO_2 and SO_4^{2-} i.e., TS. It was found that the deposition fluxes and the global deposition velocities were low in the dry season (November 2011 to January 2012) where all the important meteorological parameters, i.e. the temperatures, the wind speeds, the relative humidity and the amount of rainfalls were low also during the same period (See Fig. 3a-d). The deposition fluxes during the dry season were observed within a range of $6\text{-}20 \text{ ng m}^{-2} \text{ s}^{-1}$ and the global deposition velocities were calculated to be $0.04\text{-}0.07 \text{ cm s}^{-1}$. The high values of fluxes as well as the deposition velocities were found during the hot and humid conditions (June-August 2011 and April-May 2012) where the relative humidity reached 80%. The high fluxes were found in a range of $100\text{-}120 \text{ ng m}^{-2} \text{ s}^{-1}$ and the high deposition velocities were determined to be $0.18\text{-}0.28 \text{ cm s}^{-1}$. It was detected some errors found in measurements for the values obtained in March 2012. Fig. 8 also shows a similar trend between the wind speed and the global deposition velocities.

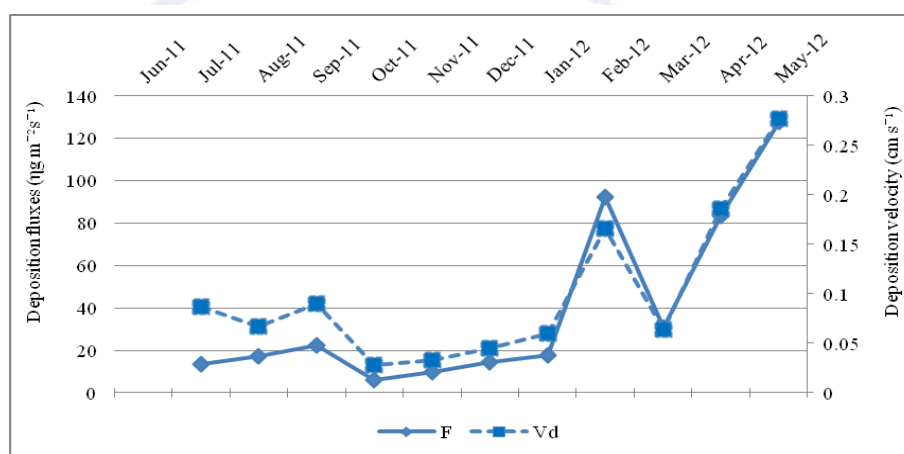


Figure 7 Monthly variation of deposition fluxes and global deposition velocities of TS during June 2011 – May 2012.

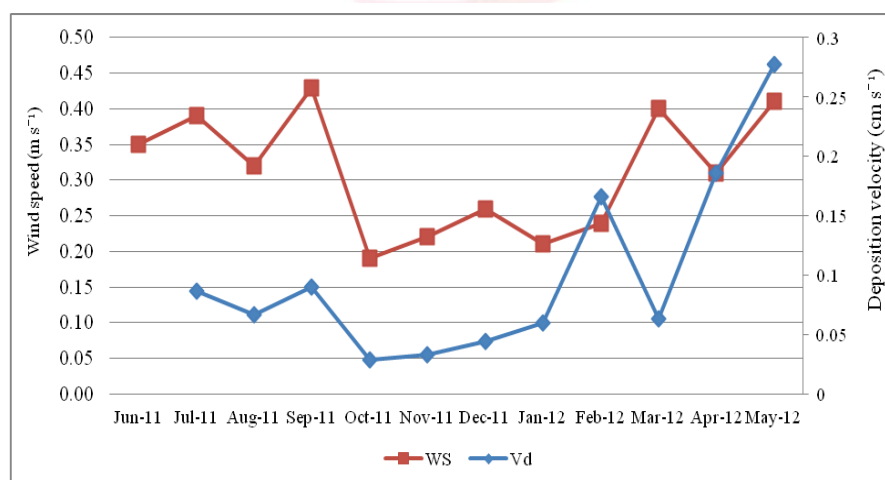


Figure 8 A similar trend of monthly variation of global deposition velocities of TS and wind speed.

4. CONCLUSION

The important meteorological parameters affecting the dry deposition fluxes of TS were observed to be the amount of rainfall, the relative humidity and the wind speed. The monthly average of temperature was not substantially varied in the tropical climate therefore, its effects on the amount of deposition was not clearly shown. The amount of TS deposition flux was observed to be $1.7 \text{ ng m}^{-2} \text{ s}^{-1}$ and $57.2 \text{ ng m}^{-2} \text{ s}^{-1}$ in the dry and wet season, respectively. The annual average of TS was $20 \text{ ng m}^{-2} \text{ s}^{-1}$. The global deposition velocity of TS was determined to be 0.9 cm/s.

5. ACKNOWLEDGMENTS

The authors acknowledge Mr. Taksin Artchawakom, director of SERS and all staffs for their support of this study. This work received a grant from the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology.

6. REFERENCES

1. Desjardins, R.L. (1977), Description and evaluation of sensible heat flux detector., *Boundary-Layer Meteorol*, 11, pp. 147-154.
2. Gallagher, M.W., Clayborough, R., Beswich, K.M., Hewitt, C.N., Owen, S., Moncrieff, J. and Pilegaard, K (2000), Assessment of a relaxed eddy accumulation for measurements of fluxes of biogenic volatile organic compounds: study over arable crops and a mature beech forest, *Atmospheric Environment*, 34, pp. 2887-2899.
3. Bowling, D.R., Turnipseed, A.A., Delany, A.S., Baldocchi, D.D., Greenberg, J. P. and Monson, R. K. (1998), The use of REA to measure biosphere atmosphere exchange of isoprene and other biological trace gases, *Oecologia*, 116, pp. 306-315.
4. Businger, J.A., Oncley, S. P., (1990), Flux measurement with conditional sampling., *Atmospheric and Oceanic Technology*, 7, pp. 349-352.
5. Majewski, M., Desjardins, R., Rochette, P., Pattey, E., Selber, J. and Glotfelty, D. (1993), Field Comparison of an Eddy Accumulation and an Aerodynamic-Gradient System for Measuring Pesticide volatilization Fluxes, *Environmental Science Technology*, 27, pp. 121-126.
6. MacPherson, J.I.a.D., R. L. (1991), Airborne tests of flux measurement by the relaxed eddy accumulation technique. Proceeding of the seventh Symposium on Meteorological observations and Instrumentation, New Orleans, LA, *American Meteorological Society*, pp. 13-18.
7. Baker, J.M., Norman, J.M. and Bland, W. L., (1992), Field scale application of flux measurement by conditional sampling., *Agricultural and Forest Meteorology*, 62, pp. 31-52.
8. Gaman, A., Rannik, U. and Aalpo, P., Pohja, T., Siivola, E., Kulmala, M., Vesala, T (2004), Relaxed Eddy Accumulation System for Size-Resolved Aerosol Particle Flux Measurement, *American Meteorological Society*, 21, pp. pp.933-943.
9. Myles, L.T., Meyer, T. P. and Robinson, L. (2007), Relaxed eddy accumulation measurements of ammonia, nitric acid, sulfur dioxide and particulate sulfate dry deposition near Tampa, FL, USA, *Environmental Research Letters*, 2, pp. 8 pages.
10. Pattey, E., Desjardins, RL, Rochette, P. (1993), Accuracy of the relaxed eddy accumulation technique, evaluated using CO₂ flux measurements., *Boundary-Layer*

- Meteorol*, 66, pp. 341-355.
11. Hamotani, K., Uchida, Y., Monji, N. and Miyata, A. (1996), A System of the Relaxed Eddy Accumulation Method to Evaluate CO₂ Flux over Plant Canopies, *Agricultural and Forest Meteorology*, 52, pp. 135-139.
 12. Acid Deposition Monitoring Network in East Asia (2000), Guideline and Technical manual for Acid Deposition Monitoring network in East Asia, pp.
 13. Grant, W.B. (2003), *Acid rain and deposition: Handbook of Weather, Climate, and Water; Atmospheric Chemistry, Hydrology, and Societal Impacts*. vol. John Wiley and Sons, New Jersey.
 14. Held, A., Zerrath, A., McKeon, U., Fehrenbach, T., Niessner, R. and Kaminski, U. (2008), Aerosol size distributions measured in urban, rural and high-alpine air with electrical low pressure impactor (ELPI). , *Atmospheric Environment*, 42, pp. pp.8502-8512.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is enclosed within a circular graphic composed of two overlapping, thick, curved lines. The upper-left portion of the circle is a light red color, while the rest of the circle is a light blue color, matching the text.

Ecological Study of Selected Lentic Water Bodies of Ahmadabad, Gujarat India

Manisha Desai

Bhavan's Sheth R A College of Science Ahmedabad, India

0253

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

In ecology the environment of lakes is referred to as *lacustrine*. The lakes are quiet large bodies of fresh water usually deep enough that their beds lay much beyond the photosynthetic zone. Fluctuations in the lake level are because of climatic conditions and human water requirements. Lentic limnology refers specifically to still waters. For the present study four lakes were selected, which are located at Thaltej, Ambli, Makarba and Sola villages. Physical parameters include (air and water temperature and TDS) chemical parameters (pH, Do, BOD, COD, CL-, Ca⁺², Mg⁺²) were analyzed during January 2010 to December -2010. During drought period the water level decreased and concentration of the most physico-chemical parameters were increased. Finely concluded that lakes water is not suitable for Drinking as well as irrigation purpose.

Key words: Ecological Study, Physico-chemical characteristics, Lentic water bodies, Ahmedabad

INTRODUCTION

Limnology is the study of fresh waters and their ecology. Lentic limnology refers specifically to still waters. Limnology is obviously a considerable and complex field that we won't pretend to cover in this manual. Rather, we will cover a few concepts necessary for a basic understanding of how lakes work and respond to pollution. With a grasp of these concepts you should be in a position to design a better monitoring program. If you are interested in learning more about lake ecology, there are several sources of good information for lay people. People often visualize a lake as a uniform mass of water, almost like a full bathtub that is evenly mixed from top to bottom, side to side and front to back. In fact, lakes are extremely heterogeneous, or patchy. The physical, chemical, and biological characteristics of lakes are extremely variable. Lakes vary physically in terms of light levels, temperature, and water currents. Lakes vary chemically in terms of nutrients, major ions, and contaminants. Lakes vary biologically in terms of structure and function as well as static versus dynamic variables, such as biomass, population numbers, and growth rates.

Ahmadabad city is located at 23⁰.03' N 72⁰.58' E in western India at an elevation of 53 meters (174 ft). The city sits on the banks of the river Sabarmati, in north-central Gujarat. Theltej lake is located at Tahltej village. Its total storage capacity is 32.2 crore liters and circumference is 1617 M.. Ambli lake is located at Ambli village near national highway no.8, Ahmedabad.its total storage capacity is 11.1 crore liters. Lake circumference is 662 M. Makarba lake is located at Makerba village near famous Sarkhej Rosa mosque, Ahmedabad. Its total storage capacity is 26.5 crore liters. Lake Circumference is 1461M. Sola Lake is located at Sola village. Its total storage capacity is 24.6crore liters and lake circumference is 1364 M. The lakes are large or considerable body of water within land (Wetzel, 1983). The maintenance of a healthy aquatic ecosystem is dependent on the physico-chemical properties of water and the Biological diversity.

METHODOLOGY

Water samples were collected monthly January2010 to December 2010 from the lentic water bodies

Physicochemical analysis :

Water samples were collected and preserved (IS: 3025 (part I), (1987)) in clean, transparent and double corked plastic bottles. Physical parameters include (air and water temperature and TDS) chemical parameters (pH, DO, BOD, COD, CL⁻, Ca⁺², Mg⁺²) were analyzed during January 2010 to December -2010. Physico-chemical parameters were studied using standard methods given by APHA (1998).

RESULTS AND DISCUSSION

The present study of the parameters calculated for January-2010 to December - 2010.in Table-1 to 4. The parameters are considered as the most important principles in the identification of the nature, quality and type of the water (fresh, brackish or saline) for any aquatic ecosystem (Abdo-2005).

Table-1 Water Analysis of Thaltej Lake during the year 2010.

Parameter	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
Temperature	25.1	26.2	31.3	32.2	34.9	36.5	37.2	27.8	29.2	31.3	25.4	22.2
TDS(ppm)	824	903	833	820	984	902	820	219	302	342	381	589
pH	6.4	6.8	6.6	6.9	6.3	6.8	6.8	6.7	7.3	7.1	7.4	7.1
DO(mg/l)	3.5	1.6	1	2.5	0.7	0.5	0.8	1.5	1.8	1.1	1.6	3
BOD(mg/l)	55	48	68	22	38	23	25	11	8.2	7	6.8	30
COD(mg/l)	126	106	156	104	280	180	157	50	41	12	39	55
Cl ⁻ (mg/l)	414.9	453.91	474.89	412.2	524.83	114.55	602.96	109.96	168.9	149.96	170.9	254.9
Ca ⁺ (mg/l)	150	140	150	150	110	40	50	70	60	60	90	60
Mg ⁺ (mg/l)	160	160	190	171	180	60	60	70	110	110	100	220

Table-2 Water Analysis of Ambli Lake during the year 2010.

Parameter	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
Temperature	26.3	27.3	31.2	36.2	35.9	36.7	37.4	27.8	28.4	30.1	25.3	22.2
TDS(ppm)	382	503	418	512	720	666	660	81	98	182	198	254
pH	6.9	6.5	7.3	6.9	6.8	6.7	6.7	7.1	7.5	6.6	6.4	7.1
DO(mg/l)	2.1	3.5	3	3	0.5	0.5	0.7	1.4	1.9	2.1	1.8	2.5
BOD(mg/l)	7	3.6	9	5	3.6	1.5	2.6	4.7	6.5	51	10.1	27
COD(mg/l)	15	10	28	18	21	20	21	4	9.5	131	12.6	44
Cl ⁻ (mg/l)	364.92	299.96	320.93	332.91	749.76	890	524.2	24.99	63.91	44.98	62.93	64.98
Ca ⁺ (mg/l)	190	160	170	170	50	170	60	40	60	60	90	80
Mg ⁺ (mg/l)	120	140	130	180	70	150	90	50	70	110	100	140

Table-3 Water Analysis of Makarba Lake during the year 2010.

Parameter	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
Temperature	26.4	29	36	36.5	36.2	36.8	37.4	28	29.1	31.7	25.6	22.5
TDS(ppm)	913	978	1050	1080	1390	1288	1020	966	512	192	303	418
pH	6.8	7.3	7.7	7.1	8.4	7.9	7.5	6.7	7.7	8.0	7.6	7.9
DO(mg/l)	2.2	3.2	3.3	2.9	0.8	0.5	0.5	1.7	1.9	1.3	1.1	2.2
BOD(mg/l)	32	40	36	27	17	12	10	4.1	6.9	11	6.1	7
COD(mg/l)	150	106	202	121	51	25	23	27	6.3	2	0	0
Cl ⁻ (mg/l)	469.89	528.89	599.86	456.87	544.83	441.99	322.99	58.9	48.92	64.98	188.91	234.94
Ca ⁺ (mg/l)	110	130	100	150	100	60	50	40	50	60	60	50
Mg ⁺ (mg/l)	140	160	200	158	120	110	50	50	50	40	80	70

Table-4 Water Analysis of Sola Lake during the year 2010.

Parameter	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
Temperature	24.6	26.3	31	36.2	34.9	36.1	37.2	27.8	28.9	30.6	25.3	22.6
TDS(ppm)	792	908	1050	938	763	623	723	123	158	233	280	477
pH	6.5	7	7.2	7.7	7.1	7.2	7.1	6.8	7.2	7.5	7.5	7
DO(mg/l)	1.6	1.5	0.8	1.8	0.6	0.5	0.4	1.6	1.2	0.75	2.9	2.6
BOD(mg/l)	5	17	11	5	27	21	11	4	9	5	24	27
COD(mg/l)	5	27	2	2	89	58	30	10	14	7	38	258
Cl ⁻ (mg/l)	394.91	413.2	464.9	412.8	395.88	255.96	148.99	64.97	68.91	89.97	158.91	174.96
Ca ⁺ (mg/l)	160	210	150	220	130	70	50	50	70	60	80	60
Mg ⁺ (mg/l)	200	190	260	236	180	80	140	60	80	100	100	190

Temperature of water is one of the most important factors in an aquatic environment. During January -2010 to December-2010, the temperature varied from 37.4 °C July -2010 in Ambli and Makarba lakes (Table-2 and 3) and lowest value from 22.2°C December -2010 in Thaltej and Ambli lakes (Table-1 and 2).

Total Dissolved Solids are simply the sum of cations and anions concentration expressed in mg/l. A high content of dissolved Solids elevates the density of water, fresh water organisms residue solubility of gases (like O₂) reduces utility of water for drinking purpose and result into eutrophication of the aquatic ecosystem. TDS in this lake fluctuated between highest range of 1399ppm May-2010 in Makarba lake and lowest ranged from 81ppm in Ambli lake (Table-3 and 2). The highest value was recorded at March to May-2010 day of Holi to mass bathing, offering food, flowers, coconut and other religious matter etc.

pH regulates most of the biological processes and bio-chemical reactions. (Sculthorpe-1967) reported that pH, free CO₂ and ammonia are more critical factors in the survival of aquatic plants and fishes than the oxygen supply. Fluctuations in pH values mostly depend upon ingredient input in the water bodies. The pH varied from 8.4 May-2010 in Makarba Lake and Lowest concentration form 6.2 May-2010 in Thaltej lake.

Dissolved oxygen (DO): The presence of dissolved oxygen is required to prevent odor and is suitable for use by aquatic plants and other life forms. The dissolved oxygen was found within 0.4(mg/l) Jul- 2010 in Sola Lake and highest range of 3.5 mg/l in Thaltej lake January-2010 and Ambli lake February-2010 (Table-4, 1 and 2). Low oxygen contents were observed in January-2009 Table No-2. Because dissolved oxygen decreases with increases in temperature and Biochemical oxygen Demand.

BOD is important parameters and indicates contamination with water. The values of BOD were found in the highest range 68.0 mg/L in Thaltej Lake March-2010, and 1.5 mg/L in Ambli lake June-2010(Table-1 and 2) respectively. Slightly higher values of COD warn about the pollution content caused by anthropogenic activities. The minimum value of BOD was recorded at the surface layer during the functioning period of the aeration units. BOD indicates the presence of microbial activities and dead organic matter on which microbes can feed. BOD is directly linked with decomposition of dead organic matter present in the lake and hence the higher values of BOD can be directly related with pollution status of the lake (WQM-1999). An inverse relationship was found between the dissolved oxygen concentration and biological oxygen demand values (*Cosgun et. al.* 1987).

Chemical oxygen demand (COD): COD indicates the pollution level of a water body as it is related to the organic matter present in the lake (WQM-1999). COD concentrations in the Lowest range of 0.0 mg/l in Makarba Lake November-December -2010 and Higher range of 280.0 mg/l in thaltej lake May-2010 Respectively (Table -1 and 3). The increase in COD concentration was found in the bottom water where organic matter is more (Prasad, 1976).

Chloride is found widely distributed in nature in the form of salts of sodium, potassium and calcium. The chloride status in lake water is indicative of pollution, especially of animal origin. In the present study chloride concentration in lake water

was found raining between minimum range of 24.99 mg/l August-2010 and maximum range of 890 mg/l during June-2010.

During the period under study the **Calcium Hardness** of lake water varied from **lowest** level 40 mg/l in Thaltej June-2010, Ambli and Makarba lake August-2010 and highest concentration 220 mg/l in Sola lake April-2010 (Table-1, 2,3 and 4). The highest value of **Magnesium Hardness** recorded at 260 mg/l Mar-2010 in Sola lake and Lowest value was recorded at the Makarba lake 40.0 mg/l October-2010 (Table-4 and 3) respectively. The source of hardness in lake water is mainly due to the addition of calcium and magnesium through surface area run-off from agricultural and other catchments areas during period.

CONCLUSION:

The Water samples were collected from Different Point of Thaltej, Ambli, Makarba and Sola Lake. The higher ranged of TDS and COD were above BSI and WHO Standards .The Concentration of parameters like D.O>pH> Temperature > BOD > Ca>Mg>COD>Cl and >TDS Were studied comparatively during January-2010 to December-2010. The results suggested that water was not suitable for drinking Purpose.

References:

Abdo, M. H..(2005): Physico-chemical characteristics of Abu Za'baal Ponds, Egypt. *Egyptian J. of aquaticresearch*, 31(2): 1 – 15

APHA (1998): Standard Methods for the Examination of Water and Waste Water, 20th Edition. American Public Health Association, Washington DC

Coscun,l ., Yatreri, S., Mirat, T., & Gurol D.,(1987):Removel of Disolved organic Contaminants by ozonation. *Environmental progress*,6(4),240-244

IS 3025: Part 1, (1987): Methods of Sampling and Test (Physical and Chemical for Water and Wastewater - Part 1: Sampling (first revision)

Prasad, D.Y. & Qayyum, M.A., (1976):Pollution aspects of Upper Lake Bhopal. *Indian Journal of Zoology* 4(1), 35-46(1976).

Sculthorpe, C.D.,(1967):Biology of aquatic Vascularplants. Edwerd Arnold pub.ltd.,London:610

Wetzel, R.G. (1983):Limnology, 2"d Edition. Saunders College Publishing, Philadelphia, PA

WQM Report (1999): Annual report on Water Quality Monitoring of upper and lower lakes Bhopal: Volumes I and II

*Applications of Sequential Power Flow Analysis for High and Low Voltage
Distribution Systems to Energy Loss Evaluation for Dwelling Units or Buildings*

Nien-Che Yang, Rex Tsaihong

Yuan Ze University, Taiwan

0255

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

In this paper, a sequential power flow calculation method for high- and low-voltage distribution systems is proposed. The proposed method is employed to assess the energy losses for a single-phase, 3-wire, 2×110V branch circuits of a typical dwelling unit. The daily, weekly, monthly and annual energy losses of a dwelling unit are obtained by a succession of precise power-flow analyses considering the daily and seasonal use of lighting and typical electrical appliances in a dwelling unit. Based on numbers of dwelling units or households and detailed analysis results of their power consumption, the energy losses, financial loss and carbon emissions of dwelling units in Taiwan are presented. The outcomes are of value to residential and commercial buildings for energy conservation and the implementation of sustainable development policies in Taiwan.

Keywords: Distribution System, Energy Loss Evaluation, Power Flow Analysis, Global Warming.

1. Introduction

Nowadays, the efficient use of energy resources has become an essential element for rapid progress of industry and commerce. Most energy resources used by people are derived from nature. For a long time, the harmony between humankind and nature has been maintained. The human population has increased markedly since the industrial revolution. The demands of energy resources become more and more obvious. However, the use of natural resources has a significant effect on the environment.

Taiwan is a mountainous island situated in a subtropical zone. It depends on imports for approximately 97.9% of primary energy [1]. At present, the applications of solar power, wind power, biomass power, geothermal power, small hydro-power, tidal power and other renewable energy generation are continually promoted in Taiwan. On the other hand, the problems caused by the use of energy resources can be divided into three parts: (1) Energy Production, (2) Energy Transmission, and (3) Energy Consumption. In this paper, the ranges between energy transmission and energy consumption, including line losses of primary and secondary distribution power systems, are discussed. As well, the characteristics of home appliances are all taken into consideration in the proposed method.

In 2001, the electricity consumption in residential sector was about 26% of the total electricity energy used in Sao Paulo State, Brazil [2]. In 2004, the residential electricity consumption was about 29.24% of total electricity consumption in the EU-15 [3]. In addition, the residential energy consumption in the UK has consumed 28% of the total energy use, and the residential energy consumption in the USA was 22% of the total energy demand [4]. In 2006, the residential and commercial energy consumptions in Malaysia were 13.6% of total energy use [5]. In Taiwan, the residential sector consumed 44.4 billion kWh in 2011, which equivalent to 18.33% of the total energy consumed [6]. Residential electricity consumption in Taiwan is shown in Fig. 1.

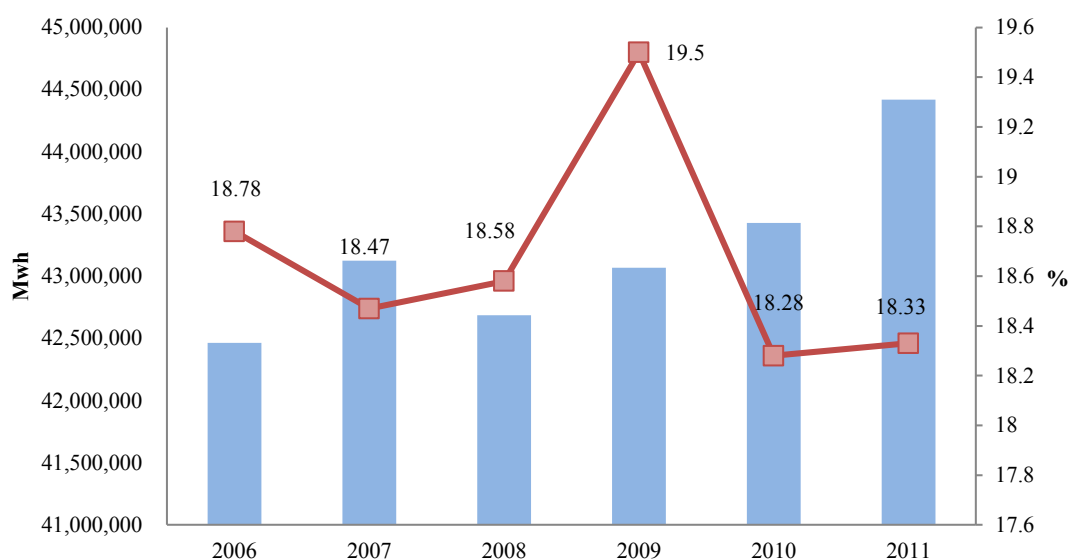


Fig. 1. Residential electricity consumption in Taiwan

To improve the energy efficiency of power systems, an effective method for evaluating energy losses is required [7]. The existing energy loss estimation methods can be used to assess energy losses in large systems in a precise way, but they are not suitable for estimating the annual energy losses in branch circuits or feeders of households or buildings [8]. In a household, various home appliances often are connected with branch circuits. Because the power consumption behaviors of the electrical home appliances may change time to time, they may have a considerably effect on the accuracy of loss evaluations for low-voltage distribution systems. In low voltage distribution systems, especially in branch circuits or feeders, the system topologies and power consumption behaviors of each load should therefore be reflected. Unfortunately, the existing probabilistic energy loss estimation methods cannot take into account the real characteristics of the small load variance in low voltage distribution systems.

In this paper, a sequential power flow method for high- and low-voltage distribution power systems is proposed to assess the energy losses of branch circuits or feeders by considering the system topologies and power consumption behaviors of home appliances along the circuits. The proposed method is employed to assess the total energy loss of typical residential distribution systems in Taiwan.

2. Sequential Power Flow Method for High and Low Voltage Distribution Systems

In the existing power flow approaches, the distribution transformers and their loads are integrated and are tapped off the primary mains. The power losses in secondary distribution systems are ignored. In practical terms, with the wide coverage of distribution networks, any gain in saving energy could tremendously improve the operation efficiency of a distribution system. That is, the line losses in residential or commercial distribution systems cannot be neglected. The flow chart of the proposed sequential power flow method for high- and low-voltage distribution systems is shown in Fig. 2. The solution procedure of the proposed method is described below, step by step:

- Step 1.** Set initial node voltages and form K matrix directly from input data for primary and secondary distribution systems.
- Step 2.** Calculate node injected currents, branch voltages and update node voltages for primary distribution systems.
- Step 3.** Set initial node voltages, calculate node injected currents and update node voltages, and compute the total node injected currents for secondary distribution systems.

The iterative process of the proposed method is continued until the residuals of the bus voltages are all less than a specified tolerance.

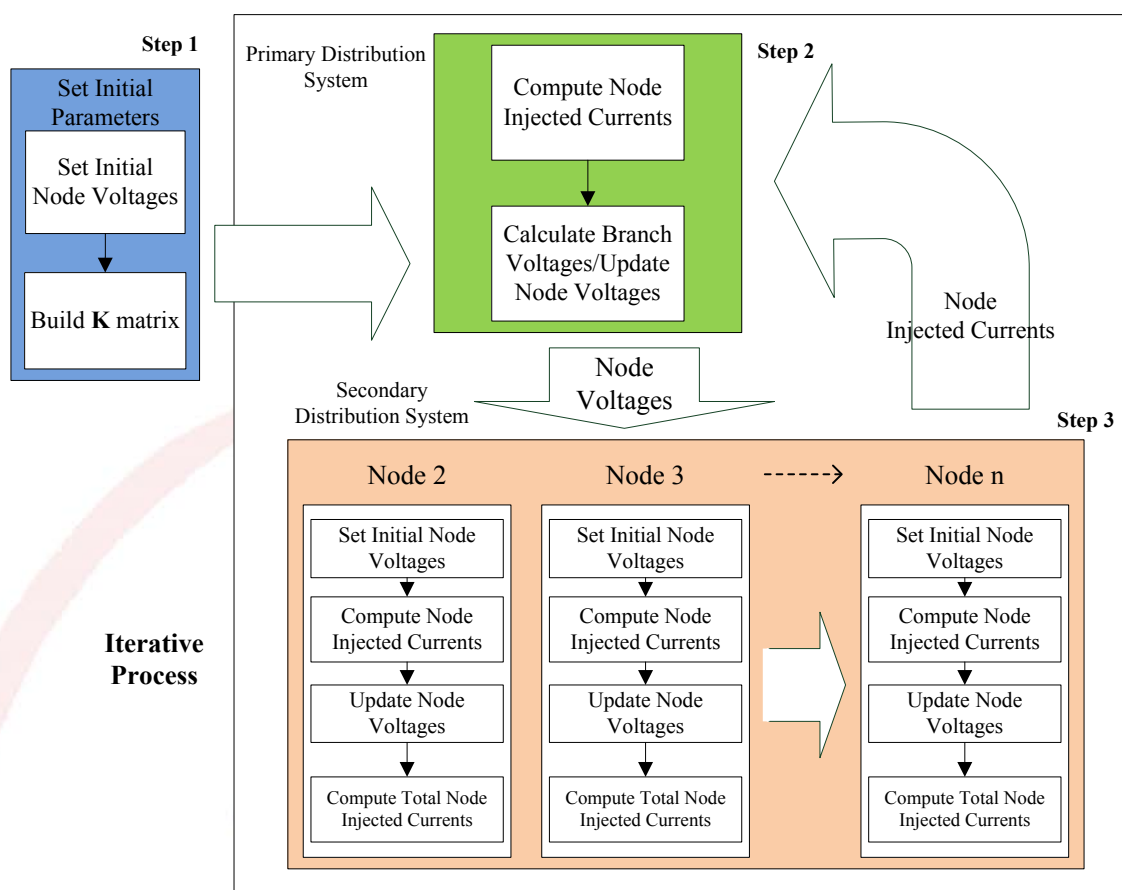


Fig. 2. Flow chart for sequential power flow solutions

3. Energy Loss Estimation Method for Low Voltage Distribution Systems

Because the branch circuits of a household or building are located in the most downstream portions of power system, the energy losses of branch circuits or feeders of households or buildings should be evaluated in detail or the whole system energy losses cannot be estimated accurately. In this paper, an effective method is proposed to estimate the energy losses of the branch circuits or feeders of a home or building.

Considering the system topologies and power consumption behaviors of small home appliances along branch circuits or feeders, the proposed method can estimate the real power for each time interval first, followed by daily, weekly, monthly and annual energy loss estimations [9]. In other words, to perform annual energy loss estimation, the four steps of power-flow calculations are required, such as: (1) daily power-flow calculation (DPFC), (2) weekly power-flow calculation (WPFC), (3) monthly power-flow calculation (MPFC) and (4) annual power-flow calculation (APFC).

To take into consideration the daily and seasonal use of various kinds of small home appliances, several sets of typical daily-load curves (DLCs) have been generated. In the proposed method, 16 DLCs are required to describe the real and reactive power consumption behaviors for each kind of home appliance. The schematic diagram of the energy loss estimation is shown in Fig. 3.

For a specific network topology, operating and loading condition, three-phase power-flow calculation can be employed to determine the system electrical parameters [10]. At any instant, real power loss in each line segment can be estimated by a three-phase power-flow calculation. Extending for an accurate power-flow calculation, a precise annual power-flow calculation can be determined.

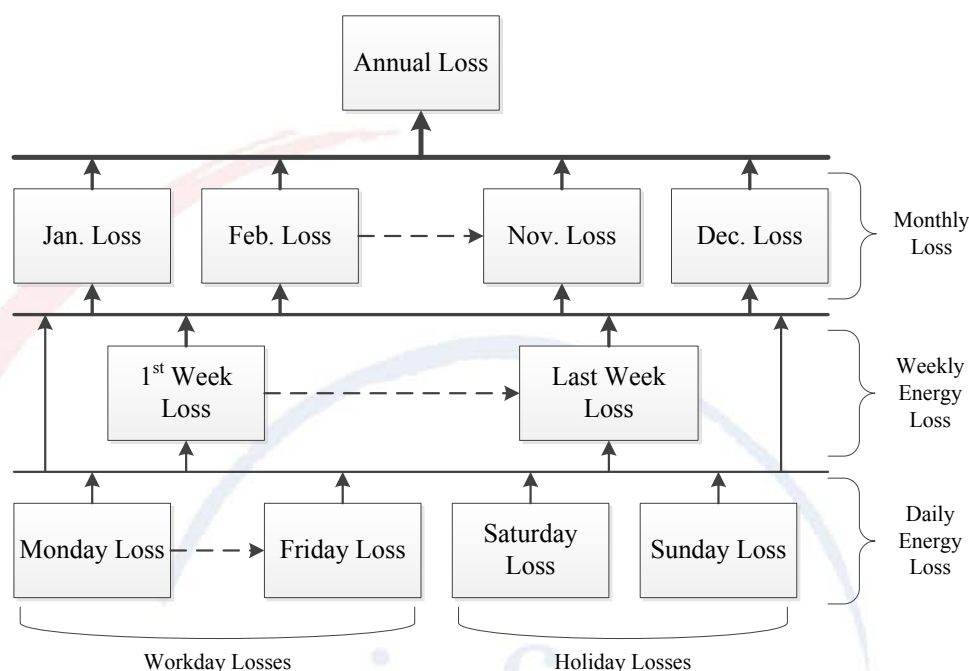


Fig. 3. Energy loss estimation scheme for low voltage distribution system

3.1 Daily energy loss estimation

In order to accurately assess a daily energy loss, the daily use of electric home appliances along branch circuits or feeders should be reflected. In the proposed method, a set of 16 DLCs is developed for each kind of electric home appliance. Several sets of the typical DLCs are required to be created for all kinds of electric home appliances. The daily and seasonal use of electrical home appliances may vary from time to time, day to day, and season to season. Therefore, the changes in power consumptions of electric home appliances all should be considered. In order to assess the daily energy loss accurately, the load survey is required to develop the typical DLCs for each kind of electrical home appliance. Moreover, the time intervals for DLCs will affect the accuracy and computing time of power loss estimation. In other words, the longer the time interval, the lower the accuracy of the estimation results and the less computing time will be obtained. In this paper, the time interval of 15 min was adopted. That is, there are 96 time intervals in each DLC. To perform daily energy loss estimation, the 96 instantaneous power loss estimation results are summed up.

3.2 Weekly energy loss estimation

The daily and seasonal use of electrical home appliances may be different from workdays to holidays. The DLCs are distinguished into the power consumption characteristics of workdays and holidays in a week. In general, the workdays are from Monday through Friday. The weekly holidays are Saturday and Sunday. In other words, there are 5 workdays and 2 holidays in a week. The weekly energy loss

can be estimated by considering the distinct power consumption characteristics between workdays and holidays.

3.3 Monthly energy loss estimation

By summing up the proper daily or weekly energy losses of the concerned month, the monthly energy losses can be determined. For a certain year, the numbers of days in different months may be different. In a common year, there are 365 days and there are 28 days in February. On the other hand, in a leap year, there are 366 days and there are 29 days in February. To simplify the discussion, the numbers of days for all months are assumed to be 30 days, and are assumed to be 21 workdays and 9 holidays.

3.4 Annual energy loss estimation

The daily and seasonal use of electrical home appliances may have significant differences among the four distinct seasons. For different seasons, different DLCs should be obtained for the same electrical appliance. Besides, the different power consumption behaviors of electrical home appliances on workdays and holidays should be taken into consideration as well. That is, the daily and seasonal use of electrical home appliances should all be considered.

In order to perform annual energy loss estimation, 8 typical daily energy loss estimations are necessary, such as: (1) Spring Workday, (2) Spring Holiday, (3) Summer Workday, (4) Summer Holiday, (5) Fall Workday, (6) Fall Holiday, (7) Winter Workday and (8) Winter Holiday. By arithmetic calculations using 8 typical daily energy losses by the proper number of days, the annual energy loss can be estimated. Also, the annual energy loss can be estimated by using the proper monthly power loss.

The proposed sequential three-phase power-flow calculations can be employed to estimate the system electrical parameters for a day, a week, a month or a year. The results of the power flow calculations can be employed to examine the strategies of system operations. To provide high quality power to consumers, the results of the power flow calculations can also be employed to review the requirements of voltage regulation and control of the feeders. Depending on the short-term and long-term load forecasting and feeder load management, the overloading problems for feeders and transformers can therefore be avoided. In the next section, the proposed sequential three-phase power-flow calculation will be employed to estimate the annual energy losses of the typical residential distribution system in Taiwan.

4. Energy Loss Estimation for Typical Residential Distribution Systems in Taiwan

In Taiwan, most of the households are served by a $1\Phi 3W$ 110/220V system with two phase conductors, one neutral conductor and one grounding conductor. The voltages of two 110V phase conductors are out of phase by 180° . The 110V and 220V rated electrical appliances can all be served by this system. The lighting and lower-power consumption appliances are fed by the 110V branch circuit. Moreover, the higher-power consumption appliances are all served by the 220V branch

circuit. The parameters and partial data for the sample system shown in Fig. 4 are tabulated in Table 1. This typical household wiring system consists of 10 branch circuits and 2 spare circuits.

Circuit #1 and Circuit #2 are used to serve home lighting branch circuits. Circuit #3 to Circuit #6 are used to serve receptacle branch circuits. Circuit #7 is an individual branch circuit for kitchen appliances. Circuit #9 to Circuit #11 are used to feed individual branch circuits for air conditioners. Circuit #8 and Circuit #12 are spare circuits. Many sets of typical DLCs are used, but only the typical DLCs for summer workday are shown in Figs. 5 and 6.

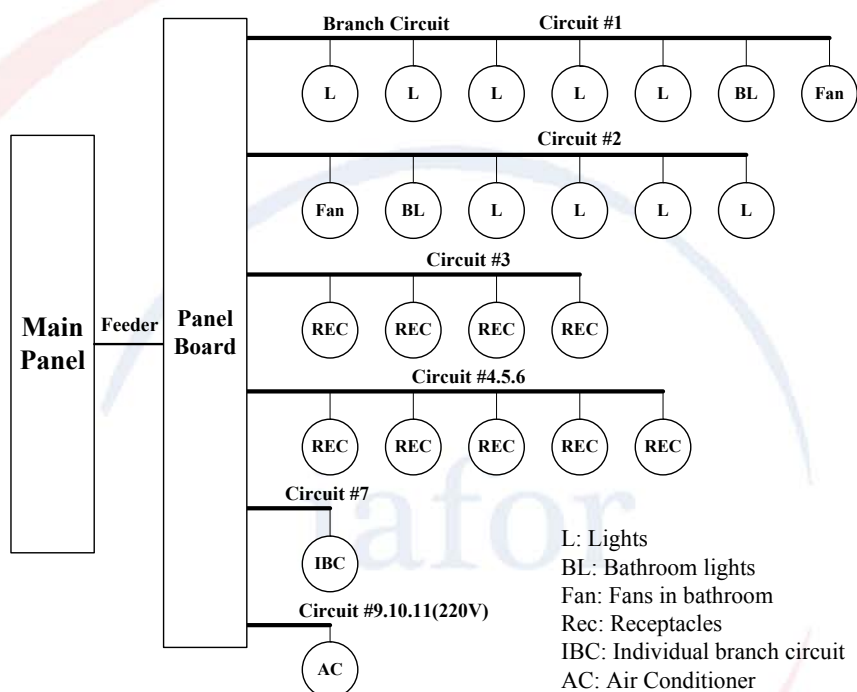


Fig. 4. One line diagram for typical residential distribution system

Table 1. Parameters and partial data for sample system

	Lights	TV	Refrigerator	Air conditioner
P(W)	180	150	91	1600
Q(var)	159	132	78	1200

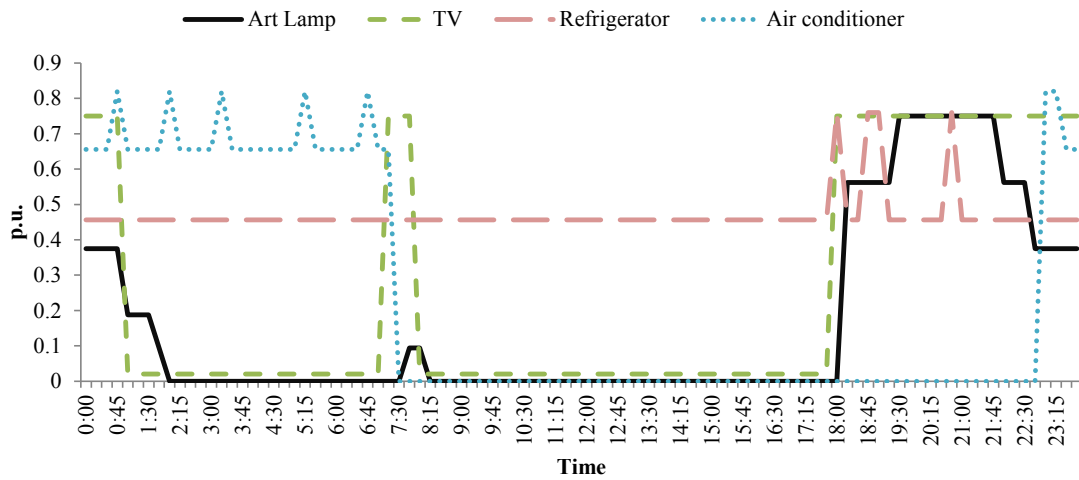


Fig. 5. Typical DLCs of active powers for summer workday

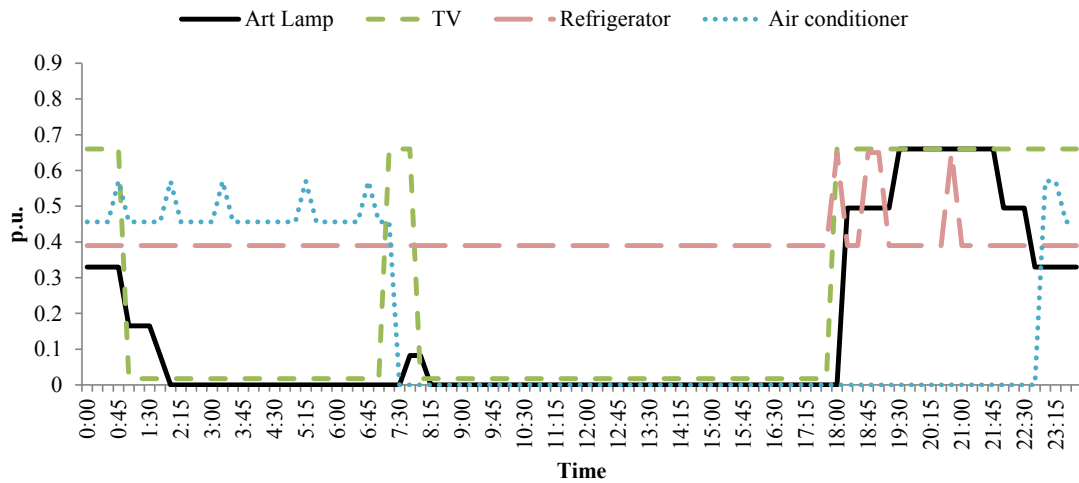


Fig. 6. Typical DLCs of reactive powers for summer workday

In this paper, the electrical home appliances are all shown as injected currents. Furthermore, by considering the system topologies and power consumption behaviors of electrical home appliances along circuits, the proposed sequential power-flow method can estimate the energy loss accurately. The daily, weekly and monthly energy losses are shown in Figs. 7, 8 and 9, respectively. As can be seen from Table 2, the workday energy loss, holiday energy loss, weekly energy loss, monthly energy loss and annual energy loss can be obtained.

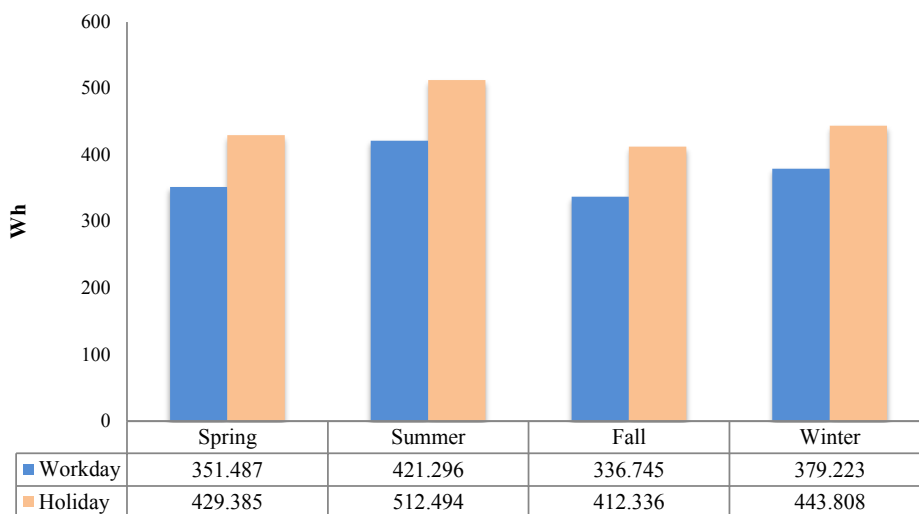


Fig. 7. Daily energy losses for four seasons

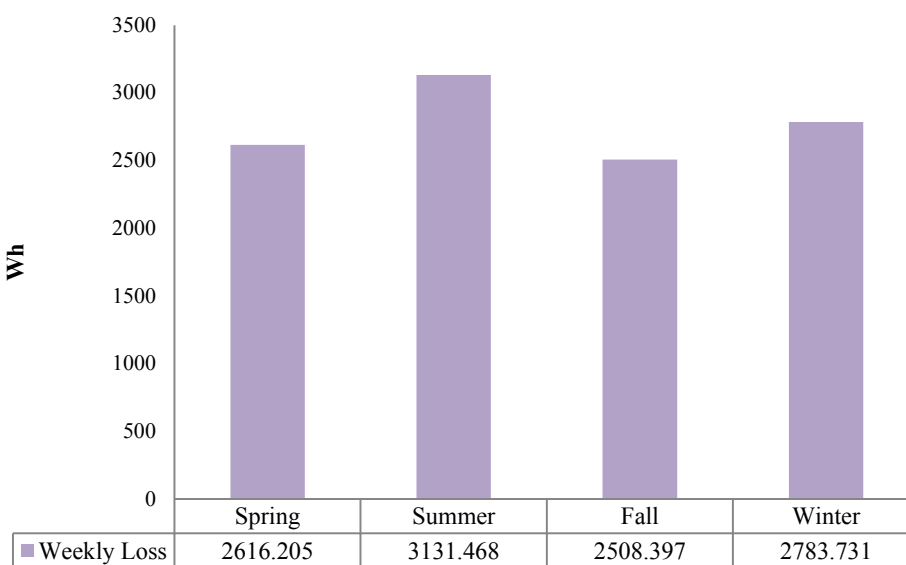


Fig. 8. Weekly energy losses for four seasons

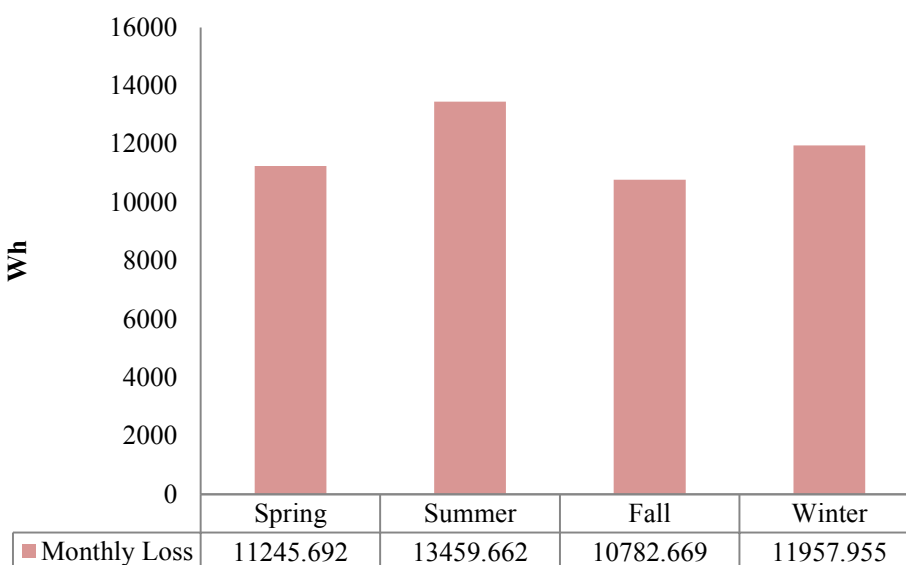


Fig. 9. Monthly energy loss for four seasons

Table 2. Energy losses for four seasons

	Spring (Wh)	Summer (Wh)	Fall (Wh)	Winter (Wh)	Annual (kWh)
Workday	339.486	461.478	334.776	428.162	
Holiday	403.882	553.23	398.246	450.02	
Weekly	2,505.194	3,413.85	2,470.372	3,040.85	
Monthly	10,764.144	14,670.108	10,614.51	13,041.582	
Annual					147.271

The annual energy loss is around 147 kWh per household. The energy loss for the summer season is about 44kWh. If the average price of electricity for the summer season is 4.5 NTD (New Taiwan Dollar)/kWh, the cumulative electricity price for the summer season is 198 NTD. On the other hand, the energy loss for the non-summer seasons is about 103 kWh. If the average price of electricity for the non-summer seasons is 4.0 NTD/kWh, the cumulative electricity price for the non-summer seasons is 412 NTD. The cumulative cost of the annual energy loss for a single residential user is 610 NTD.

According the 2007 Taiwan Bureau of Energy Annual Report, an emission factor for CO₂ is 0.637 kg-CO₂ /kWh. Therefore, the extra CO₂ emission for a typical residential distribution system is 93.42 kg/year per household.

According to the 2011 Taiwan Power Company (Taipower) annual report, the number of households in Taiwan is round 12.76 million. Therefore, the total CO₂ emission of the residential distribution system, caused by energy losses, is up to 1,192,958,000 kg. In terms of economic losses, the cumulative electricity consumption of the energy losses is up to 1,875,720,000 kWh. That is, the cost of energy losses in residential distribution systems is about 7,783,600,000 NTD. The cumulative energy consumption and CO₂ emission are shown in Table 3.

Table 3. Cumulative energy consumption and CO₂ emission

	Energy losses (kWh)	Cost of losses (NTD)	CO ₂ emission (kg)
Single user	147	610	93.492
12.76 million users	1,875,720,000	7,783,600,000	1,192,958,000

5. Conclusions

In this paper, the sequential power-flow method has been proposed for evaluating energy losses in branch circuits and feeders for primary and secondary distribution systems. In the proposed method, the system topologies and the characteristics of home appliances all can be taken into consideration. By using the proposed sequential power flow method for high- and low voltage distribution systems, the annual energy loss can be estimated in an accurate way. The results of this paper are of value to residential and commercial building in designing the finest energy-saving wiring designs, improving

system efficiency, and therefore, reducing the carbon dioxide emissions.

6. Acknowledgements

This paper has been sponsored by National Science Council, Taiwan, R.O.C. (NSC 101-2221-E-155-054).

References

- [1] D. Y. L. Chan, K. H. Yang, C. H. Hsu, M. H. Chien, and G. B. Hong, "Current situation of energy conservation in high energy-consuming industries in Taiwan," *Energy Policy*, vol. 35, no. 1, pp. 202-209, Jan, 2007.
- [2] C. A. Mariotoni, and P. R. Santos, "Household-electric equipment diffusion and the impacts in the demand of residential electric energy in Brazil," *Energy and Buildings*, vol. 38, no. 6, pp. 563-567, Jun, 2006.
- [3] B. Atanasiu, and P. Bertoldi, "Residential electricity consumption in New Member States and Candidate Countries," *Energy and Buildings*, vol. 40, no. 2, pp. 112-125, 2008.
- [4] L. Perez-Lombard, J. Ortiz, and C. Pout, "A review on buildings energy consumption information," *Energy and Buildings*, vol. 40, no. 3, pp. 394-398, 2008.
- [5] A. Al-Mofleh, S. Taib, M. A. Mujeebu, and W. Salah, "Analysis of sectoral energy conservation in Malaysia," *Energy*, vol. 34, no. 6, pp. 733-739, Jun, 2009.
- [6] *Energy Statistical Annual Reports*, Bureau of Energy, Ministry of Economic Affairs, Taiwan, 2012.
- [7] T.-H. Chen, and N.-C. Yang, "Simplified annual energy loss evaluation method for branch circuits of a home or building," *Energy and Buildings*, vol. 42, no. 12, pp. 2281-2288, 2010.
- [8] O. M. Mikic, "Variance-Based Energy Loss Computation in Low Voltage Distribution Networks," *Power Systems, IEEE Transactions on*, vol. 22, no. 1, pp. 179-187, 2007.
- [9] N.-C. Yang, and T.-H. Chen, "Assessment of loss factor approach to energy loss evaluation for branch circuits or feeders of a dwelling unit or building," *Energy and Buildings*, vol. 48, no. 0, pp. 91-96, 2012.
- [10] T.-H. Chen, and N.-C. Yang, "Loop frame of reference based three-phase power flow for unbalanced radial distribution systems," *Electric Power Systems Research*, vol. 80, no. 7, pp. 799-806, 2010.

*Surveying Historic Buildings
Valuing Sustainability in Places of Worship*

Magdalini Makrodimitri, James Campbell

University of Cambridge, UK

0263

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Historic buildings contribute positively to all aspects of sustainable development. They are more than an environmental and cultural asset; they are an important driver for economic development and delivering social objectives.

In the first instance this paper looks at the factors that need to be considered in order to assess the sustainable performance of listed buildings. There is an increasing awareness of the necessity of balancing comfort with energy efficiency. In order to be sustainable historic edifices, including places of worship – which account for a large part of the cultural heritage in the UK– need to be willing to adapt to modern comfort requirements but the question is how to do so without risking damaging the historic fabric and exactly how far it is right to adapt these structures at all rather than adjust our ideas of comfort.

Historic buildings provide particularly difficult challenges to manage environmentally both because alterations have to avoid destroying the historic character of the building and because changes in the internal environment can easily have adverse effects on that historic fabric.

The results of detailed survey of four case-studies, including monitoring, and building thermal simulation and comfort surveys applied to historic church buildings are used here to generate conclusions on the thermal efficiency, performance and risks associated with changing micro-climatic conditions of places of worship.

This paper suggests broadening existing sustainability criteria for such edifices in order to include the wider range of factors that affect sustainability in the historic built environment.

Keywords: historic buildings, thermal comfort, sustainability, conservation, energy

INTRODUCTION

Historic buildings by definition consist of structural elements and artworks that are uniquely valuable and laws are formulated in most countries to afford them protection against demolition. However, the rising expectations of thermal comfort constitute an additional threat to the preservation of these edifices (Camuffo et al., 2007). Even in the heritage sector, the needs of modern society cannot be entirely ignored. And to a certain extent it can be argued that the structural materials and elements that make up all existing buildings, including those of historical importance, which constitute natural resources in themselves, should be preserved where possible to achieve sustainability (Meryman, 2005).

Improving the performance of the building envelope is often the first action to be considered when starting any sustainable retrofit of a building. In the modern structures this is typically achieved by insulating, sealing and draught-proofing the building envelope, which reduces heat losses in walls, ground floors, roofs and through loose windows fittings. However, the materials that make up or are found in older buildings require higher rates of ventilation and much of this required ventilation was provided in the past by fortuitous air leakage- the buildings' "leakiness" (Heritage, 2008). It has become increasingly apparent that sealing and draught-proofing historic buildings can cause significant deterioration of the internal fabric and the artifacts they contain and can also have a negative impact on indoor air quality and the occupants' health. This research paper looks at the environmental performance of historic churches, whose construction typology - high ceilings, massive un-insulated masonry walls, decorative finishes, etc. - provides particularly difficult environmental challenges. It provides key insights into sustainability in the historic built environment and the factors contributing to the sustainability of historic structures; it highlights and presents a review of the most significant issues of revising sustainability rating systems in order to include the whole range of factors that affect sustainability in the historic built environment.

SUSTAINABILITY, CLIMATE CHANGE AND CONSERVATION

Conservation and sustainability are related in a broader ecological sense (Rodwell, 2007). English Heritage's "Regeneration and the Historic Environment Heritage as a catalyst for better social and economic regeneration" (2005) highlights the benefits of using existing buildings rather than constructing new ones. In the words of another paper: "The greenest building is the one that's already built" (National Park Service. U.S. Department of the interior, website, 2012). One important reason for retaining any existing building including those of historic importance is that any new building will involve considerable embodied energy (Jackson, 2005). The carbon released in building construction has already been long expended in an existing building. Reusing buildings limits the need for new building materials and reduces the structural waste from demolition work (English Heritage, 2005). At the same time, conservation is considered to be the most cost-effective form of preserving energy in the built environment, since it appreciates the value of existing structures and thus embodied energy (Sedovic and Gotthelf, 2011).

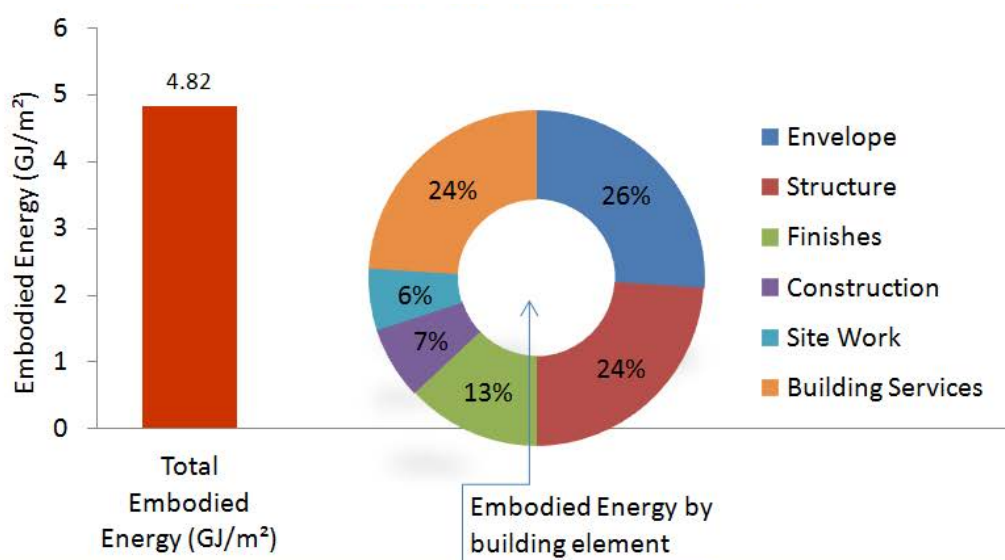


Figure 1 Embodied energy- note that 24% spent wasted on buildings services, a figure than can be substantially reduced by passive energy design (Cole and Kernan, 1996).

Although, the majority of historic buildings have been constructed with local materials which tend to enclose low embodied energy, the total amount of energy possessed by both materials and the labour to construct the buildings is enormous (Figure 1) (Sedovic, 2003).

Sustainability needs to be seen in its broader sense and not just in terms of carbon emissions (Technical Preservation Services, 2004). There are economic and social aspects of sustainability. On the social level, the sense of *place* is often dependent on the retention of key buildings and landscapes. In England older buildings generally have a greater economic value than new ones of similar uses. Areas with a rich historic legacy have been show to have strong senses of local identity, and historic continuity is an important local educational resource. Historic buildings and other historic assets of urban environment promote community spirit and are often selected as places to host local social events (wedding, funerals, celebrations etc). Moreover historic buildings provdie a physical record of the past, the destruction of which reduces our knowledge irreversibly. Few historic buidlings used much energy for heating or lighting when originally constructed. Where they are inefficient it is modern adapttations have made them so. In the past levels of comfort expected of building were far lower than today. Extensive research has shown that historic buildings can be more environmentally sustainable and their environmental performance can be, as good as, new-build projects (Pickard, 2004). On the economic side, conservation and revival of historic environment creates jobs and thus assists the growth of local economies (English Heritage, 2002) and there is no doubt that an environment of high quality positively affects the performance of any business or community activities. However any scheme needs to be aware of the risks of additions to historic building. It

is not simply a matter of adding heating to existing buildings. Some heating can even be beneficial in certain climates, but poorly-designed heating or cooling systems can cause deterioration to fabric and artworks, as they cause variations of temperature and humidity beyond the limits required for conservation (Curteis, 2008).

SUSTAINABILITY AND CONSERVATION

Historic environment conservation is closely connected to sustainable development and regeneration. In the UK, government statements praise the relationship between the historic environment sector and sustainability (Pickard, 2004). It is recognised that a building can be valuable simply because it represents the social and cultural attitudes of local people. Conservation needs to aim at preserving the character and fabric of the historic building while meeting the needs of people who use them (Pearce, 1989). J. Douglas in his book *Building adaptation* (2002) goes further, suggesting that all conservation work should be combined with regeneration work to improve people's lives in ways that include the quality of local environment. English Heritage has long stressed that existing structures can be adapted to modern needs when required. Indeed there are countless examples where this has been carried out. Sensible alterations or the addition of existing buildings contribute to the sustainability of the urban environment as this can offer people a sense of the familiar along with the excitement for the new (English Heritage, 2005). Harvey (1972) warns however that it is difficult to decide how far it is possible to alter a historic building without losing its architectural and historic qualities. In all historic buildings including church buildings which are the focus of this paper, special attention to building requirements and implementation of sustainable measures is essential. Places of worship are recognised to constitute a unique type of building and thus normal conservation or environmental design methods recommended for towns and other traditional structures are often not applicable to them (DEFRA, 2009).

ENVIRONMENTAL PERFORMANCE OF HISTORIC STRUCTURES: THE CASE OF ENGLISH CHURCHES

Churches constitute a significant part of the heritage of Western Europe. Whatever their size and religion, from cathedrals to chapels, churches in the UK have always been seen as vitally important by the majority of locals, congregations and visitors alike (Taylor, 2010). Unfortunately over the last few decades many churches in the UK have been abandoned (Bird, 1959). In England congregations have been falling and clergy seeking to expand them are often quick to blame cold and draughty churches. Most historic churches remain in use for worship but with aging and dwindling congregations. Worship is churches' primary and main purpose, and as a rule historic buildings are best used for their intended purpose. Alternative (conversion to housing, offices etc) tend to be especially damaging to the special architectural or historic interest of the building and thus not always a sustainable choice (Kelleher, 2003).

Securing sustainability of church buildings therefore means maintaining the building structure and contents and while achieving a welcoming environmental conditions for participants. Ecclesiastical buildings are challenging case studies; given that churches

represent a large part of the historic built environment in the UK (Over 30,000 churches are listed in the UK, while Church of England is caring for over 13,000 listed places of worship). As energy costs increase and congregations reduce cutting energy use is a necessary aim for the church. On a smaller scale, church buildings also pose particular challenges to achieve an environmentally sustainable performance because they are complex structures; their large volume creates additional difficulties in managing heating and air movement internally to achieve satisfactory comfort conditions; being occupied infrequently sets hurdles to the decision-making of installation of mechanical equipment and in parallel achieve energy conservation and acceptable comfort; and lastly as they are often buildings whose preservation is mandated by law any environmental adaptation needs to be done with the minimum interruption to physical fabric and contents.

COMPARATIVE ENVIRONMENTAL PERFORMANCE OF CASE-STUDIES

This study focuses on four case studies which have been used to test and challenge current thinking on the performance of specific heating methods with regards to building behaviour and formation of specific microclimatic conditions; and the on-site measured values of Temperature and Relative Humidity. Among other conclusions, the research has shown that long-term monitoring can be a successfully employed approach for analysing the microclimate of historic buildings and churches in particular. However, the identification of any thermal stratification inside the enormous volume of church buildings is particularly difficult due to access limitations. A plethora of factors may affect the environmental conditions at the upper levels of the building, such as intermittent occupancy, non-specific schedule for windows and doors opening, instantaneous operation of heating or even occasional failure of the building envelope.

It is important to remember that in England most older churches were originally constructed without any heating provision, heating being uncommon until the late nineteenth century. Retaining the original microclimate conditions by avoiding changing heating, ventilation or other mechanical service operations, maintains a state of equilibrium is achieved between the moisture in the building structure and that in the air (Curteis, 2004). Among all possible influences, heating has been proven to affect the church microclimate most intensively, especially in the case of heating use for thermal comfort provision for short time periods which usually causes environmental distress to the building structure and is likely to become the source of deterioration of plaster, stonework and other historic material.

The following study is based on monitoring of Great St Mary's, St Botolph's, All Saints church and Queens' College chapel in Cambridge, UK, which employ representative heating methods and mechanical equipment. Each case employs a different combination of heating system and strategy that causes particular variations in the building environmental response.

Despite the different methods employed, the Temperature per month in all case studies shows remarkably homogenous conditions at both the lower occupied levels and in upper parts of the buildings. (Figure 2) The buildings with constant heating strategies (Great St Mary's and All Saints) maintain rather high temperature conditions (average 15°C throughout the year). The intermittently-operated localised heating system in St Botolph's church has little influence on the internal microclimate of the church which generally follows the fluctuation patterns of the external conditions; however the building still acts as a buffer zone that maintains the indoor Temperature at approximately 5°C above outdoor Temperature level. Furthermore the lack of heating at the generally heated Queens' College chapel during out-of-term time within the heating period provides significant differences in the thermal conditions in the chapel.

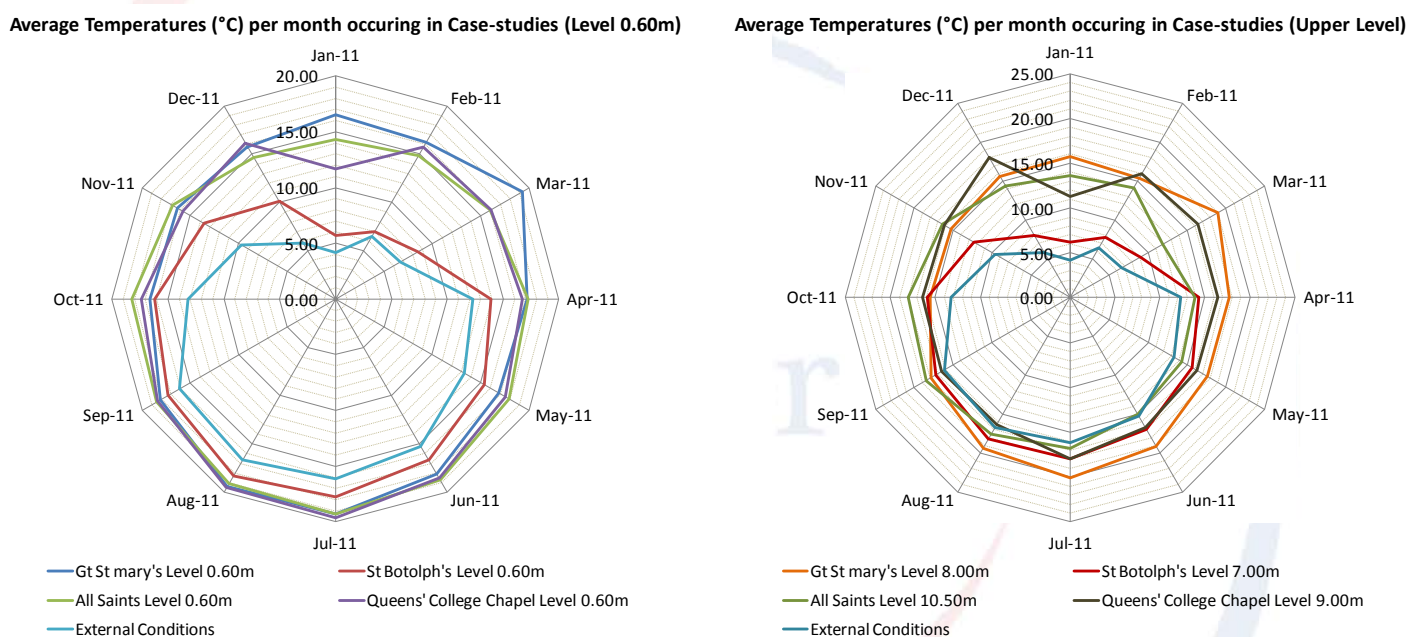


Figure 2: Average Temperature per month occurring on the occupancy level and upper building part in all case-studies.

Detailed analysis provides more interesting results. The regressed temperature against relative Humidity values on a typical Sunday when services took place in all case studies, show concentrated values at the occupied level in all case studies. (Figure 3) However the regression analysis reveals more varied results in the upper parts of case studies, most significantly at St Botolph's church which is heated intermittently. The heating systems used in three out of four cases (Gt St Mary's, All Saints and Queens' college chapel) produce their effect by radiant means (and convective means in some auxiliary spaces of Gt St Mary's) which do not introduce any further particles into the internal microclimate. However, in the case of St Botolph's church, which is heated only for limited hours per week, the church is using both radiant local heating method through heating panels on pews and portable gas flame heaters. The gas heaters are very efficient in producing fast and relatively low cost heat, however they have the huge disadvantage that the main combustion product of Liquid Petroleum Gas (LPG) is water, each 1kg of gas burned producing about 1.5kg water (Curteis, 2004). The

result is that using gas heaters in a large church for only one or two hours, causes dramatic rises in absolute humidity, resulting in condensation, immediately after they are turned off. Thus, RH in St Botolph's church fluctuates rapidly compared to other intermittently heated cases, such as Queens' college chapel when the heating is radiant and it operates for much longer periods before it is switched off. This is important because high levels of humidity and particularly condensation, are detrimental to pictures, timber, paintwork and plaster and also, through mould growth, to human health. The conclusion is that general low level constant heating is better for the building. This however is not necessarily the most energy efficient solution, nor the most comfortable.

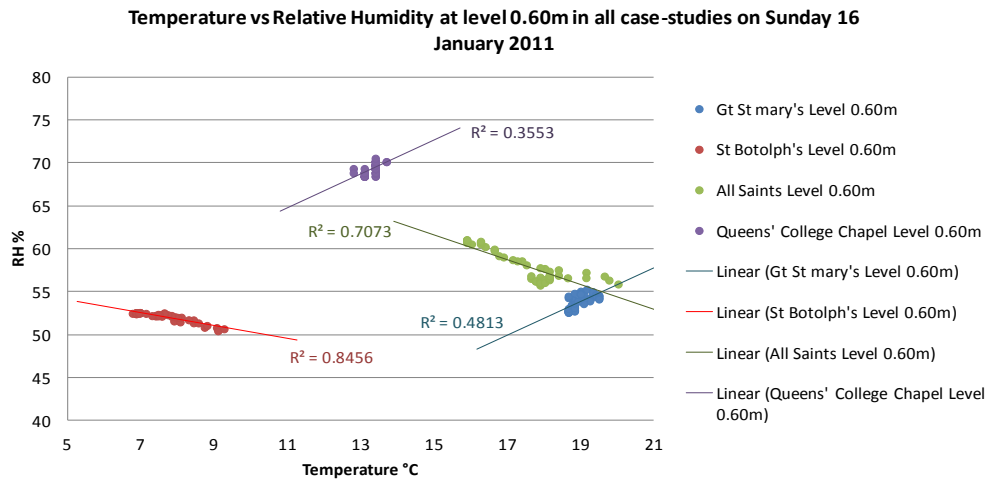


Figure 3: Temperature and RH correlation on occupancy level (0.60m from floor) in case studies during a typical one-day period.

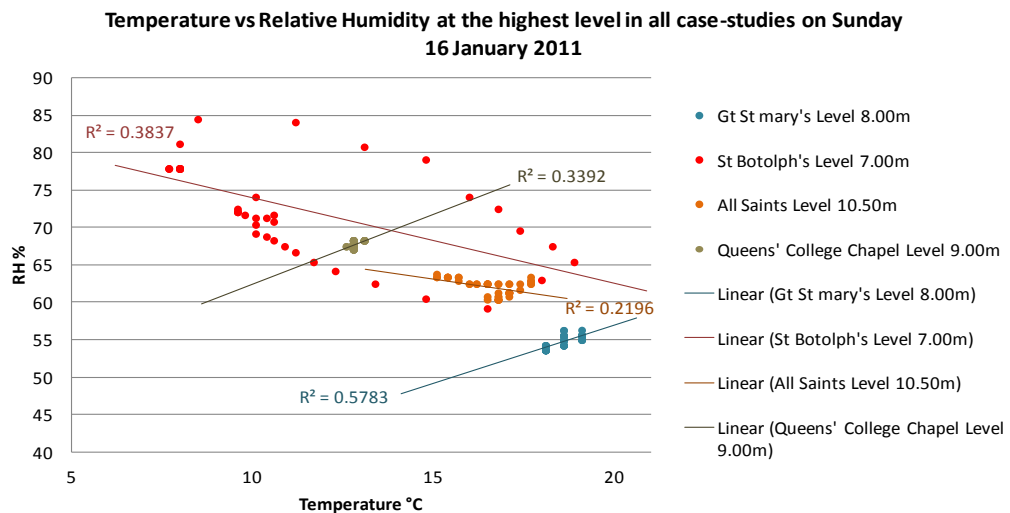


Figure 4: Temperature and RH correlation on upper part of case studies (average of 8 m from floor) during a typical one-day period.

ENERGY CONSUMPTION IN PLACES OF WORSHIP

The energy consumption of a church varies with size, age, heating type, weekly occupancy and the community use of the buildings (CofE, 2008). Managing and reducing energy consumption can have significant benefits for everyone. Reducing energy consumption reduces costs, and helps reduce the volume of harmful greenhouse gases being released into the atmosphere (CofE, 2008). Church of England has undertaken surveys of church halls and other ecclesiastical buildings in order to estimate the energy consumption in its premises with the intention of producing general guidance in due course on energy saving measures. 60 church buildings within the Diocese of London and Westminster were inspected as part of the Church of England's environmental audits during 2009 and 2012. Those series of audits were part of the Diocese of London's response to the church of England's environmental campaign, named "Shrinking the Footprint", which aims to reduce carbon emissions of the whole organisation's premises by 80% by the year 2050 (CofE, 2008). The aforementioned environmental audits examined the churches' energy use and carbon footprint as a result of fuel and water consumption, waste and recycling. It was found that fossil fuels constituted the largest source of carbon dioxide emissions. The survey has also revealed that approximately 43% of churches use natural gas and 21% use oil for space heating. In addition comparison between a rural and urban church revealed that the two types of church varied in terms of energy use patterns. The rural church used the majority of total energy consumed for space heating (79%) and lighting (17%), while the urban church used only 53% of total energy consumption for heating (CofE, 2008). In many cases, in the urban churches, especially the ones that are in constant operation, energy usage can be attributed to other uses (i.e. kitchens, cafés, offices, etc) which made up a considerable percentage of the total energy consumption. Figures 5 and 6 illustrate findings of the survey conducted in a rural and an urban church that hosts community actions.

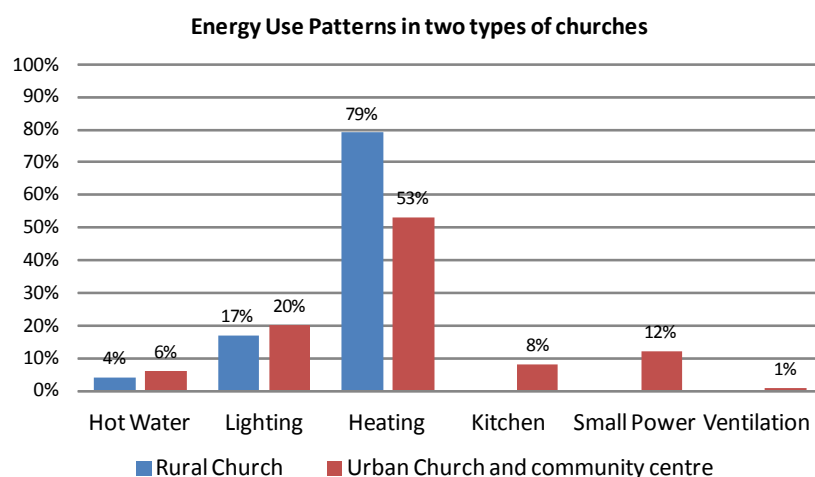


Figure 5 Energy use patterns in a Rural and Urban church.

It is evident that the majority of energy used in both cases can be attributed to space heating. However the average energy consumption of a rural church is estimated to be

less than a tenth lower than the annual energy consumption in an urban church. (Figure 3-2) It is clear that occupancy patterns play an important role in church buildings energy use; rural churches have limited occupancy periods compared to urban churches and use almost all the energy they consume for space heating during church services.

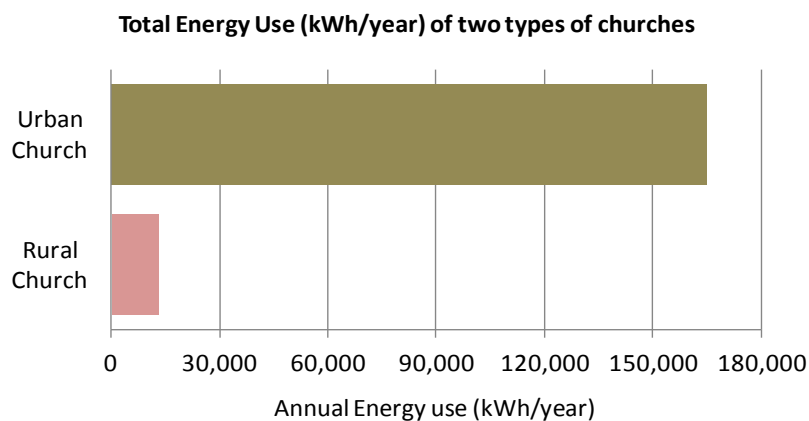


Figure 6 Total Annual Energy use of Rural and Urban church with community use.

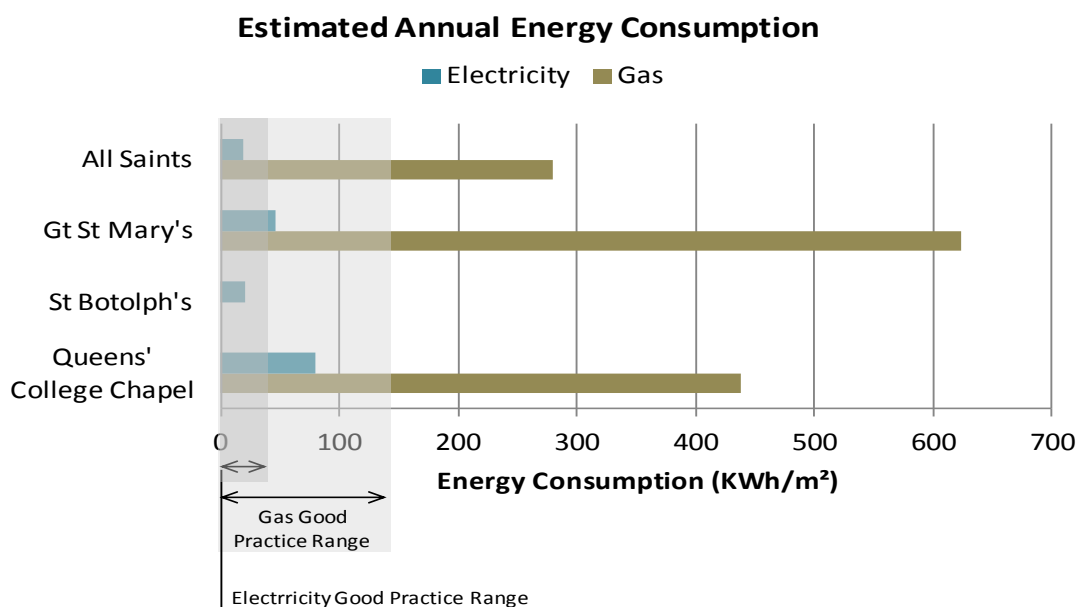


Figure 7: Estimated Annual Energy Consumption in four churches in Cambridge.

MEASURES FOR ENERGY CONSERVATION IN CHURCH BUILDINGS

Carbon dioxide emissions from churches arise from a limited number of activities. Mainly emissions come from energy used when heating and lighting a church but at larger sites other activities like hot water generation, kitchen and catering activities and office energy use will also contribute. It should be noted that using energy, whether it is electrical energy or fossil fuels like gas, oil or coal, will generally result

in the release of carbon dioxide emissions into the atmosphere (CofE, 2008). Small scale wind generation or solar power are generally not viable for most churches in the UK. Table 1 presents a summary of suggested energy saving actions that church building managers and users could undertake in order to achieve specific potential savings on their utilities bills (see). These measures can be of low, medium or high cost and would include:

- Establishing a schedule for energy conservation by empowering energy saving considerations to building users:
 - Inform and consistently educate users about benefits of building energy conservation and methods of reducing energy demand in their building.
 - Conduct regular monitoring of building energy consumption by either manual meter readings or via installation of specialised monitoring equipment, e.g. energy meters with pulse output transmitters (if affordable). This is the simplest method of energy-monitoring a church without need to install any extra hardware since regular meter readings and bills are kept to compare performance annually against benchmarks (Diocese of London, 2011).
 - Map the energy use patterns within the building through observation of energy end uses in order to identify activities that use excessive energy.
 - Introduce energy benchmarks to building users and provide them with regular feedback in order to understand the impact of particular activities or behaviours on energy consumption of their church.

- Effective settings and control of heating in churches can save up to 80% of energy use (Diocese of London and Carbon Trust, 2011). Measures to improve heating controls can vary:
 - Adjust temperature set-points to match requirements for heating levels in church environments.
 - Set appropriate time schedule controls to avoid waste of energy during long period when the building is not occupied.
 - Consider creating zones within church building according to use patterns.
 - Take advantage of the high thermal capacity of historic churches thermally heavyweight structure.

- Investing in energy efficient plant equipment and controls can lead to significant reduction of energy demand:
 - Low energy lighting lamp technologies and controls, e.g. Task/Ambient Lighting Schemes.
 - Low energy space heating systems in combination with creation of microenvironments for occupied zones, e.g. Floor-warming, pew heating.
 - Insulation of hot water pipework.

- Although often constrained because of heritage characteristics of church buildings that require conservation, particular fabric improvement options may prove to be robust and offer long term benefits to energy demand reduction:
 - Add insulation where the heritage fabric allows, e.g. roof voids, but ensure ventilation to minimise the risk of condensation.
 - Check completeness and improve the condition and of roof insulation.
 - Improve air tightness through repairing building envelop failures, such as sealing penetrations and joints in walls that may form unwanted air-paths, joints of walls to roofs, cladding panels and where services penetrate.
 - Check and improve condition of windows, grouting seals, closing mechanisms to minimise air leakage paths.
 - Consider high performance glazing for replacements with argon filled voids and special coatings to reduce the U value to less than 2.0 W/m²K including frame.
 - Secondary Glazing with high performing glass thin gap double glazing has been used successfully in heritage building refurbishments.
 - Check seals around doors, repair or replace as necessary.
 - Consider the fitting of draught lobbies to minimise the heat loss through external doors used continuously by public or building occupants.

- Micro generation equipment as soon as it is not visible from important view points and does not damage historic fabric. However, since installation of renewable energy technologies entails high investment costs with long payback periods, Low and Zero Carbon Technologies (LZCT) should be considered once procedural and demand reduction measures have first been put in place. Then LZCT would offer potential for major carbon reductions.

Table 1 Suggested energy conservation action for churches based on sources: (Diocese of London and Carbon Trust, 2011).

Suggested Primary Action	Suggested follow-up options/actions	Potential cost implications	Estimated savings on annual fuel bills (% of total utility cost per annum)
Establish a schedule for energy saving	Inform/educate users about benefits of building energy conservation and methods of reducing energy demand in their building	Zero or low cost	5% - 15%
	Regular monitoring of building energy usage	Zero or low cost	5% - 15%
	Monitoring and mapping of energy use patterns within the building to identify activities that use/waste too much energy	Zero or low cost	5% - 15%
	Provide feedback to building managers and users	Zero or low cost	5% - 15%
Improve heating controls	Check temperature set points	Zero or low cost	5% – 10%
	Check time schedule of controls	Zero or low cost	5% – 10%
	Check the zoning of heating and ventilating systems according to use patterns.	Low or medium cost	10 – 15%
	Take advantage of historic churches’ thermal mass properties.	Zero or low cost	10 – 15%
Suggested Primary Action	Suggested follow-up options/actions	Potential cost implications	Estimated savings on annual fuel bills (% of total utility cost per annum)
Energy efficient systems and controls	Low energy lighting	Medium cost	Up to 50%
	Low energy space heating and controls according to occupation patterns	High cost	Up to 20%
	Insulation of hot water pipes.	Low cost	Up to 5%
Fabric improvements	Insulate where heritage fabric allows but ensure ventilation to minimise the risk of condensation.	Medium or high cost	Up to 10%
	Improve air tightness to establish better control of air movement through the building.	Medium or high cost	1% - 10%
Low and Zero Carbon Technologies	Photovoltaic Panels: Electricity Production	High cost	Up to 76% reduction of electricity (mains) consumption
	Solar Thermal Panels for Domestic Hot Water (DHW) provision	High cost	Potential for 100% offsetting of gas (mains) use for DHW Up to 56% reduction in carbon emissions (gas consumption may be 0 if gas boiler is not used as back up to heating and hot water system)
	Biomass heating	High cost	Up to 34% (GSHP) would displace gas used for heating but with additional electricity use and would have longer payback period than biomass boilers.
	GSHP (Ground Source Heat Pumps): Space heating	High cost	

Regular meter readings were made in 2010 of the four church buildings in Cambridge in order to estimate the energy consumption per month (Figure 7). The survey was conducted in four representative churches with different types of heating strategies:

- Great St Mary’s church, Cambridge: Constant Central (Trench) heating

- St Botolph's church, Cambridge: Intermittent Local (Electric Panels on Pews) heating
- All Saints church, Cambridge: Constant Central heating, Thermostatically controlled to keep the church at conservation temperatures (11.5°C -12°C)
- Queens' College Chapel: Central heating with water pipes on windows level.

Queens' college chapel and Great St Mary's church consumed large amounts of gas (m^3/m^2) and electricity (KWh/m^2) due to regular use, compared to All Saints and St Botolph's church. The case-studies that used gas for heating space consumed much more fuel (KWh/m^2) than the 'good practice' quantity suggested by the benchmark - $151\text{KWh}/\text{m}^2$. The electricity consumption per annum seems to be closer to the suggested values (CofE, 2008). St Botolph's has been shown to perform poorly in conservation terms, leaving the question of whether All Saints provides adequate thermal comfort.

THERMAL COMFORT IN PLACES OF WORSHIP

One of the evident purposes of the Building Research & Information special issue 'Comfort in a Lower Carbon Society' (Shove, 2008) was to underscore how cultural and historical context has a significant impact upon the techniques of achieving human comfort deemed appropriate at the time. This undertaking is useful because it challenges assumptions that are often otherwise made about the ambient conditions with which we should provide people when these assumptions could easily lead towards certain undesirable outcomes. Supplying the same immediate environmental conditions to people scattered across the varied local climates around the world would require enormous amounts of energy. The effect of these assumptions might also mean many people could quickly become so used to specific ambient conditions that they turn their backs on the varied benefits that often follow the decision to spend time outdoors (Shove, 2008).

Creating thermal comfort with background heating and local supplementary warmth should more often be considered as a heating strategy in churches. Aside from technical upgrades of the building fabrics and services to address thermal comfort, this strategy can easily complement such upgrades and achieve better savings (Humphreys, 2011). Studies of thermal comfort in churches have shown that the operative temperatures that churchgoers consider thermally neutral have varied greatly in different cultures (de Dear, 1998, Humphreys, 1976).

To enable comparison of perceived thermal comfort levels occurring in all four case studies, responses obtained from the thermal comfort questionnaire survey that took place in all churches have been plotted in graphs that have expressed results in percentage of total answers obtained from each case.

Figure 8 reveals that the constantly heated churches (All Saints and Gt St Mary's) with trench LPHW heating system are more likely to offer thermally comfortable environments in comparison to St Botolph's and Queen's College chapel whose

answers are distributed towards the cool range of perceived thermal comfort graph. Although in both later churches responses present a rather normal distribution, large percentage of respondents indicated cool and slightly cool feeling, due to lack of constant heat inputs and thus low radiant temperatures expected to occur in these cases.

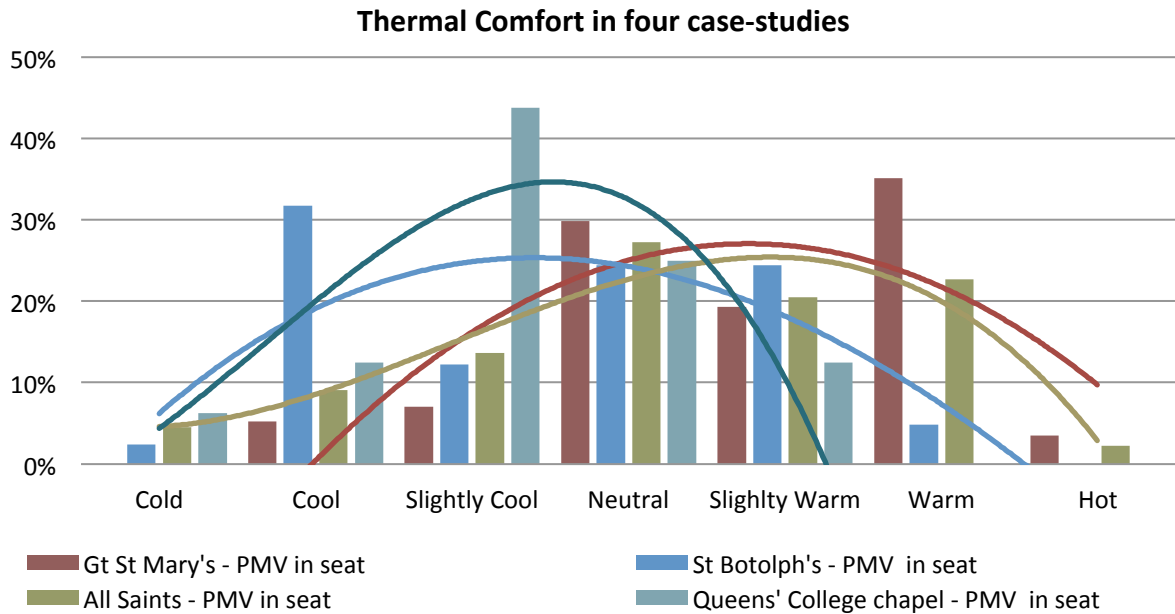


Figure 8 Perceived thermal comfort levels inside all four case-studies.

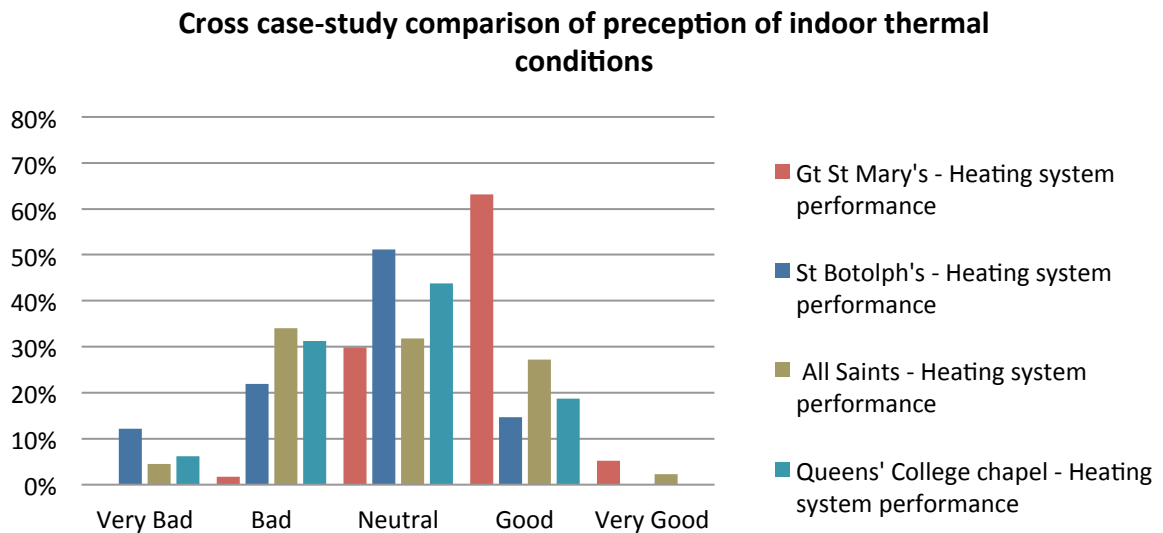


Figure 9 Rating of overall thermal conditions occurring inside all four case-studies as indicated by questionnaire survey respondents.

CONCLUSIONS

It is key to improve energy and environmental management of historic buildings with minimal intrusion. As in all other sectors, sustainable development in the historic built environment becomes a necessity. It is imperative for historic structures to reduce their footprint too. However, to achieve this, from an environmental performance point of view, buildings need to satisfy three key elements:

- **Energy efficiency**

Historic buildings and especially church buildings can often be found on exposed sites; structures are often massive, porous and damp. Due to the heritage value of their fabric and artefacts they contain, there are significant constraints on the type of environmental adaptation measures which can be used to upgrade their efficiency. For example, thermal insulation can be installed in roofs but is very difficult to incorporate in walls without significant effects on the building's appearance. Most improvements focus on renewing or upgrading existing building services, mainly heating systems in historic churches. However, building services are often difficult to select appropriately thanks to limited knowledge of the mechanisms that affect building fabric conservation and occupants' satisfaction; and due to restrictions on budgets to run them.

- **Conservation of historic fabric**

To maintain usability and increase interest in historic buildings, it is important to conserve fabric and conserve in vigorous and economical ways. However historic structures, such as church edifices pose more serious difficulties in applying effective and appropriate control of the environment than other building types. Best practice scenarios and principles are essential.

- **Human factor**

Although general guidance for design criteria for comfort exists, these need to be re-assessed. The research undertaken in four case studies in Cambridge, has proven that existing conditions should be further investigated to take into account human perception as well, rather than simply using predicted comfort models. Very often requirements of people, objects and fabric, appear to be in conflict; however this research suggests that it is possible to combine occupant satisfaction, conservation and energy efficiency.

Nevertheless, it is imperative to achieve better communication among key stakeholders, including practitioners, such as architects, conservators, building services engineers, building managers and curators, in order to achieve effective exchanges of knowledge that can balance the requirements of each party and thus

benefit a wider public audience and society. Interdisciplinary thinking can result in better solutions.

Most of the adaptation solutions already exist and do not require of very complicated and technologically advanced equipment. The most important requirement is having a comprehensive insight into the environmental requirements of occupants, historic elements and the energy saving options available. It is often said that the “best is enemy of good”, often analysis shows that trying to improve rather than reach some notional ideal may be the best and most practical solution for interventions in the historic built environment.

REFERENCES

- BIRD, P. 1959. Churches, Artists, and People. *Studies in Conservation*, 4 (2).
- CAMUFFO, D., PAGAN, E., SCHELLEN, H., LIMPENS-NEILEN, D., KOSLOWSKI, R. & BRATASZ, L. 2007. *Church Heating and the Preservation of the Cultural Heritage. Guide to the Analysis of the Pros and Cons of Various Heating Systems. Results of the European project Friendly Heating (EVK4-CT-2001-00067)*, Brussels, European Commission.
- COFE 2008. Shrinking the footprint, The Church of England's National Environmental Campaign, Guidance on Energy Efficient Operation and Replacement of Plant and Equipment. *Deliverable D9 Carbon Management Programme*. London: Church of England.
- CURTEIS, T. 2004. Environmental Conditions in Historic Churches: Examining their effect on wall paintings and polychrome surfaces *Transactions of the Ecclesiastical Architects and Surveyors' Association*, 5 36 - 46.
- CURTEIS, T. 2008. The survey and identification of environmental deterioration. *The Building Conservation Directory*. London: Cathedral Communications Ltd.
- DE DEAR, R. J., & BRAGER, G.S. 1998. Developing and adaptive model of thermal comfort and preference. *ASHRAE Transactions*, 104 (1).
- DEFRA 2009. Waste Strategy, Annual Progress Report 2008/09. London: Department for Environment, Food and Rural Affairs.
- DIOCESE OF LONDON 2011. Options, Challenges, Solutions, Limitations. *Environmental Challenge*. London: Diocese of London.
- DIOCESE OF LONDON AND CARBON TRUST 2011. Generic Building Solutions. *In: ARUP (ed.)*.
- DOUGLAS, J. 2002. Building adaptation. Oxford: Butterworth-Heinemann.
- ENGLISH HERITAGE 2002. Heritage Dividend 2002. Swindon: English Heritage.
- ENGLISH HERITAGE 2005. Regeneration and the Historic Environment. Heritage as a catalyst for better social and economic regeneration. London: English Heritage.
- HARVEY, J. 1972. *Conservation of Buildings*, London John Baker.

- HERITAGE, E. 2008. Energy conservation in traditional buildings. London: English Heritage.
- HUMPHREYS, M., NICOL, F., & ROAF, S. 2011. Keeping warm in a cooler house creating thermal comfort with background heating and local supplementary warmth. *Historic Scotland Technical Paper 14*. Scotland: Historic Scotland.
- HUMPHREYS, M. A. 1976. Field studies of thermal comfort compared and applied. *Journal Inst. Heating & Ventilation. Engineering* 44 5-27.
- JACKSON, M. 2005. Embodied Energy and Historic Preservation: A Needed Reassessment. *APT Bulletin*, 36 (4): 47-52.
- KELLEHER, S. (ed.) 2003. *New Work in Historic Places of Worship*, Swindon: English Heritage
- MADDEX, D. & NATIONAL TRUST FOR HISTORIC PRESERVATION IN THE UNITED STATES 1981. *New energy from old buildings*, Washington, D.C., Preservation Press.
- MERYMAN, H. 2005. Structural Materials in Historic Restoration: Environmental Issues and Greener Strategies. *APT Bulletin*, 36 (4): 31-38.
- PEARCE, D. 1989. Conservation today. London.
- PICKARD, R. 2004. The Role of Historic Buildings in Urban Regeneration: Eleventh Report of Session 2003–04. *House of Commons ODPM: Housing, Planning, Local Government and the Regions Committee*. London: The Stationery Office Limited.
- RODWELL, D. 2007. *Conservation and Sustainability in Historic Cities*, Oxford, Blackwell publishing Ltd.
- SEDOVIC, W. 2003. History's Green Genes. *The second International conference on Sustainability (GreenBuild), 12-14 November 2003*. Pittsburgh, PA: Green Building Council.
- SEDOVIC, W. & GOTTHELF, J. H. 2011. Paradox to Paradigm. Sustainability & Performance of Heritage Buildings. *Proceedings of Energy Management in Cultural Heritage conference, 6-8 April 2011*. Dubrovnik, Croatia.
- SHOVE, E., CHAPPELLES, H., LUTZENHISER, L., & HACKETT, B. 2008. Comfort in a lower carbon society. *Building Research & Information*, 36 (4): 307-311.
- TAYLOR, J. 2010. Listed Places of Worship. *The Building Conservation Directory*. London: Cathedral Communications Ltd.

Maintenance of Water Depth in Navigation Canals Versus Wetland System Loss- The Case of Canoly Canal, Calicut, Kerala, India

Anjana Bhagyanathan, Kasthurba A.K

National Institute of Technology, India

0266

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Inland navigation canals built during the Colonial Period in India, more often than not, connect distinct watersheds, and rely upon wetlands to sustain water levels required for navigation. This study addresses the impacts such navigations canals have on the surface flow patterns of the wetlands by analysing the case of Canoly canal and Kottuli Wetlands in Calicut, Kerala. The canal was constructed during the British rule in 1848. The canal connects two watersheds, that of the Kallayi river and Mangala river, linking both the estuaries and is geographically aligned to direct the flow of water from two wetland systems, Kottuli and Perunthuruthi to sustain water levels. Two thirds of the northern reaches of the canal falls in the Mangala basin and the southern part in the Kallayi river basin. The Kottuli wetland covering an area of 87.04 hectares is one of the 115 wetlands identified by the Ministry of Environment and forests, Government of India under the National Wetland Conservation Programme. Surface water from the wetlands flows into the canal through weirs while the groundwater seepage is generalised along the length of the canal. . Presently there are two proposed interventions for the canal. The Kerala Shipping and Inland Navigation Department's proposal to revive the West Coast Canal System, of which Canoly canal is a part, includes deepening and widening of the canal to ensure flow and to hold passenger and cargo vessels. The Irrigation Department proposes to deepen Canoly Canal to improve the flood drainage and domestic sewage into the canal. This scenario was analysed with respect to the drainage pattern of the region. A topographical map of 2m contour interval was prepared based on Google Earth imagery using Autocad. Surface drainage flow patterns were demarcated using Arcmap. Flow dynamics between the wetlands and the canal was documented with field observations. The study showed that the canal changed the flow pattern from the wetland. The outflow to the Arabian Sea has been diverted to the canal, both from the surface and the aquifer. This channelizes the flow, thus increasing the outflow and hence decreasing the water holding capacity. Further deepening of Canoly canal as proposed by the Shipping and Inland Navigation Department can result in outflow of water from Kottuli wetlands into the canal both from the surface and the aquifer; the extent of wetland loss will depend on the depth proposed for the canal. This will change the hydrodynamics of the wetland on which is the most important determinant for establishment and maintenance of ecosystem processes. The study recommends that this balance of water exchange needs to be understood and impacts quantified before any intervention that can potentially alter the hydrodynamics. Successful water management requires the adoption of methodologies which consider all bodies of water within a basin as opposed to just one body in a system.

iafor

The International Academic Forum

www.iafor.org

STUDY AREA

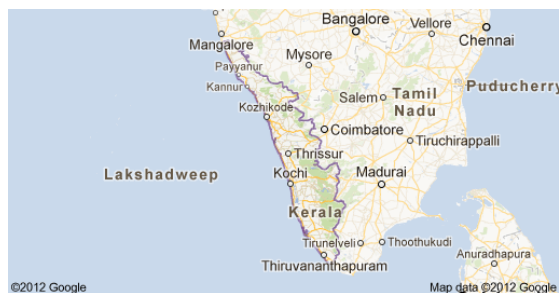


Figure 1. Location N

4

Kozhikode (Calicut), is on the south west coastal belt of India (Fig. 1). The coast of the district is about 71 Km and the area is 91 square kilometers. Kozhikode city is the nodal point for the four districts in the northern region of the state of Kerala. Kozhikode has traditionally been developed as a centre for forest and agro based industries. It has a high order of development in trade especially in food grains, marine products and spices. The city offers high potential for development of the entire northern region of the state. In view of this, Kozhikode is considered as one of the priority cities in the state. (District Urbanization Report, Kozhikode, 2011). The district has a humid tropical climate and an average annual rainfall of approximately 300mm (Bazak and Nazimuddin, 1988)



Figure 2. Kozhikode district map and study area

Canoly Canal

The Canoly Canal is part of the West Coast Canal system and is situated in the city of Kozhikode (See fig 2). The canal was constructed during the British rule in 1848 under the orders of the then Collector, the administrative head of the region, Mr. R. Canoly. The canal is 11.4 km long, the width ranges from 6m to 20m and water depth in the peak rain period varies from 0.5 to 2m (Harikumar et al, 2004). Most of the length of the canal, except the northern part, is heavily urbanized (Fig. 3). The canal connects the Kallayi River in the south and the Mangala River in the north, passing through Kottuli wetlands and Perunthuruthi wetlands

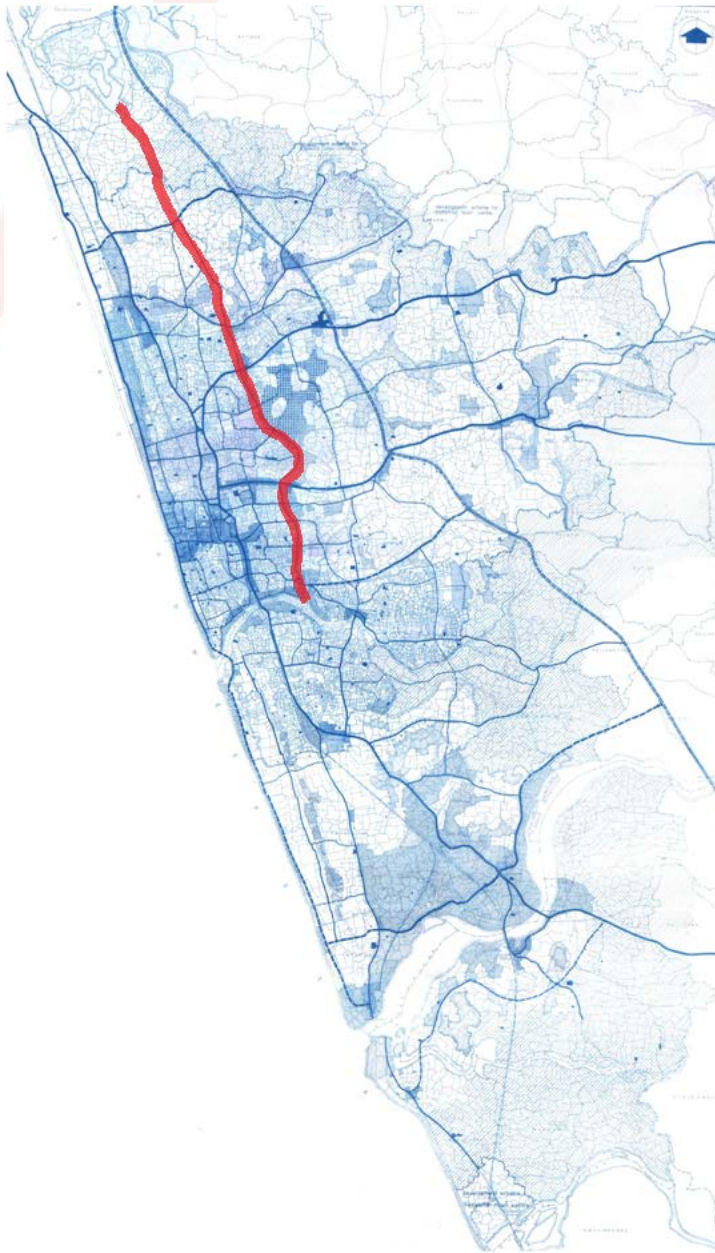


Figure 3. Canoly Canal in Kozhikode Corporation Limits

WETLANDS

Kottuli Wetlands

Kottuli wetland is one of the largest eco- patches within the city limits. It is interlinked with Canoly canal which receives tidal influx from the estuary of river Kallayi. The wetland covering an area of 87.04 hectares is rich in species of mangroves and mangrove associates. It is reported to be rich in aquatic organisms and bird species. This wetland has been identified by the Ministry of Environment and Forests, Government of India, under National Wetland Conservation Programme. It is one of the 115 wetlands identified as on June 26, 2009 by the programme (Government of India, 2009).

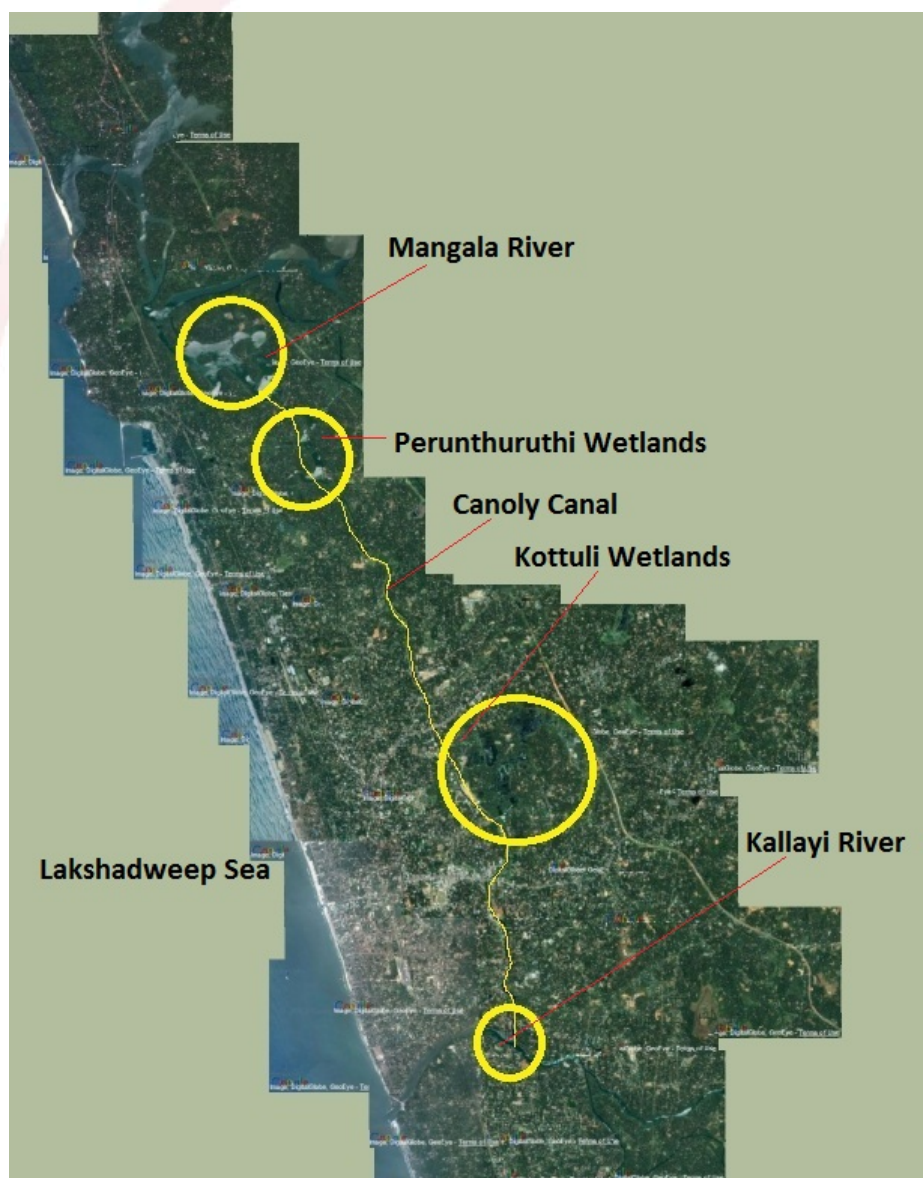


Figure 4a. Canoly Canal and wetlands location – Google satellite imagery

Perunthuruthi Wetlands

The Perunthuruthi Wetlands cover an area of about 60 hectares, in two parts. The northern part is called Mangala River, though morphologically it is part of the estuary of Korappuzha. It receives tidal influx from Korappuzha River. The second part has no surface connection to Mangala River. It is located further south and east of Mangala river estuary. It experiences tidal influx and salinity consequently through the Canoly Canal. The area is under aquaculture.

OBJECTIVE OF THE STUDY

Canals meant for navigation, more often than not, connect distinct watersheds, and rely upon wetlands to sustain water levels required for navigation. Interventions meant for the canals are undertaken without considering the qualitative and quantitative impacts on the wetlands they are connected to. The Kerala Shipping and Inland Navigation Department's proposal to revive the West Coast Canal System includes the deepening and widening of Canoly Canal. The National Bank for Agriculture and Rural Development (NABARD) is assisting the project to de-silt the Canoly canal and Kallayi River. The proposal to deepen Kallayi River to ensure flow from the canal to the river is funded by the River Management Fund. The objective of the project is to improve drainage in the city.

This study addresses the impacts on hydrodynamics in Kottuli wetlands by the proposed deepening of Canoly Canal. A similar study undertaken on Mangala river and Perunthuruthi wetlands will help draw up development plans for land use and inland navigation that take into account the impacts on the wetlands.

LIMITATIONS

The study concerns itself only with the flow patterns deduced from topographical analysis and field observations. Qualitative aspects like pollution and salinity intrusion have not been dealt with here, but have been covered in other studies (Hamno and Pettersson, 2005). Quantitative aspects of the flow dynamics is a further area of study.

TOPOGRAPHY

The Canal is oriented to direct inflow from 4 water bodies:

1. Mangala River
2. Perunthuruthi Wetlands
3. Kottuli Wetlands
4. Kallayi River

The highest elevation is found at Kunduparamba and lowest at Kottuli. (see Fig. 3) The red line shows the alignment of the canal and the dark ones are 5m contour lines. The blue areas represent water bodies.

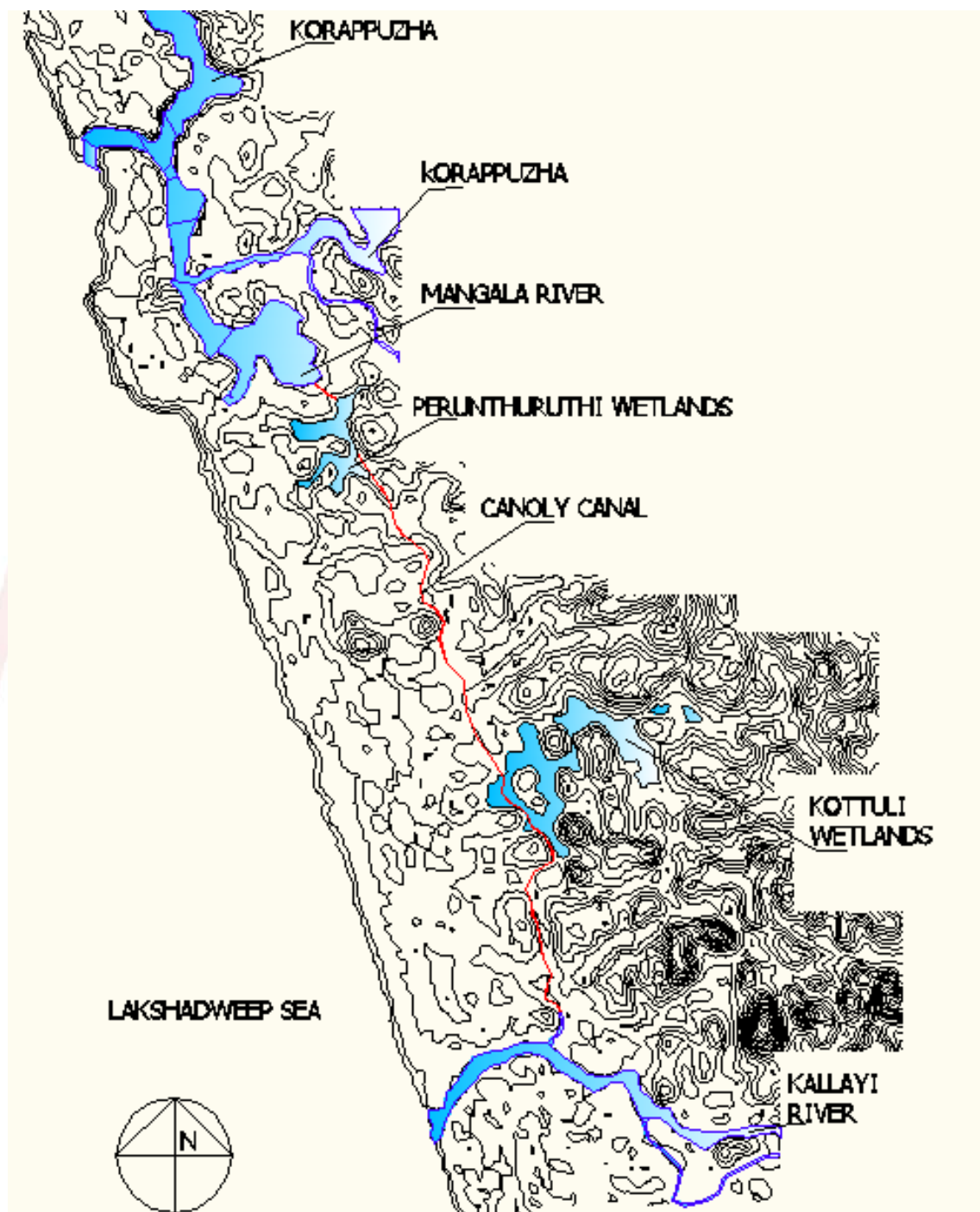


Figure 4b. Topography of canal environs

HYDROLOGY

Surface Water Hydrology

Analysis of the topography of the region shows that the stretch of the canal from Elathur to Kunduparamba falls in the Mangala river basin, and the rest, from Kunduparamba to Kallayi, falls in the Kallayippuzha (Kallayi river) basin. The canal passes through the ridge between

the two basins between Puthiyangadi and Kunduparamba; this is also the point that has maximum depth of the canal, minimum water depth and minimum tidal fluctuations.

Tidal influx into the Canal is experienced for a distance of 3km into the canal from both ends, from Mangala River and Kallayi River (Hamno and Pettersson, 2005). Other than secondary tributaries of Kallayi river, it is the two wetlands – Kottuli and Perunthuruthi, that maintain the water level in the canal in the mid sections (Anjana, AKK and Deepak, 2013). Fresh water from the wetlands flows into the canal and into the Kallayi estuary and reaches the sea. The quantum of this outflow needs to be determined to estimate the extent of fresh surface water loss involved.

Ground Water Hydrology

Kozhikode district is underlain by a shallow unconfined sandy aquifer with thickness varying from 4m to 12m (Bazak and Nazimuddin, 1983). The depth to the groundwater varies over the year from 0.21 m and 4.5 (Bazak and Nazimuddin, 1988). The least depth (to groundwater) is during the monsoon period, June to November, when the recharge is large. The areas to the west of Kottuli wetlands, beyond the Mini Bypass Road which are presently under residential land use, are flooded during the monsoons (The Hindu, June 13, 2010; November 1, 2008).

The depth of the canal ranges from 3.8m to 11m, (Hamno and Pettersson, 2005). Ground water seeps into the canal in varying quantities through the length of the canal depending on the water table depth at individual locations. The flow is assumed to be the maximum at Kottuli wetlands and Perunthuruthi wetlands where the water table is at its highest (0.21m during monsoon months). The quantum of outflow of groundwater into the canal, the estuaries and eventually to the sea can be measured to quantify aquifer depletion with accuracy.

KOTTULI WETLANDS-MODELLED FLOW PATTERN IN 1848

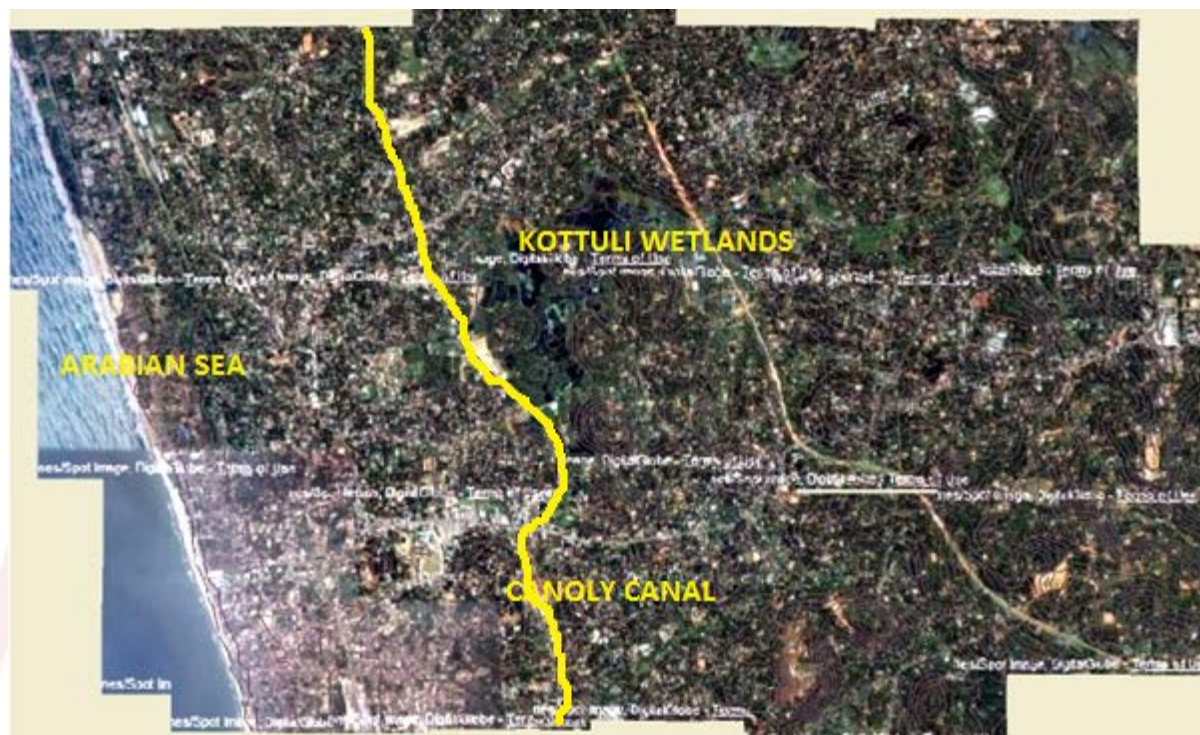


Figure 5 . Kottuli wetlands area; Google satellite imagery

The above figure illustrates how the Canoly /canal is oriented to direct the ground and surface water from Kottuli wetlands into the canal. A topographical map of the region with a contour interval of 2m was prepared based on the elevation information from Google Earth. The flow pattern of the region discounting the canal was analysed using Arcmap. The pattern shows a generalised flow towards the west, the Arabian Sea. Once the canal was built in 1848, the surface water and ground water was directed to the canal to maintain the water level for navigational purposes. Water from the canal flowed into the Kallayi river in the south and subsequently into the sea. This channelisation of outflow led to rapid loss of water into the sea both directly as above and indirectly by cutting off sheet flow towards the west. This results in loss of water extent and ground water recharge.

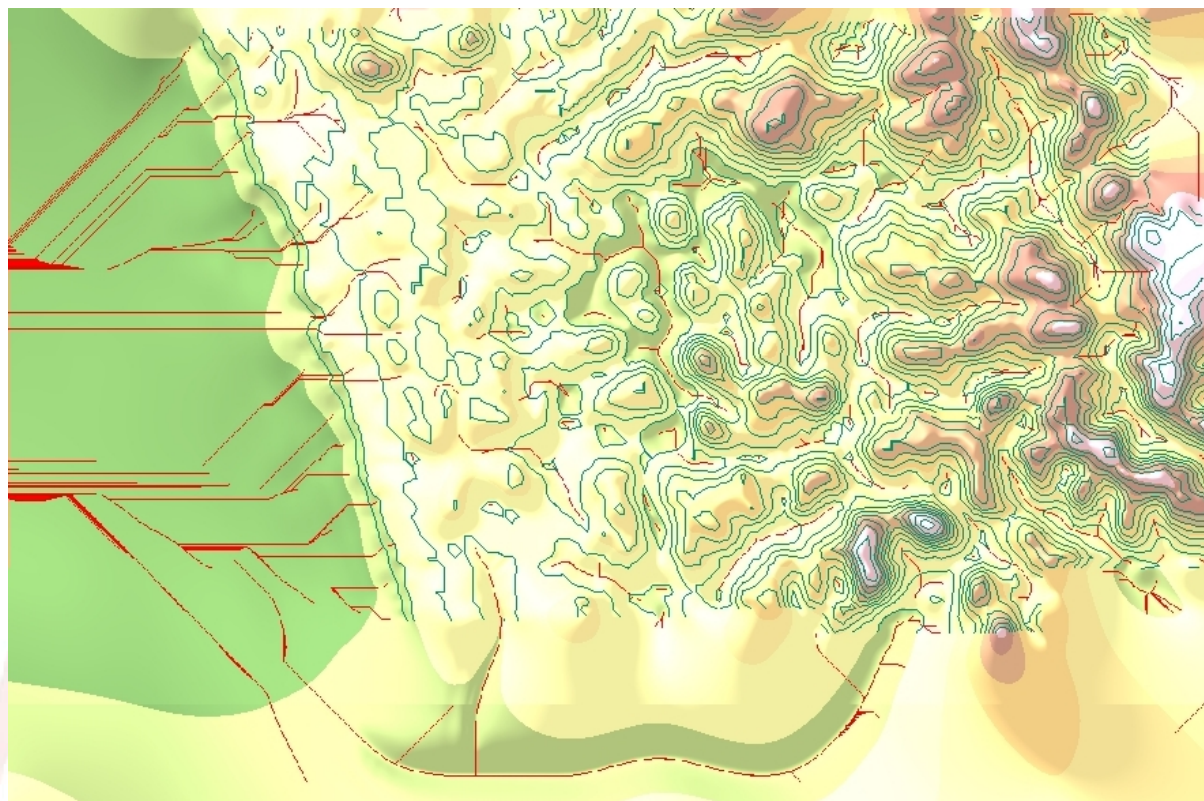


Figure 6. Flow pattern discounting the canal

KOTTULI WETLANDS – MODELLED SURFACE WATER COVERAGES

Viewed in isolation, the Canoly Canal and Kallayi River deepening project, aiming to improve the infrastructure and transport in the city, appear to have no negative externalities. But, the Canoly Canal connects the basins of Kallayippuzha and Korappuzha. This interconnectedness demands inspection of the water dynamics in an integrated fashion and points to a significant potential depletion of the wetlands. The methodology and results of this impact are discussed in this and following sections.

The present move by the Kerala Shipping and Inland Navigation Department and the Irrigation and Drainage Department to deepen the Kallayi River and Canoly canal can increase the outflow into the canal – both surface and ground water – thereby changing the seasonal pattern of water level which is the signature of the wetlands. The ground water flow into the canal will be through approximately 1300 sq m in Kottuli wetlands and 1080 Sq m in Perunthuruthi wetlands, assuming a deepening of 2m. Although the drainage through large tracts of wetlands points to a large quantity of water loss, its quantification is conspicuous by its absence.

The message of ‘The Economics of Ecosystems and Biodiversity for Wetland’ report commissioned by the Ramsar convention is, ‘drain it, lose it’. A fall in water level in the wetlands can change the ecosystem. Flora and fauna dependent on depth and extent of water and valuable ecosystem services like ground water recharge, flood mitigation, nutrient recycling will be disturbed, not to mention resource for sustainable tourism and recreation.

The flow of water into the canal from the sea is at the two mouths during high tides. Fig. 5 (reproduced from Hamno and Pettersson, 2005) shows that the inflow into the canal is about 1/7th of the outflow. Given that there was rainfall in the region the day before the study was conducted (Hamno and Pettersson, 2005), this variance is still significant. The outflow from the canal is more through the Kallayippuzha mouth. This could be explained by 2 factors:

1. The flow of water from the Kottuli wetlands and secondary tributaries of Kallayi River into the canal
2. Ground water flow into the canal through the entire length of the canal

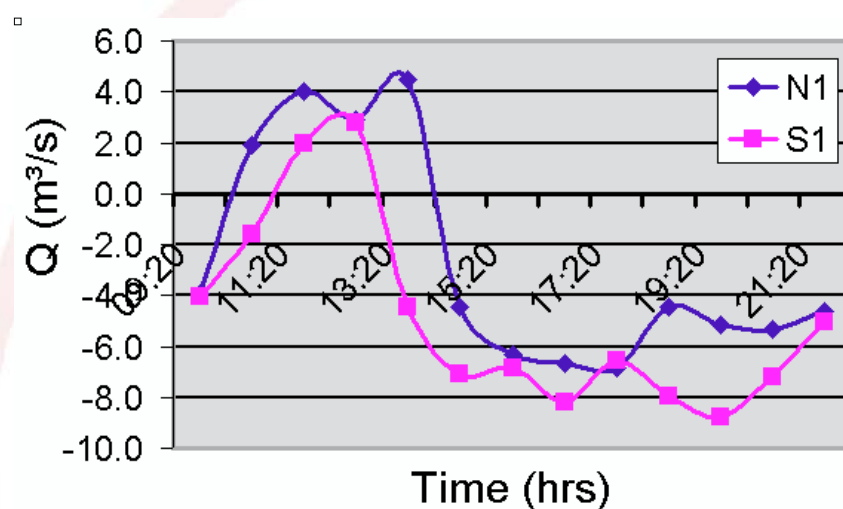


Figure 7. Flow in and out at both mouths (N1, S1) of canal

Sizing Methodology and Results

A topographical map with 2m contour intervals was prepared for the region, using spot levels from Google satellite imagery of 2007. The extent of water now (2007) was mapped with imagery and field observations (see Fig 6b). The depth of the canal at Kottuli proposed to be deepened by 2m from the current 8.4m (Hamno and Pettersson, 2005), the surface water level would also fall by 2m causing a shrinkage of the wetland area (see Fig 6c). Fig 6a is the reconstructed extent of Kottuli wetlands before the Canoly canal was built in 1848. The present depth of the canal bottom at Kottuli area is 8.4m (Hamnos and Pettersson, 2005). The reconstruction takes a decrease in water level equal to half the depth of excavation involved (that is, 4.2m). This, in our view, is the least that the Wetlands might have extended to back in 1848.

The next major event in the history of the wetlands is the construction of the Mini Bypass road and Bypass Roads both of which caused further fragmentation of the wetlands. Fragmentation of water surface water makes the filling process easier, therefore accelerating its pace. This analysis shows the strong depletion of the wetlands by the canal and its deepening (see Fig 8, 9 and10). This shrinkage is caused by the direct consequence of surface water level dropping (land ‘reclamation’) and accelerated by the subsequent fragmentation of the wetlands (making way for roads, residential and commercial developments).

9. CONCLUSION

The height of water table, precipitation, runoff, evaporation and the flow into the canal are the major factors in the hydrodynamics of Kottuli wetlands. This hydrodynamic is the most important determinant for the establishment and maintenance of specific types of wetlands and wetland processes (Mitsch and Gosselink, 2007). This balance needs to be understood and impacts on each of the systems – rivers, canal and wetlands – analyzed before interventions, which could potentially change the hydrodynamics.

If the Canoly canal is deepened, the outflow from the surface and the aquifer at Kottuli wetlands into the canal will increase, leading to a reduction in the area of wetlands. The degree of fragmentation will also increase owing to the topography of the region. This study brings to light the effect of Canals on wetland systems. This would assist planners in making informed and carefully calibrated decisions in the spheres of wetland conservation, canal development and land use allocation.

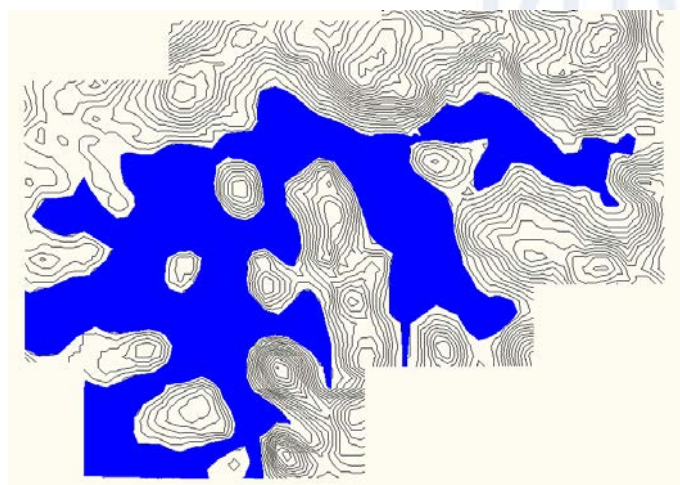


Figure 8. Hypothesized extent of Kottuli wetlands before Canoly Canal based on topography

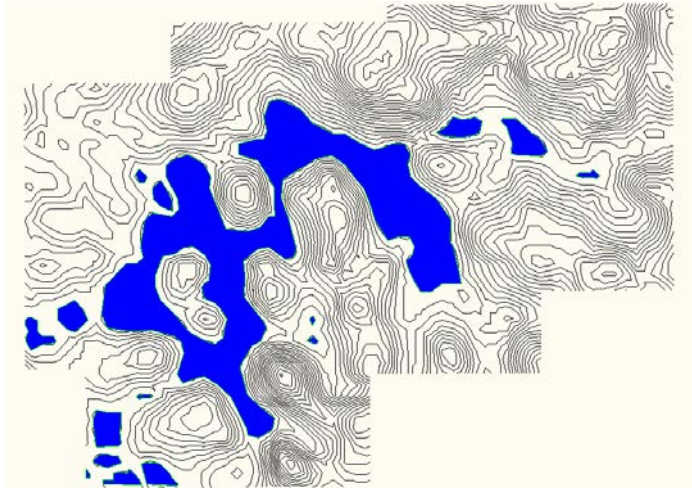


Figure 9. Present (2007) extent of wetlands based on topography

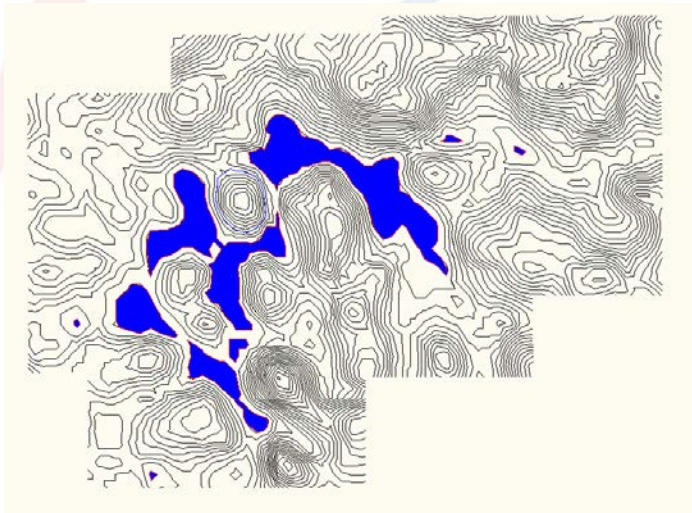


Figure 10. Extent of Kottuli wetlands assuming a deepening of 2m in the canal

10. RECOMMENDATIONS

If the watersheds approach to surface water management is undertaken for the city, such inconsistencies can be ironed out. The interconnected nature of river systems means that successful water management requires the adoption of methodologies which consider all bodies of water within a basin as opposed to just one body in a system. Depending on the flow dynamics, any alteration in one body can have implications in the system as a whole or parts. The river basin provides the natural unit for such an approach.

The basins needs to be demarcated and the flow pattern identified. The first step in the direction is the preparation of topographical map of the region with a contour interval of at least 2m. This will have uses in other spheres of urban management too, like the designing of water supply and sewerage system, transport network, water harvesting, irrigation network and delineating boundaries of natural resources for conservation efforts and planning.

REFERENCES

- Huggett R (1998): Fundamentals of Biogeography, Routledge, Taylor and Francis, London & NY.
- Harikumar PS and Jisha TS (2010): Distribution Pattern of Trace Metal Pollutants in the Sediments of an Urban Wetland in the Southwest Coast of India, International Journal of Engineering Science and Technology, 2 (5): 840 – 850.
- Anders Hamno and Asa Petterson (2005): Impact of Major Waterway Systems on Groundwater Quality, TRITA-LWR Masters Thesis, Stockholm.
- Kerala, Town and Country Planning, Dept. of. (2011): District urbanization report: Kozhikode.
- Anjana Bhagyanathan, A.K.Kasthurba, Deepak Dhayanithy (2013): Impact of Colonial Navigation Canals on Wetland Systems in India- The Case of Canoly Canal and Kottuli Wetlands, Calicut, Kerala
- Harikumar et al, Integrated Development Plan for Kozhikode city, Centre for Water Resources Development and Management, 2004
- Guidelines for Conservation and Management of Wetlands in India, Ministry of Environment and Forests, Government of India, 2009
- Sreedhara Menon A. (1997): Kerala – Land and People, In: Balachandran Thampi k. (edited) The Natural Resources of Kerala, World Wide Fund for Nature - India. 1-10
- Basak and Nazimuddin M (1983), Groundwater in the Coastal Belt: Kozhikode District, Centre for Water Resources Development and Management- Ground water Division, p 50
- Nazimuddin M and Basak P (1988), Groundwater Availability and its Distribution Along the Coastal Belt of Kozhikode District, Ground water Development on Coastal tracts,, Proceedings of National Seminar held at Trivandrum, 1988, College of Engineering, Trivandrum p 2-8
- Mitsch WJ and Gosselink JG (2007), Wetlands, Wiley, NJ, US.

Electronic Transferred Information:

<https://maps.google.co.in/maps> Electronic

*Evaluation of Cadmium Concentrations in the Surface Sediments of Salt River
Estuary, Taiwan*

Chiu-Wen Chen, Chih-Feng Chen, Cheng-Di Dong

National Kaohsiung Marine University, Taiwan

0283

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Major objectives of this study are to evaluation the pollution and potential ecological risk of cadmium (Cd) in the sediments of Salt River estuary, Taiwan. Nine monitoring stations were installed near the estuary of Salt River to collect sediment samples for analyzing Cd. Results of laboratory analyses show that contents of Cd in the sediments are between 0.25 and 2.54 mg/kg with an average of 1.05 ± 0.85 mg/kg. The spatial distribution of Cd reveals that the Cd concentration is relatively high near the river mouth, and gradually diminishes toward the harbor region. This indicates that upstream industrial and municipal wastewater discharges along the river bank are major sources of pollution. Results from the enrichment factor analysis imply that the sediments can be characterized as minor to severe degree of Cd enrichment. Results of geo-accumulation index analysis indicate that the sediments can be characterized as moderate degree of Cd accumulation. Results of potential ecological risk index indicate that the sediments at Salt River estuary have high to serious ecological potential risk.

Keywords: Cadmium, Ecological Risk, Enrichment Factor, Geo-accumulation Index, Sediment.

1. Introduction

Salt River is approximately 5 km long, and drains a catchment of less than 12 km². The river flows through the Linhai Industrial Park and China Steel Plant (the largest steel plant in Taiwan) and finally discharged into Kaohsiung Harbor (Fig. 1). In the Linhai Industrial Park, there are more than 482 registered industrial factories that discharge their treated wastewater into the Salt River. Results from recent investigation indicate that the Kaohsiung Harbor is heavily polluted, and the Salt River is one of the major pollution sources [1]. The river received untreated municipal and industrial wastewater discharges causing serious deterioration of the river water quality and the environmental quality near the river estuary to threaten the water environmental ecological system seriously.

Cadmium (Cd) is extremely toxic to most plants and animal species [2-4]; its presence threatens the water ecological environment. Therefore, much research effort has been directed toward the distribution of Cd in water environment. Anthropogenic activities including municipal wastewater discharges, agriculture, mining, fossil fuels, and discharges of industrial wastewater are the major source of Cd pollution [4]. Cadmium has low solubility in aqueous solution; it is easily adsorbed on water-borne suspended particles. After a series of natural processes, the water-borne Cd finally accumulates in the sediment, and the quantity of Cd contained in the sediment reflect the degree of pollution for the water body [5]. The objective of this study is to investigate the Cd distribution in the surface sediment near Salt River estuary so that the degree of Cd accumulation and potential ecological risk can be evaluated.

iafor

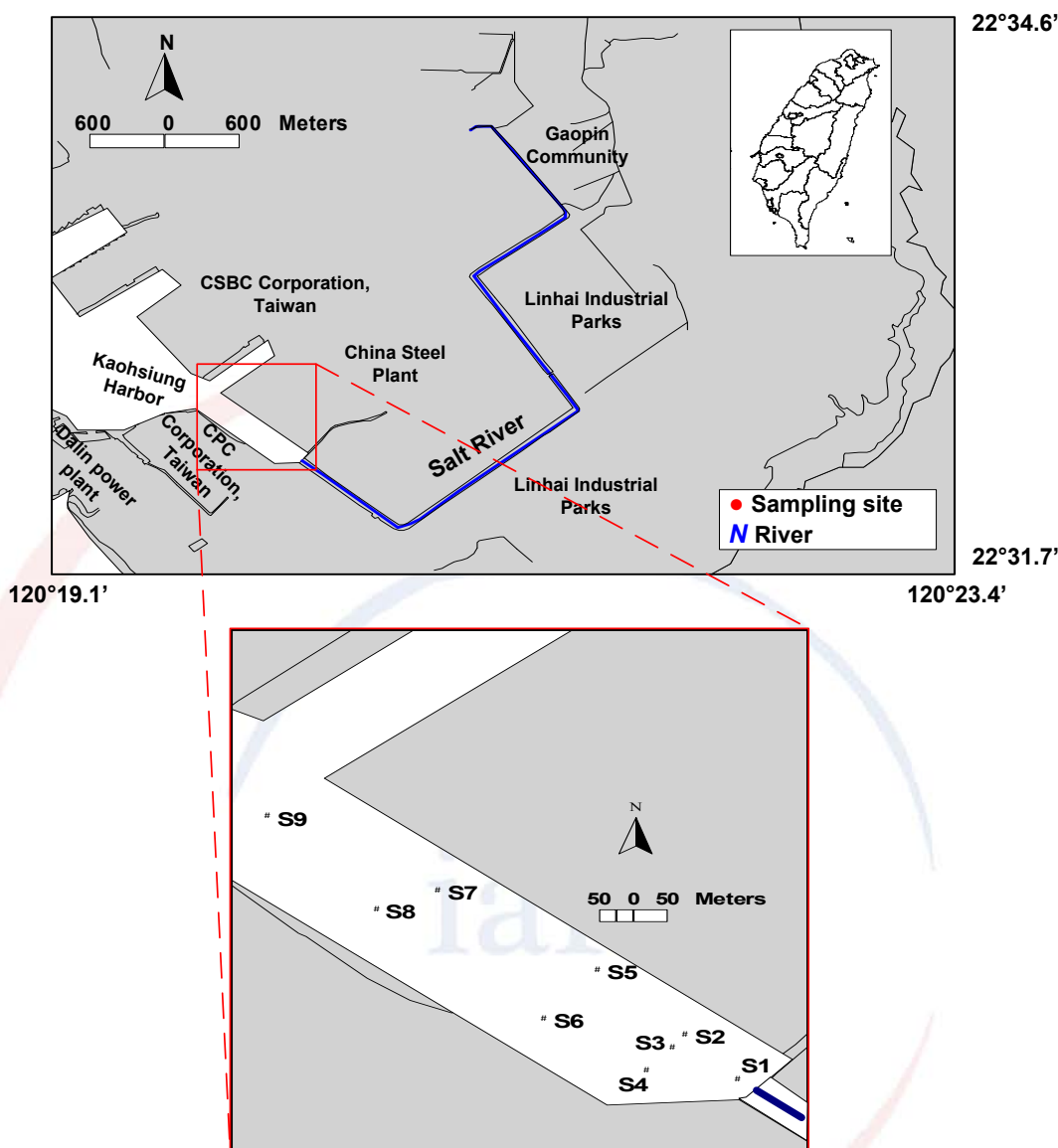


Figure 1. Map of the study area and sampling locations.

2. Materials and Methods

Surface sediment samples were collected at nine stations near Salt River estuary (Figure 1) with Ekman Dredge Grab aboard a fishing boat. The sampling stations, sample collection, and characteristics of the sediment (e.g. particle size and organic matter (OM)) have been reported in detail previously [6]. For Al and Cd analyses, the sediments were screened through 1 mm nylon net to remove particles with diameters larger than 1 mm. 0.5 g dry weight of the sediment sample was mixed with a mixture of ultra-pure acids ($\text{HNO}_3:\text{HCl}:\text{HF} = 5:2:5$), and was then heated to digest. The digested sample was filter through 0.45 μm filter paper; the filtrate was diluted with ultra-pure water to a pre-selected final volume. The Al and Cd contents were determined using a flame atomic absorption spectrophotometry (Hitachi Z-6100).

Statistical data analyses include average, standard deviation, maximum and minimum. In this study, the enrichment factor (EF) and geo-accumulation index (I_{geo}) were applied to evaluate the degree of Cd pollution and the associated potential ecological risk index (PERI). EF is defined as: $EF = (X/Al)_{\text{sediment}} / (X/Al)_{\text{crust}}$, where (X/Al) is the ratio of Cd to Al. The average Cd and Al content

in the earth crust were 0.2 mg/kg and 8.23%, respectively, that excerpted from the data published by Taylor (1964) [7]. The I_{geo} is defined as [8]: $I_{geo} = \log_2 (C_n/1.5B_n)$, where C_n is the measured content of element Cd, and B_n is the background content of Cd 0.2 mg/kg, in the average shale [7]. Factor 1.5 is the background matrix correction factor due to lithogenic effects. The potential ecological risk index PERI is defined as [9]: $PERI = PI \times T_i$, where PI (pollution index) = (C_i/C_f) ; C_i is the measure concentration of Cd in sediment; C_f is the background concentration of Cd; T_i is its corresponding coefficient, i.e. 30 for Cd [9]. In this study, the average Cd content in earth crust of 0.2 mg/kg [7].

3. Results and Discussion

3.1 Distribution of Cadmium in Sediments

Contents of Al in the sediment of Salt River estuary are between 3.34 and 5.8% with an average of $4.95 \pm 0.72\%$. All sediment samples collected at Salt River estuary contain 0.25–2.54 mg/kg of Cd with an average of 1.05 ± 0.85 mg/kg (Figure 2). Concentration distributions of Cd in Salt River estuary sediment shown in Figure 2(b) reveal that the sediment Cd content is relatively higher near the boundary of the river estuary, and gradually decreases in the direction toward the harbor. Because Salt River is subject to upstream discharges of treated and un-treated domestic and industrial wastewaters, the pollutants are transported by river flow and finally accumulate near the river estuary. Some pollutants may drift with sea current to be dispersed into open sea.

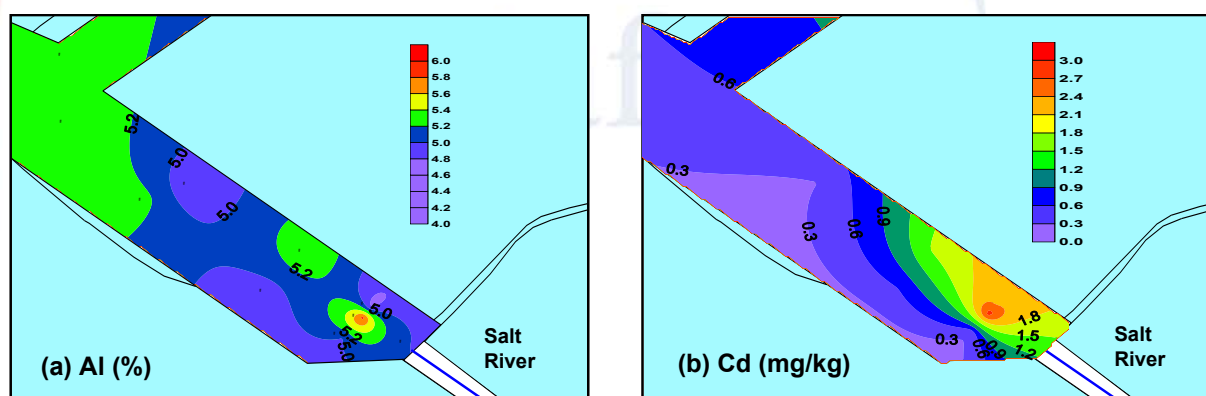


Figure 2. Contour map of Al (a) and Cd (b) contents in the surface sediments of Salt River estuary.

3.2 Enrichment Factor

The enrich factor (EF) is a useful tool for differentiating the man-made and natural sources of metal enrichment [1,10]. This evaluating technique is carried out by normalizing the metal concentration based on geological characteristics of sediment. Al is a major metallic element found in the earth crust; its concentration is somewhat high in sediments and is not affected by man-made factors. Thus, Al has been widely used for normalizing the metal concentration in sediments [1,10]. When the EF of a metal is greater than 1, the metal in the sediment originates from man-made activities, and vice versa. The EF value can be classified into 7 categories [17]: 1, no enrichment for $EF < 1$; 2, minor for $1 < EF < 3$; 3, moderate for $3 \leq EF < 5$; 4, moderately severe for $5 \leq EF < 10$; 5, severe for $10 \leq EF < 25$; 6, very severe for $25 \leq EF < 50$; and 7, extremely severe for $EF \geq 50$. Table 1(a) show EF values of the sediment Cd for the Salt River estuary region; the Cd concentration is consistent with the Cd EF value for all sampling sites, and all EF values are greater than 1. This indicates that the sediment Cd has enrichment phenomenon

with respect to the earth crust and that all Cd originates from man-made sources. Sites S1, S2 and S3 are classified as severe enrichment, Sites S5, S6 and S9 are classified as moderate enrichment, and the other Sites are classified as minor enrichment. These results point out that the sediment near the river mouth experiences severe enrichment of Cd that originates from the upstream sources of pollution. Additionally, the average EF value of 8.3 obtained in this study is lower than the average EF value of 11.4 reported earlier [1] indicating that the upstream pollution has been reduced so that the accumulation of pollutants in sediments is not as serious as during earlier years. This observation may show the effectiveness of intercepting the Salt River flow and dredging the river estuary.

Table 1. EF, I_{geo} , PI, and PERI of Cd for each station studied at Salt River estuary

Site	(a) Enrichment factor			(b) Geo-accumulation index			(c) Potential ecological risk		
	EF value	EF class	EF level	I_{geo} value	I_{geo} class	I_{geo} level	PI	PERI	Risk level
S1	11.5	5	severe	2.2	3	moderately strong	18	525	serious
S2	17.4	5	severe	2.7	3	moderately strong	25	750	serious
S3	17.8	5	severe	3.1	4	strong	32	951	serious
S4	2.9	2	minor	0.2	1	none to medium	4	131	higher
S5	11.8	5	moderate	2.4	3	moderately strong	19	581	serious
S6	4.6	3	moderate	0.9	1	none to medium	7	206	high
S7	2.6	2	minor	0.0	1	none to medium	4	113	higher
S8	2.0	2	minor	-0.3	0	none	3	94	higher
S9	3.8	3	moderate	0.7	1	none to medium	6	188	high
Mean	8.3	4	moderately severe	1.3	2	moderate	13	393	serious

3.3 Geo-accumulation Index

Similar to metal enrichment factor, index of geo-accumulation (I_{geo}) can be used as a reference to estimate the extent of metal accumulation. The I_{geo} value can be classified into 7 classes: 0, none for $I_{geo} < 0$; 1, none to medium for $I_{geo} = 0-1$; 2, moderate for $I_{geo} = 1-2$; 3, moderately strong for $I_{geo} = 2-3$; 4, strong for $I_{geo} = 3-4$; 5, strong to very strong for $I_{geo} = 4-5$; and 6, very strong for $I_{geo} > 5$. Based on the I_{geo} data and Müller's (1979) [8] geo-accumulation indexes, the accumulation levels with respect to Cd at each station are ranked in Table 1(b). Sites S1-S3, and S5 are classified as either strong or moderately strong accumulation, Sites S8 is classified as none accumulation, and the other Sites are classified as none to medium accumulation.

3.4 Potential Ecological Risk

The potential ecological risk index (PERI) is applied to evaluate the potential risk associated with the accumulation of Cd in surface sediments. PERI that was proposed by Hakanson (1980) [9] can be used to evaluate the potential risk of one metal or combination of multiple metals. The calculated PERI values can be categorized into 5 classes of potential ecological risks [9]: low risk ($PERI < 40$), moderate risk ($40 \leq PERI < 80$), higher risk ($80 \leq PERI < 160$), high risk ($160 \leq PERI < 320$), and serious risk ($PERI \geq 320$). Table 1(c) lists the PI value, PERI value, and risk classification for the Cd contained in the surface sediment samples collected near Salt River estuary. All nine stations are classified between high to serious risk with respect to Cd pollution. The above evaluation results indicate that the Cd contained in surface sediments at Salt River mouth has serious potential ecological risks. Therefore, effective management and control of upstream pollution should be immediately implemented in order to improve the river mouth sediment quality and lower the associated ecological risk.

4. Conclusions

The sediment samples collected at Salt River estuary contain 0.25–2.54 mg/kg of Cd with an average of 1.05 ± 0.85 mg/kg. The distribution of Cd in sediment reveals that the Cd originates from the river upstream discharges of industrial and domestic wastewaters; it is transported along the river and finally deposited and accumulated near the river estuary. Results of EF analysis indicate that the Salt River estuary sediments were minor to severe enrichment with Cd. Compared to the EF value of 11.4 reported earlier [1], the degree of Cd enrichment at Salt River estuary has been obviously reduced. This may be associated with river renovation and river estuary dredging. Results of I_{geo} analysis show that the Salt River estuary sediments were moderate accumulation with Cd. Results of potential ecological risk evaluation show that the classification of potential ecological risk for the sediment Cd at Salt River estuary is between high to serious. The results can provide regulatory valuable information to be referenced for developing future strategies to renovate and manage river estuary and harbor.

References

- [1] C.W. Chen, C.M. Kao, C.F. Chen and C.D. Dong: *Chemosphere* 66 (2007) 1431–1440.
- [2] M. Fukue, C.N. Mulligan, Y. Sato and T. Fujikawa: *Environ. Pollut.* 149 (2007) 70–78.
- [3] E. Pertsemli and D.Voutsas: *J. Hazard. Mater.* 148 (2007) 529–537.
- [4] A. Ciliberti, P. Berny, M.L. Delignette-Muller and V. de Buffr enil: *Sci. Total Environ.* 409 (2011) 4735–4745.
- [5] K. Selvaraj, V. Ram Mohan and P. Szefer: *Mar. Pollut. Bull.* 49 (2004) 174–85.
- [6] C.W. Chen, C.F. Chen, C.D. Dong and Y.T. Tu: *J. Environ. Monit.* 14 (2012) 105–115.
- [7] S.R. Taylor: *Geochem. Cosmochim. Acta*: 28 (1964) 1273–1285.
- [8] G. M uller: *Umschan* 79 (1979) 778–783.
- [9] L. Hakanson: *Water Res.* 14 (1980) 975–1001.
- [10] C.W. Chen, C.F. Chen and C.D. Dong: *APCBEES Procedia* 1 (2012) 157–162.

Sustainability through Subsistence: The Case for De-urbanization in Malaysia

Nur Mohd Hussain, Hugh Byrd

The University of Auckland, New Zealand

0297

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Industrialization was the catalyst for the growth of cities in Southeast Asia, in particular Malaysia. However, in many cities industrialization has peaked and is now declining. This raises the issue of increased urban poverty as a significant problem facing these cities in the 21st century.

Evidence from other developing countries is that faced with the choice of urban poverty or rural subsistence, there appears to be a trend towards de-urbanization. As Malaysia is unique in imposing laws that protect rural land ownership, this study investigates the capacity of the available land to absorb migrants from the city and seeks to identify whether the returning migrants have the capabilities required to maintain a subsistence lifestyle.

This paper presents a case study analyzing the trends of urban to rural migration in Malaysia. An audit of land capacity was carried out in a typical kampong and an investigation of the capability of migrants has been done in both urban and rural areas. In conclusion, this study has found that the land abandoned by the rural-urban migration of the 1970s is available and remains accessible for future use. The findings also identified several examples of returnees who have shown that they have adapted well to a rural lifestyle. The results indicate that there is evidence that de-urbanization can result in a sustainable lifestyle through subsistence living in Malaysia.

Keywords: *land capacity, society capability, de-industrialization, de-urbanization, kampong*

1.0 Introduction

The future of industrialization is rapidly changing and is in decline in the countries that were industrialized early (Whittaker, Zhu, Sturgeon, Tsai, & Okita, 2010). Malaysia was one of the first countries to industrialise in Southeast Asia and has been in decline since the first few years of this century (Rasiah, 2011). Malaysia's economic growth has been largely dependent on its resources of oil and gas in the South China Sea. The abundance of oil and natural gas that fuelled industrial growth has peaked and the depletion of resources is threatening economic recovery (Byrd, 2008).

The dwindling supplies of oil and gas in Malaysia will affect production in the industrial sectors, as with food production and job opportunities. Without these basic resources, cities will lose the vital components of economic growth.

The failure of cities as engines of growth will also affect social structures and livelihoods. As a city fails, jobs, foods and the safety of the population become less secure. Society in general will face economic hardship, resulting in urban poverty. With evidence emerging of de-industrialization, will there be a concomitant return to rural living, a case of de-urbanization?

In Malaysia, industrialization has not only improved infrastructure in the cities, but also life in rural areas through an improved electricity supply, better health services, and an increased investment in the agriculture sector. This has resulted in a reasonably high standard of living in rural areas (Byrd H., 2012). Therefore, the future challenge of poverty in Malaysia does not necessarily concern the rural poor. The future problem may instead be the urban poor who lack any form of resilience, and have forgotten the traditional ways of subsistence living.

Malaysia is fortunate to have significant areas of fertile reserve land that are covered by a unique legislation. This Malay reserve land can only be owned and held by the Malays and they are not permitted to sell (Leete, 2007; Zaki, Hamzah, Ismail, Awang, & Hamid, 2010). This legislation has been discussed by, among others, Zaki et. al (2010) who found that although the land tenure system in Peninsular Malaysia has undergone several changes since 1957, the Malay reserve land and the customary land tenure system are still much implemented especially among the rural Malay society. However, most of these reserve and customary lands have been abandoned due to rural-urban migration during the industrialization period of the 1970s. This has left the door open for the urban migrant to return to the land.

Another factor that has led to the trend of de-urbanization in Malaysia is the mobility of the population. McGee (2011) and Hadi et al. (2010) have shown that population movement has resulted in new areas of settlements or re-settlements. From the compact cities, people have begun to relocalize, a form of decentralization of the cities into sub-urban and new town developments, which are part of a trend towards counter-urbanization (Hadi, Idrus, Shah, & Mohamed, 2010; Idrus, Hadi, Shah, & Rainis, 2010; T. McGee, 2011). This movement has resulted in people living closer to rural areas.

Demographic statistics have shown a decline in the urban population since the early 20th century (Eng, 1995; Talha R., Baharudin N., & Jantan I., 2007). That year, the Department of Statistics Malaysia Census recorded that the population growth in cities decreased from 35% in 1995 to 26% in 2005 (Talha R. et al., 2007). This statistic was supported by Elias et

al.(2009) in his article on migration trends and patterns in Malaysia, which predicted a continuous urban population decline to 14% of urban population growth in 2015 (Elias O. K. & Ramli R., 2009).

Therefore, de-urbanization is a possibility for those urban dwellers that cannot adapt to the new order of an unsubsidized, failing, urban economy (Byrd H., 2012). The question arises; “Do the rural areas have the land capacity to cater to the potentially large number of returned migrants, and are those urban returnees capable of working on the land again?”

Many previous studies have focused on how to create a sustainable city and there has been an emphasis on increased compaction of cities. For example, Newman (1999) has argued for increased density on the basis of both environmental and social benefits, while Al-Kodmany (2011) has argued for density on the basis of an increased population, and Jenks (2000) has highlighted effective settlements and urban transportation. However, these arguments are based on the assumption that continued economic growth is sustainable. This paper does not make the assumption that economic growth is sustainable and focuses on ‘de-urbanization’; resilience that can be achieved by a return to subsistence living in rural areas as one of the alternatives to urbanization.

This paper has adopted the ‘*sustainability through subsistence*’ concept as one of the possibilities if de-urbanization occurs. This research uses a case study to measure the land capacity that will be available and accessible for returned migrants. It will also discuss a sample of the returned migrants who have adapted well and are living, out of poverty, in rural settlements (*kampong*).

2.0 Sustainability through Subsistence

2.1 Sustainability: Issues & Challenges of Industrialization in Cities

The concept of sustainability has become a key idea in national and international discussions for 30 years (Doughty & Hammond, 2004). The Brundtland Report (1987) and the 1992 Rio ‘Earth Summit’ raised attention about which global system would satisfy “the needs of the present without compromising the ability of future generations to meet their own needs” (Environment & Development, 1987). This has stimulated further discussions on sustainable development, urban sustainability and sustainable urban.

The sustainability concept has been greatly discussed by Ian Douglas (1983,1992), Girardet (1990, 1996), Jenks (2001), Newman (1999) and Al-Kodmany (2011). Many of their major contributions are links with the cities and address issues of urban sustainability. Jenks (2001) and Girardet (1990) agree on compacting cities to make them more sustainable, while Champion (2001) and McGee (1971, 1987) emphasize the idea of accelerating urban growth to concentrate people into larger agglomerations in order to make cities livable. Both these concepts agree, however, that cities would continue to lead economic growth. This is related to the discussions of the Urban Foundation (1993) on urban management, which has a section on enhancing urban productivity, citing that “the economic future of a developing country lies in the productivity of its cities” (cited in Drakakis-Smith (1995).

Drakakis-Smith (1995) on the contrary, discusses the present inadequate environmental situation, which raises various threats to established sustainable urban development such as the issues of employability, poverty, basic needs and human needs. The issue of limits to city

growth by Meadows, Randers, & Meadows (2004), has also drawn world attention to the city's ability to be sustainable. Recent publications by other scholars further discuss de-industrialization trends (Rasiah, 2011; Rowthorn, Rowthorn, & Ramaswamy, 1997).

Many agree that de-industrialization has contributed to a widening income inequality and the displacement of workers, which has consequently led to urban poverty. This situation has been further discussed by David Brady and Michael Wallace in their article entitled 'Deindustrialization and Poverty: Manufacturing Decline and AFDC Reciprocity in Lake County, Indiana 1964-1993', in which Brady et.al (2001) conducted a survey in Lake County, Indiana to investigate how de-industrialization has contributed to the county's impoverishment by measuring the percentage of population receiving Aid to Families with Dependent Children (AFDC). Their findings of a decrease in the percentage of giving out money for fund which supported Bluestone and Harrison's (1982) suggestions that de-industrialization can lead to a loss of both family wealth and community, and can lead to poverty. The concern with poverty is the ability of the urban household to achieve its own form of sustainable development which impinges on the sustainability of urban situation as a whole (Schwarz, 1993).

This urban poverty issues is a substantial problem due to the high urbanization rate of poor (Drakakis-Smith, 1996; Ravallion, 2002). Drakakis (1996) has argued that the most significant problem facing emerging economies is not the rural poor but the new urban poor "*Indeed the problem goes on to state accepting the poor as a necessary transition of the urban scene*" (Drakakis Smith, 1996). Drakakis (1996) has put forward the case that the pull factors of the city that offer opportunity and wealth are often unreal and take people from rural poverty, with a semblance of resilience, to an urban poverty that has no self-determination.

It has also been argued (Whittaker et. al, 2007) that the urban middle classes in the rapid developing emerging economies have also suffered. They suggest that there has been both a 'double burden of disease' and a 'double challenge of education' that has restricted human development (Monteiro, Conde, & Popkin, 2002; Organization, 2010; Popkin, 2002). The 'double burden of disease' relates not only the traditional diseases that continue in urban areas, but also the new diseases such as obesity due to increased consumption of fat and a sedentary lifestyle. Meanwhile, the 'double challenge of education' as been argue by Dore (1976) relates to the problem of divided societies where there remains not only inadequate education amongst low economic groups but also the mass education of middle-income causing 'credential inflation' without significantly increasing the quality of job prospects.

2.2 Subsistence Way of Life

One way of reducing the economic hardship result from both industrialization and de-industrialization is by implementing a return to subsistence living. Subsistence living can be defined as self-sufficient living, where the society focuses on growing enough food to feed and clothe themselves and their families (Sharif, 1986, 2003; Wharton Jr, 1969). Sharif (1986) added that this concept resembles the traditional way of living, where people managed to work and survive with what prosperity land and nature can offer.

The experiences of countries that have already faced de-industrialization have proved that self-sufficient living could have many socio-economic benefits for society. Alteri et.al (2012) and Rosset (1997), found that by participating in intensive farming, it can contributed to the improvements in the reduction of the food crisis in Cuba (Altieri et.al, 2012; Rosset, 1997).

In Detroit, Hill (1983) and Sugrue (2005) have also highlighted the fact that working on the land has helped overcome industrial failure and allowed people to survive. This finding has been supported by Wylie-Kellermann (2009), who discusses the implosion and collapse of industrial growth that has been happening over the last few decades in Detroit, which is finally catching up with the rest of the country, and with the global system, by growing back the culture of self-subsistence agriculture (Wylie-Kellermann, 1989; 2009). He adds that after the industrial heyday of Detroit had turned to rust, the city re-adapted by nourishing projects on a human scale, working on the urban community and struggling to encourage an economy of creativity and self-reliance.

The concept of 're-adapt' allows people to continue living a subsistence lifestyle (Wharton Jr, 1969). According to Chambers & Conway (1992) a livelihood is considered sufficient when the society can cope and recover from economic failure or is able to maintain its capabilities and assets. This idea was supported by Omar et al. (2013) in their article entitled '*Sufficient and Sustainable Livelihood via Community Economy: A Case of Natural Farming Program in East Malaysia*' which discovered that a natural farming program is an affordable community economic model that can improve sustainable livelihoods in rural areas (Omar, Ishak, Moen, & Arshad, 2013).

Omar et. al (2013) analyses on how the natural farming programmes can increased the society household incomes as well as reducing household food expenditure by developing edible gardens around their compounds. Their results show that the natural farming program has not only benefitted the household income but has also improved social aspects such as health, knowledge on agriculture and relationships among family members. These findings concluded that the effort of '*working on the land*' was able to contribute not only towards supporting subsistence living but also succeeded in self-generating household income.

In addition, this paper addresses '*subsistence of life*' as a way in which people can use new technologies to assist traditional life. Rural areas have vast natural resources such as land and plants which allow alternative technologies to be developed and used locally. For example solar power, which creates energy by utilizing rooftops and awnings in the big cities, has the potential to produce greater quantities of energy in the large fields and compounds of the suburban (Tumber, 2012). Tumber (2012) has given a good rule of thumb on the ability that rural areas have to generate solar energy, which is that one megawatt of solar-generated power can be produced by about eight acres of land. This is not possible within a dense, compact megacity.

Other researchers, such as Millinger (2012) have discussed the potential of solar power in the rural areas of India, which are able to increased two times more than the urban potential in producing solar power for the household electricity supply (Millinger, Mårilind, & Ahlgren, 2012). This situation has not only catered to the local demand, but has shown further benefits by reducing household expenses and generating income for the rural community.

Land with natural resources has the potential to be developed using new technologies, providing a way for rural communities to adapt well to self-sufficient living while remaining far from poor. This paper investigates the question of how much land capacity and social capability Malaysia has to support a subsistence way of life if de-urbanization occurs.

3.0 Malaysian Case Study

3.1 The Study Area

Prior to the growth created by industrialization in the 1970s, there had been a decline in agricultural development in Malaysia (Drabble, 1993). Over 800,000 hectares of agricultural land was abandoned or underutilised, and Negeri Sembilan was reported to be the state that faced the highest levels of decline. Kassim A. (1989) stated that 53.8% of agricultural land in Negeri Sembilan was underutilised in 1981. She added that these abandoned agricultural lands remained subject to ‘*Tanah Adat*’, or customary land use, meaning that they are protected by laws and cannot be sold. For these reasons, Negeri Sembilan has been purposely chosen for this study, not only because of its abandoned land, but also for the unique history and laws surrounding customary title.

The case study is based in the *mukim* of Seri Menanti, in the district of Kuala Pilah, Negeri Sembilan, which is still considered the stronghold of *adat* (culture), especially as practised in the Negeri Sembilan royal household. Kampong Gunung Pasir in Seri Menanti, Negeri Sembilan was chosen as the sample area based on criteria such as its location in the foothills of the North-South range which cross Peninsular Malaysia, enabling the land to be fertile but not exposed to excessive development. The area is not accessible in terms of a daily commute and is far from any commercial area.

Kampong Gunung Pasir covers approximately 127.48 hectares and consists of 122 houses, only 61 of which are still occupied by the 208 residents. This research has deliberately selected a sample of 30 respondents to follow in regards to house and compound activities which are based on the available green area. The intention is to investigate the land capacity and social capability of inhabitants within the sample area.

3.2 Data Acquisition

The fieldwork study in methodology process was conducted as a three-phase survey, the stages of which are: macro-scale observations (throughout the kampong); an investigation of the micro-scale potential of land capacity; and an analysis of the social capabilities involved in readapting to the land.

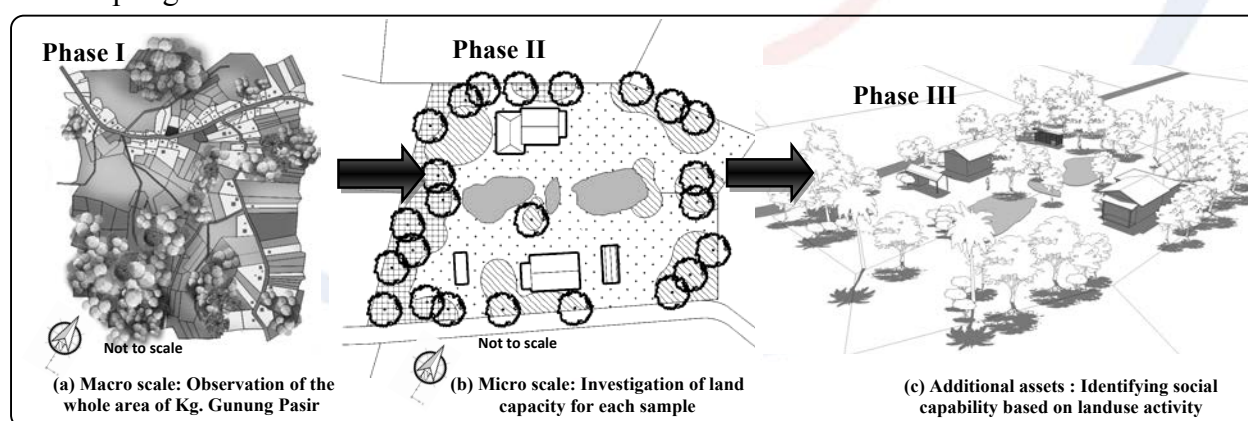


Figure 1: Stages involved in the case study in Kg. Gunung Pasir, Seri Menanti, Perak

3.2.1 Stage I: Observing the macro-scale of the land occupancy in Kampong Gunung Pasir

In this phase I study, two types of land use were analyzed by using secondary data from JUPEM Malaysia. This data was then digitized into a map by using a basic grid system in Arcview GIS. The first analysis was to measure the percentage of land used by agriculture,

and to look at the settlements in the years 1950, 1970 and 2012. The data was also transferred into tables and graphs to view the changing trends in land use.

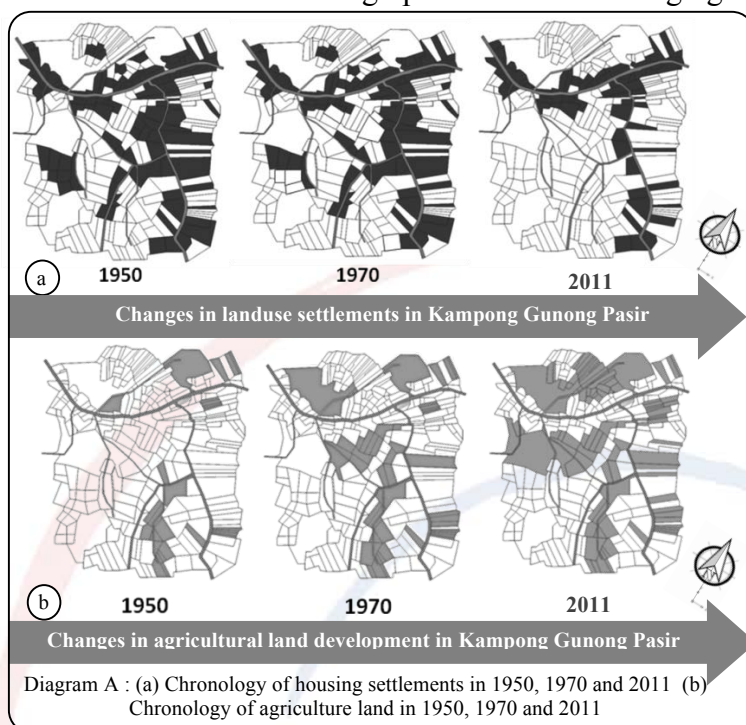


Figure 2: Diagram A shows the comparison between changes in landuse, housing settlements, & agricultural land in Kg Gunong Pasir

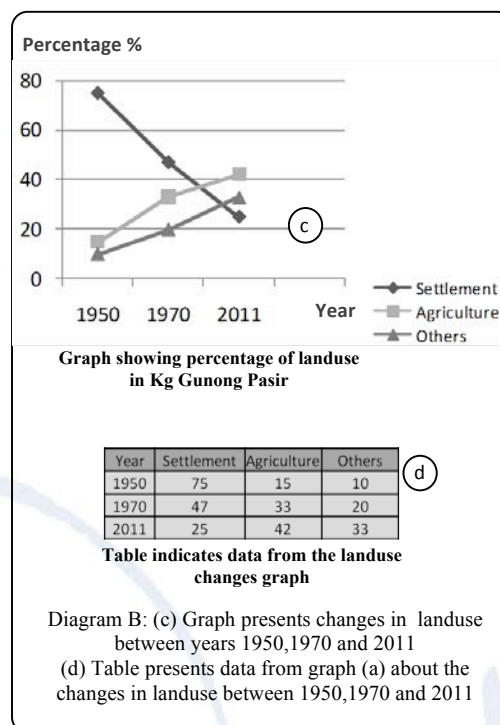
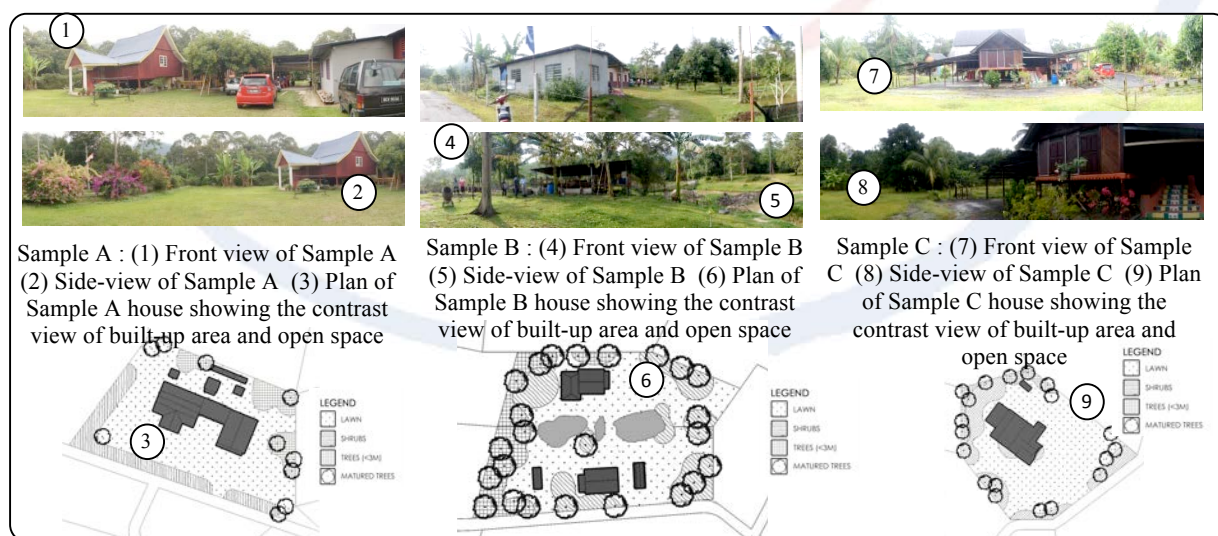


Figure 3: Diagram B shows the composite analysis of the landuse map for Kg Gunong

3.2.2 Stage II: Investigating the micro-scale potential of land capacity in each samples

In phase II, an audit of land was done in 30 samples of respondent houses and their compounds to identify and measure vegetation, arable land, abandoned land and additional assets owned by the respondents. The objective was to identify how each group utilizes their house compound and how this relates to their past use. The measurement was done using a basic grid technique in ArcView GIS 3.2.



3.2.3 Phase III: Analyzing a sample of urban returnees that have readapted to the land

Finally, from the total 30 samples of respondents, this study lists results from urban returnees who are working successfully with the prosperity of land. Most of them are working on their own land or in family ownership groups which vary in types, sizes and location. Researchers went to each respondent to do an in-depth interview. This analysis is intent on investigating how the urban returnee is able to readapt well to working the land and how they are managing to live out of poverty.

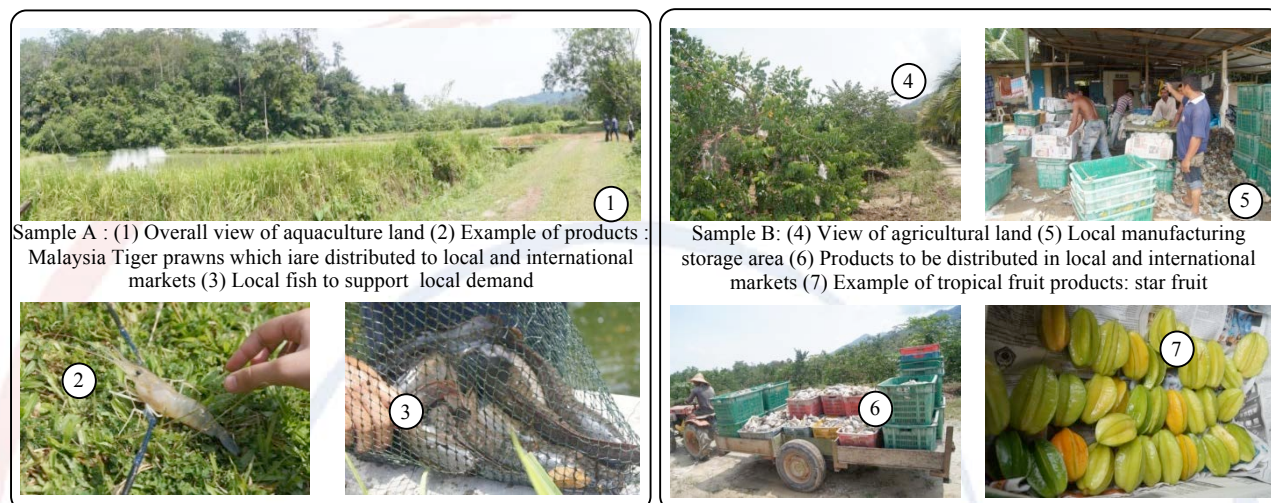


Figure 4: The picture shows an area of aquaculture owned by the urban returnees

Figure 5: The picture shows an example of tropical fruit production owned by the urban returnees

3.3 Data Analysis

Generally this quantitative study used ArcView GIS and SPSS software as tools in analyzing the data. The analyses are subject to the stages of the surveys.

3.3.1 Land use changes analysis

Analyses of land use change were performed on a grid basis, with reference to the secondary data and observations. This approach is one of the common methods used for spatial analysis and has been applied to analyzing land use patterns by (Abdullah & Nakagoshi, 2006; Haines-Young, 1992). Grids of 1kmx1km were developed using the GIS application of ArcView 3.2, which is suited to covering the whole study area (macro scale). For the grids at the border of the areas that were covered, less than 10% of the total land area was omitted to avoid inaccuracy.

3.3.2 Measuring the capacity of the Land available in case study areas

The same basic grid system was also applied to measuring the potential land capacity of each sample (at micro scale). For this analysis, the sample areas were divided into 1mx1m of grids in GIS to accurately record land use such as activities and functions, fauna and flora and other related information. At this phase of survey, a further questionnaire was also applied to compile further details on the additional assets owned by the respondents. All the data and criteria was then analysed by adopting the Spearman's Rho and Pearson Test in SPSS to measure the significant correlations between the observational data from land and the collective data from the questionnaires.

3.3.3 Measuring the Society capability on working back with land

This analysis is intended to investigate how the urban returnee is able to readapt to a self-sufficient way of life. It analyses data from questionnaires and interviews and gathers observations on land (if necessary). This phase investigated the significant relationship between the availability of land and income, social activities, and perceptions. Part of the test used in this phase was a frequencies analysis, Pearson and Spearman's Rho Test from SPSS. All data analysis is presented in graphs, tables, scatter plots and reports in the next (4.0) Results and Discussions sections.

4.0 Results and Discussions

4.1 Phase I: Landuse changes

Figure 2 (in section 3.2.1) shows the changing patterns of landuse activities between three temporal years. Clearly, there was a significant decrease in settlement areas from the 1950s to the 1970s and up to 2011 (refer Figure 2 (Diagram A(a))). These changes occurred during the rural to urban migration period, when most of the houses (settlements) were left unattended and abandoned.

This unattended land is protected under the Malay Reserves Land and Customary Land Act, meaning it has legal protection and cannot be worked or sold. This situation has led to the agricultural decline in Negeri Sembilan in early 1980s (Kassim, 1988, 1989). Kassim (1989) also highlights that this landuse changes situation has shrink the agricultural mass production into domestic used due to the loss in local demand. However, beginning in the early 20th century, the 9th Malaysia Plan has been revised, and has started to raise the attention needed to re-emphasize the importance of agriculture in Malaysia's economic development.

This effort can be seen in the Figure 2 (Diagram A(b)), where agricultural land has started to replace abandoned settlements. However these changes are only possible on the Malay Reserves land, where government policy allows developments which might be of benefit to society. The customary lands remain unattended.

4.2 Phase II: Land availability and capacity in Kg. Gunong Pasir, Seri Menanti, Neg. Sembilan

Firstly, to investigate land capacity, this study measured the green area (land that is not used or is covered by a permanent building) by using the basic grid technique. Figures 6 and 7 shows the percentage of green ratios and a ranking of land availability in the each household dwellings. Generally, the graph shows that each house in the *kampung* has a minimum of 30msq of green area. Both graphs indicate where the ratio of the green areas in each households unit reached the minimum of 50% of the overall house compound, showing that each house have green areas.

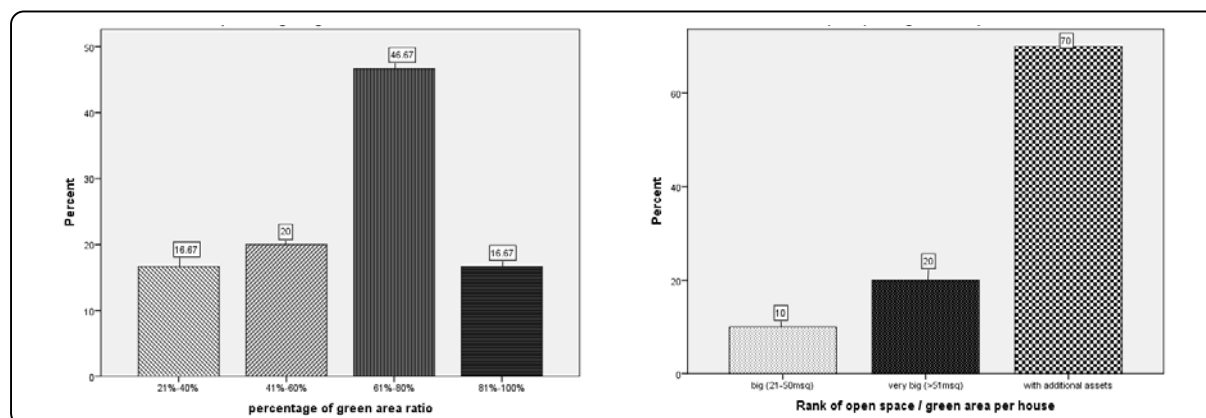


Figure 6: Graph showing the percentage of green ratio in Kg. Gunung Pasir

Figure 7: Graph showing the rank of land availability within respondent houses

Next, is to identify the factors that might contribute to the availability of a green area in each individual dwelling. The time spent in cities and the time the respondents have spent in their *kampong* were both analyzed after people returned to see if there was a significant correlation between previous experiences and the ability of the respondents to adapt to the land.

By using the bivariate correlation of Pearson's Test, an analysis was made of the correlation between the **length of time respondents lived back in the *kampong*** with the **size of the green area per dwelling**. The concern is to see whether a longer time in the *kampong* contributes to a greater effort being made on the land. Results demonstrate that $p=0.314$, which shows that the correlation is not significant (for $p<0.05$).

Meanwhile, the bivariate correlation test between the **duration living in cities** with the **size of green area owned in each household** has also been tested. This Pearson's Test also resulted into a non-significant correlation of $p=0.29$. This shows that the dependent way of life created in cities does not influence the urban returnee's activity and perception to land when they return.

Therefore, this study found that both the living in cities and time spent in the *kampong* after returning does not have a significant correlation in terms of the size of green land available. The results show that people are not influenced by their previous experiences but adapting with current situation.

4.3 Phase III: The returnees' capability to readapt to the land

In phase III, several tests have been made to identify the relationship between factors that contribute to the returnees' capability to readapt to the land. This study analyses the **reasons that made the urban migrant return**. Generally, the investigation shows that people return for a reason, the most common of which is to fulfil the family's will (inherited land), 40% of the total respondents, followed by 26.67% for retirement reasons and the search for better opportunities in the *kampong*. These reasons bring about the conclusion that most of the respondents migrated to the cities for temporary purposes only.

Besides the ‘pull factor’, where the government offers more education, jobs and income to the migrants, the culture in *Minangkabau* (Negeri Sembilan) of ‘*adat merantau*’ has also

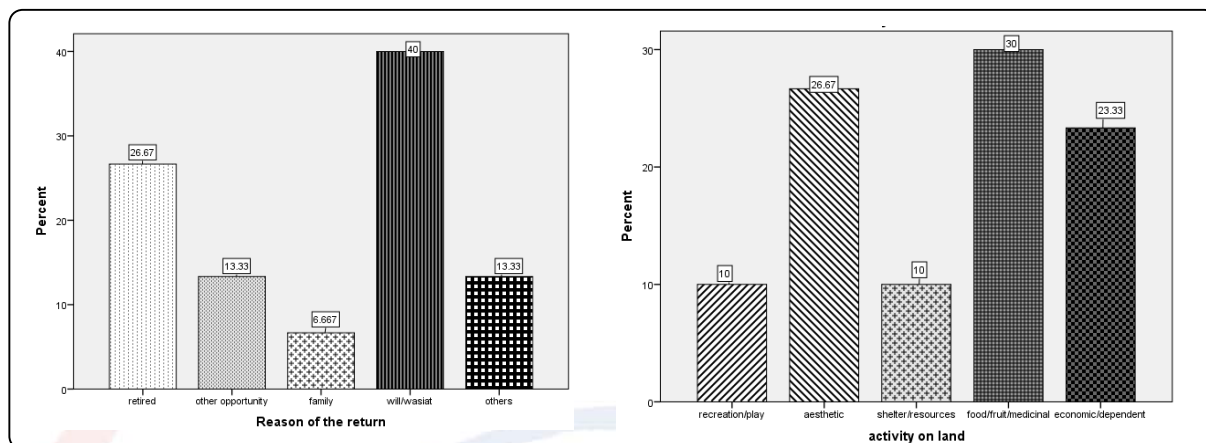


Figure 8: Graph showing percentages based on reasons to return

Figure 9: Graph showing the returnees activities on the land

became the push factor that has made people move. However, these pull and push factors are temporary, as the choice of returning back to the *kampong* is accessible at any time.

Figure 9 shows the activities that the respondents relate to on the land. From the graph, 30% of the total shows a connection through foods or edible products, while 26.67% are using land for aesthetic purposes and satisfaction. Another influential factor was economic dependence, an indication of 23.33%. This shows that land is able to serve as having an economic value which supports the new life in the *kampong*.

To support the investigation into the respondents’ activities on the land, this study has analysed a bivariate correlation significance test between the **activity on the land** with the **years of living in the city** (experience living in cities). The results of Spearman’s Rho Test show that the correlation is not significant $p=-0.238$. This shows that the urban returnees experience of living in cities does not have effect on how and what do they expected from land. Although the urban dwellers used to be dependent on manufactured products, they are still able to readapt to the conditions of life on the land when necessary.

An investigation was also done into the correlation between factors **experienced during childhood** (the upbringing in the *kampong* before migrating to the city) with the **current activities occurring on the land**. By using Spearman’s Rho Test again, the study found that there is no significant relation to the p value which is $p=-0.065$. This shows that the memory of previous experiences in the *kampong* does not have any significant effect on the returnees’ activities on the land.

From the tests on both; **experiences during childhood** and **life in the cities** does not influence the returnees’ capability on the land. Basically, people want to work towards a better quality of life. Champion (2001) and Rees (1996) agree that economic status has been a conventional motive to explain why people move. Chuen et. al (2011) argues that people adapt to the current situation and are not influenced by previous experience or thoughts about future generations.

Finally, this study has analysed a correlation test between the **respondent's sources of income** and the **ranking of that income**. Spearman's Rho Test also shows that there is no significant relation ($p=0.178$) between the source of income and the ranking of income. This indicates that there are no differences in the ranking of income whether working in cities or working on the *kampung*. Both incomes are sufficient to support the necessities. These findings are interesting as previously, (Ariffin, 1994) argued that people migrate to a city for a better jobs, education, income and a better quality of life. However, this study argues that there is no difference between achieving an income, education and health care living in cities as compared to living in a *kampung*.

Moreover, this study also supports the findings that previous experience does not influence the current way of life and that when people return, although they lack some skills and knowledge, they are still able to readapt to living on the land.

5.0 Conclusion

The audit on land that has been done in Kampong Gunong Pasir, in Negeri Sembilan, has shown that societies are able to achieve sustainability through subsistence. The results obtained from the surveys identified both potential in the land capacity which can be reutilized, and that the returning migrant has the capability to readapt to living on the land. About 50% of the unattended houses and land are due to rural-urban migration associated with the legislation on land ownership. This has created a significant potential for the land to be available and accessible for the return migrant, if de-urbanization occurs.

Moreover, the sample of current successful urban returnees, when combined with recent initiative such as the natural farming program (Omar et al., 2013), has shown that returning migrants are able to adapt well to a new kind of life and are capable of living above the poverty line while working on the land.

Thus, instead of facing economic hardship, caused by deindustrialization in the cities, working back on the land offers a subsistence way of surviving that is in line with sustainability. This can improve the environment and offer socio-economic activities and a healthy lifestyle, which lead towards a more resilient future.

6.0 References

- Abdullah, S. A., & Nakagoshi, N. (2006). Changes in landscape spatial pattern in the highly developing state of Selangor, peninsular Malaysia. *Landscape and Urban Planning*, 77(3), 263-275.
- Al-Kodmany, K. (2011). Tall Buildings, Design, and Technology: Visions for the Twenty-First Century City. *Journal of Urban Technology*, 18(3), 115-140.
- Altieri, M., & Funes-Monzote, F. (2012). The Paradox of Cuban Agriculture. *Monthly Review*, 63(8).
- Ariffin, J. (1994). *From kampung to urban factories: findings from the HAWA study*: University of Malaya Press.
- Byrd, H. (2008) *Energy & Ecology: a view of Malaysia beyond 2020*. USM Press
- Byrd H. (2012) From Kampong to City and back again. In T. N. Z. A. I. Bulletin (Series Ed.), *Asia Info* (pp. 5). The University of Auckland: New Zealand Asia Institute.

- Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*: Institute of Development Studies (UK).
- Champion, T. (2001). Urbanization, suburbanization, counterurbanization and reurbanization. *Handbook of urban studies*, 160.
- Chuen Khee, P., Yet Mee, L., & Chee Keong, C. (2011). The economic impact of climate change on food security in Malaysia.
- Dore, R. (1976). *The Diploma Disease. Education, Qualification and Development*.
- Doughty, M. R. C., & Hammond, G. P. (2004). Sustainability and the built environment at and beyond the city scale. *Building and environment*, 39(10), 1223-1233.
- Douglas, I. (1983). The urban environment.
- Douglass, M. (1992). The political economy of urban poverty and environmental management in Asia: access, empowerment and community based alternatives. *Environment and urbanization*, 4(2), 9-32.
- Drabble, J. (1993). *Malaysia Crossing the Industrial Divide: State, Society, and the Politics of Economic Transformation in Malaysia*. By Alasdair Bowie. New York: Columbia University Press, 1991. Pp. xvi, 222. Map, Notes, Bibliography, Index. *Journal of Southeast Asian Studies*, 24(02), 422-424.
- Drakakis-Smith, D. (1995). Third World cities: sustainable urban development, 1. *Urban studies*, 32(4-5), 659-677.
- Drakakis-Smith, D. (1996). Third world cities: sustainable urban development II—population, labour and poverty. *Urban studies*, 33(4-5), 673-701.
- Elias O. K., & Ramli R. (2009). Female Migration in the context of National Migration Trends and Patterns: A comparison of the 1980-1990 period with the present. In J. Ariffin (Ed.), *Readings on Women and Development in Malaysia : A Sequel* (pp. 179-199). Malaysia: MPH Group Publishing Sdn. Bhd.
- Eng, C. K. (1995). THE DYNAMICS OF URBAN DEMOGRAPHIC CHANGE IN MALAYSIA: AN ANALYSIS OF THE 1991 POPULATION CENSUS. *Asian Geographer*, 14(1), 58-70.
- Environment, W. C. o., & Development. (1987). *Our common future*: Oxford University Press Oxford.
- Girardet, H. (1990). The metabolism of cities. *The Living City*. London: Routledge.
- Girardet, H. (1996). *The Gaia Atlas of Cities: new directions for sustainable urban living*: Gaia books.
- Hadi, A. S., Idrus, S., Shah, A. H. H., & Mohamed, A. F. (2010). Malaysian urbanization transition: from nascent, pseudo to livable mega-urban region. *Malaysian Journal of Environmental Management*, 11(1), 3-13.
- Haines-Young, R. H. (1992). The use of remotely-sensed satellite imagery for landscape classification in Wales (UK). *Landscape Ecology*, 7(4), 253-274.
- Hill, R. C. (1983). Crisis in the motor city: The politics of economic development in Detroit. *Restructuring the city*, 80-125.
- Idrus, S., Hadi, A. S., Shah, A. H. H., & Rainis, R. (2010). Neighbourhood expansion and urban livability in Seremban municipality area, Malaysia. *Malaysian Journal of Environmental Management*, 11(1), 37-47.
- Jenks, M. (2001). *Compact cities: sustainable urban forms for developing countries*: Routledge.
- Kassim, A. (1988). Women, Land and Gender Relations in Negeri Sembilan: Some Preliminary Findings. *Southeast Asian Studies*, 26(2), 132-149.
- Kassim, A. (1989). Patterns of Land Ownership and Inheritance in Negeri Sembilan: Some Implications for Agricultural Development. *Southeast Asian Studies*, 27(3).
- Leete, R. (2007). *Malaysia: From Kampung to Twin Towers: 50 Years of Economic and Social Development*: Oxford Fajar.
- McGee, T. (2011). The Urbanisation Transition in Malaysia in the Twenty-First Century. *Akademika*, 81(2), 109-121.
- McGee, T. G. (1971). *The urbanization process in the third world*: London: G. Bell and Sons, Ltd.
- McGee, T. G. (1987). *Urbanisasi Or Kotadesasi?: The Emergence of New Regions of Economic Interaction in Asia*: East-West Environment and Policy Institute.
- Meadows, D. H., Randers, J., & Meadows, D. (2004). *Limits to Growth: Limits to Growth*: Chelsea Green.

- Millinger, M., Mårilind, T., & Ahlgren, E. (2012). Evaluation of Indian rural solar electrification: A case study in Chhattisgarh. *Energy for Sustainable Development*.
- Monteiro, C. A., Conde, W. L., & Popkin, B. M. (2002). Part I. What has happened in terms of some of the unique elements of shift in diet, activity, obesity, and other measures of morbidity and mortality within different regions of the world? *Public Health Nutrition*, 5(1a), 105-112.
- Newman, P. W. (1999). Sustainability and cities: extending the metabolism model. *Landscape and Urban Planning*, 44(4), 219-226.
- Omar, A. R. C., Ishak, S., Moen, J. A., & Arshad, M. M. A. M. (2013). Sufficient and Sustainable Livelihood via Community Economy: Case of Natural Farming Program in East Malaysia. *Asian Social Science*, 9(5), p110.
- Organization, W. H. (2010). Obesity and overweight: fact sheet no. 311. September 2006. *Online document at: www.who.int/mediacentre/factsheets/fs311/en/index.html Accessed September, 13.*
- Popkin, B. M. (2002). Part II. What is unique about the experience in lower-and middle-income less-industrialised countries compared with the very-highincome industrialised countries? *Public Health Nutrition*, 5(1a), 205-214.
- Rasiah, R. (2011). Is Malaysia Facing Negative Deindustrialization? *Pacific Affairs*, 84(4), 714-735.
- Ravallion, M. (2002). On the urbanization of poverty. *Journal of Development Economics*, 68(2), 435-442.
- Rees, W. E. (1996). Revisiting carrying capacity: area-based indicators of sustainability. *Population & Environment*, 17(3), 195-215.
- Rosset, P. (1997). Alternative agriculture and crisis in Cuba. *Technology and Society Magazine, IEEE*, 16(2), 19-25.
- Rowthorn, R., Rowthorn, B., & Ramaswamy, R. (1997). *Deindustrialization: its causes and implications* (Vol. 10): International Monetary Fund.
- Schwarz, A. (1993). Looking Back at Rio'. *Far Eastern Economic Review*, 28, 48-52.
- Sharif, M. (1986). The concept and measurement of subsistence: a survey of the literature. *World Development*, 14(5), 555-577.
- Sharif, M. (2003). A behavioural analysis of the subsistence standard of living. *Cambridge Journal of Economics*, 27(2), 191-207.
- Sugrue, T. J. (2005). *The origins of the urban crisis: Race and inequality in postwar Detroit*: Princeton Univ Pr.
- Talha R., Baharudin N., & Jantan I. (2007). Population and Housing Census 2000 - Migration Patterns in Malaysia 23rd. *POPULATION CENSUS CONFERENCE Utilization of the 2000 and 2005 Rounds of Asia-Pacific Censuses* (16th. - 18th. April 2007 ed.). Christchurch, New Zealand: UNSD-New Zealand Statistics Department in Christchurch, New Zealand.
- Tumber, C. (2012). *Small, Gritty, and Green: The Promise of America's Smaller Industrial Cities in a Low-carbon World*: Mit Pr.
- Wharton Jr, C. R. (1969). Subsistence agriculture: concepts and scope. *Subsistence Agriculture and Economic Development*, 12-20.
- Whittaker, D. H., Zhu, T., Sturgeon, T., Tsai, M. H., & Okita, T. (2010). Compressed development. *Studies in Comparative International Development*, 45(4), 439-467.
- Wylie-Kellermann, B. (1989). Discerning the Angel of Detroit. *Sojourners*, 10, 17-21.
- Wylie-Kellermann, Bill. (2009, May 1). Resurrection city: auto idolatry and casino economics have left Detroit tottering on the brink. What will it take for Motown to rise again? *The Free Library*. (2009). Retrieved May 12, 2013 from [http://www.thefreelibrary.com/Resurrection city: auto idolatry and casino economics have left ...-a0199068305](http://www.thefreelibrary.com/Resurrection+city:+auto+idolatry+and+casino+economics+have+left+...-a0199068305)
- Zaki, P. H., Hamzah, M. Z., Ismail, M. H., Awang, K. W., & Hamid, H. A. (2010). Malay customary tenure and conflict on implementation of colonial land law in Peninsular Malaysia. *Journal of Law and Conflict Resolution*, 2(2), 33-45.

*A Study of Feasibility of Pretreatment Process to Utilize Lignocellulosic Biomass as
Materials for Biodiesel Production*

Malinee Sriariyanun*¹, Patchanee Yasurin*², Jirapa Phetsom*³, Kraipat
Cheenkachorn*¹

*¹King Mongkut's University of Technology, Thailand, *²Assumption University,
Thailand, *³Maharakham University, Thailand,

0304

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Biomass is the most abundant renewable resource in the world and has potential to use as alternative materials to fossil resources for production of chemicals and fuels. For the effective conversion from biomass to biofuels or other chemicals, it requires high efficient hydrolysis of cellulose to glucose or fermentable sugars. In this study, lignocellulosic biomass, rice straw, rice husk, and water hyacinth were pretreated with different chemicals, or pretreated with microwave heating, or with combination of chemicals and microwave heating. Pretreated biomass was saccharified by using commercial cellulase enzymes and released sugar contents were measured. The combination of two pretreatment methods exhibited a synergy effect with 71.77% of the enzymatic sugar conversion. To study the possibility to utilize sugars from saccharified biomass, the *de novo* biosynthesis of fatty acid ethyl esters (FAEEs) in *Acinetobacter spp* were observed. The key biochemical reaction is the esterification between fatty acyl Co-A and ethanol using diacylglycerol acyltransferase (DGAT). The highest FAEE production up to 1,040±51 mg/l was found in *A. baylyi* culture that use biomass hydrolysate as a sole carbon source.

1. Introduction

The continuous growing of industry worldwide leads to the increasing of energy demand to support their production processes. Natural petroleum is the main resource to generate energy, however its price is increasing substantially. To increase the security in energy situation, it is important to develop the alternative option of petroleum fuels.

Biodiesel is one of renewable biofuels to replace petroleum diesel that contributes to the reduction of pollution emission and increasing of energy supply. Biodiesel is fatty acid alkyl esters (FAAE), which includes fatty acid methyl ester (FAME) and fatty acid ethyl ester (FAEE), and is conventionally produced through the transesterification reaction between methanol (or ethanol) and triacylglycerol (TAG). Likewise, FAAE is also synthesized by esterification process between fatty acid and alcohol [1] as shown in Fig.1. TAG is mainly obtained from oilseed plants and microalgae, therefore sustainable supply of TAG is a major bottleneck for current biodiesel production.

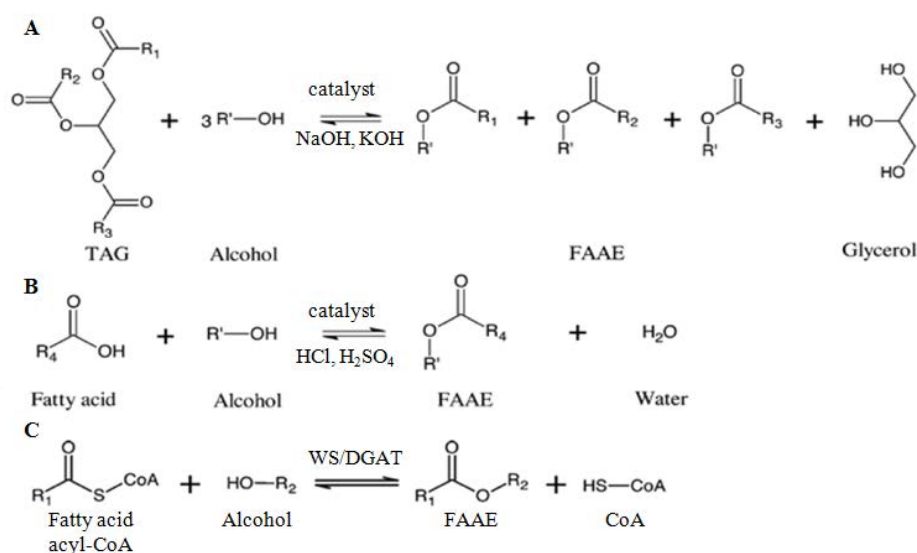


Fig.1. FAAEs are produced through (a) transesterification and (b) esterification reaction. (a) FAAE is produced by transesterification reaction between TAG and alcohol using NaOH or KOH as catalyst. (b) Fatty acid reacts with alcohol to produce FAAE via esterification process using acid as catalyst. (c) Fatty acid acyl-CoA reacts with alcohol to produce FAAE via esterification process using DGAT enzyme as catalyst.

FAAEs are also produced through *in vivo* esterification reaction between fatty acid acyl-CoA and alcohol using diacylglycerol acyltransferase (DGAT) enzyme as a catalyst (Fig.1). DGAT is the key enzyme for biosynthesis of storage lipids found in *Acinetobacter baylyi* [2]. In living organisms, fatty acids and their derivatives are generally produced as they are the important organic molecules that affect the regular function of cells, for example the structure of cell membrane. Fatty acids are synthesized from glucose through multi-step metabolic pathways [3]. Interestingly, starting from glucose as a material, ethanol is also produced through anaerobic fermentation giving a possibility to produce FAAE *in vivo* using glucose as raw material [4].

Considering to the whole plants, approximately 70% of total dry mass is lignocellulose that is mainly consisted of three types of polymers including cellulose, hemicellulose, and lignin [5]. Cellulose is a homopolymer of glucose, while hemicellulose is heteropolymer of hexose and pentose

sugars [6]. Because sugars are available in lignocellulose biomass, it is interesting to develop the strategy to utilize lignocellulose biomass for biodiesel production instead of TAGs. This idea provide possibility to overcome the bottle-neck of limited availability of plantseeds oil, and to potentially reduce the waste produced in the fields or agricultural-related industries.

Altogether, the usage of sugar monomer derived from lignocellulosic biomass is possible. However, conversion of lignocellulose to sugars with high yield to make total operation cost becomes feasible for industrial scale is still challenging. In general, the rate-limiting step of biofuel production from lignocellulosic biomass is hydrolysis step, therefore the pretreatment process is recommended before continuing to hydrolysis. Pretreatment process helps to loosen the microfibrils of cellulose to provide the chance for cellulolytic enzymes to attach the substrate surfaces [7].

Therefore, this study aims to focus on the feasibility study of utilization of lignocellulosic biomass as material for biodiesel production through fermentation process. First, rice straw, rice husk, and water hyacinth were selected as representative of lignocellulosic biomass as they are agricultural wastes that are abundant in each year. These three types of biomass were pretreated by different chemicals and microwave heating and efficiency of each pretreatment methods were evaluated. Second, the hydrolysates of biomass containing sugars were tested as carbon sources for fermentation of *Acinetobacter spp* for FAEE or biodiesel production.

2. Materials and Methods

Materials and chemicals

Rice (*Oryza sativa*) straw, and rice husk, were obtained from local rice field in Mahasarakham province, Thailand. Water hyacinth (*Eichhornia crassipes*) were obtained from river in Bangkok, Thailand. All wet biomass was dried in hot air oven at 60 °C until dried weight is constant, milled and sieved with a 10-mesh aluminium sieves. Sieved samples were kept in sealed bags at 4 °C prior to use. Cellulase from *Trichoderma reesei* (Celluclast® 1.5L), cellobiase from *Aspergillus niger* (Novozyme 188), were purchased from Sigma-Aldrich (St. Louis, MO, USA). Other chemicals used in this study were purchased from Ajax (Bangkok, Thailand).

Pretreatment procedure

For chemical pretreatment, one gram of milled biomass was mixed with 20 ml of chemicals for pretreatment, including sodium hydroxide, hydrochloric acid, ammonium hydroxide, and urea and incubated in rotary shaker at 50 °C for 24 hr. After incubation, the slurry biomass was filtrated through a Whatman filter paper (#1004-110) with a Buchner funnel. After washing with distilled water 200 ml for 4 times, the samples were dried in oven at 60 °C until dried weight is constant, then kept in a sealed bag at 4 °C prior to digestibility evaluation. For microwave pretreatment, one gram of milled biomass was mixed with 20 ml of distilled water, then put in household microwave oven. The power of microwave exposure was adjusted and samples were exposed with different power for 5 min. After pretreatment, biomass was filtrated through a Whatman filter paper, dried, and kept in a sealed bag prior to use. For sequential pretreatment, biomass was pretreated with sodium hydroxide for 24 hr, and directly exposed with microwave. Sequential pretreated biomass was washed, dried and kept prior enzymatic hydrolysis.

Enzymatic hydrolysis

Hydrolysis of the pretreated rice straw, rice husk and water hyacinth was performed in a 50 mM sodium citrate buffer (pH 4.8) with commercial cellulase (Celluclast 1.5L) loading 20 FPU/g substrate and supplemented with 100 CBU/g substrate of beta-glucosidase (Novozyme 188). 0.5 g of pretreated biomass was mixed with 20 ml of buffer as a reaction mixture and incubated in rotary shaker at 50 °C for 48 hr with an agitation rate of 150 rpm. After 48 hr digestion, the reaction mixture was filtrated to separate the leftover biomass from the liquid fraction. The liquid fraction remained was stored in refrigerator until analysis for reducing sugars by dinitrosalicylic (DNS) method [8].

Fermentation using biomass hydrolysates

Acinetobacter baylyi (courtesy provided by Assoc. Alisa Vangnai [9]) and *Acinetobacter calcoaceticus* (ATCC31012) were streaked onto Nutrient agar (NA) plates and incubated at 30 °C for 16 hr. single colony was picked and inoculated into 10 ml of Nutrient broth medium in 50 ml flasks, and the flask were incubated at 30 °C in a rotary shaker for 16 hr. Then 1 ml of culture was inoculated in 100 ml minimal control medium (containing 15 mM KH₂PO₄, 8 mM (NH₄)₂SO₄, 2 mM MgSO₄·7H₂O, and 10 mM succinic acid, pH 7.0) and incubated at 30 °C in a rotary shaker for 20 hr. To test the ability of *Acinetobacter* to utilize saccharified sugars derived from biomass hydrolysates as carbon source, minimal medium was modified by adding filtrated (through 0.2 µm porous membrane) biomass hydrolysates to substitute succinic acid. The cells were collected by centrifugation at 5,000 rpm for 5 min and pellet was kept, the culture was extracted for gas chromatography analysis (GC).

Measurement of FAEs production

For fatty acid ethyl esters extraction based on standard method [10], culture pellet was mixed thoroughly with 10 ml of organic solvent containing chloroform and methanol (2:1 ratio by v/v). After dispersion, the whole mixture was agitated 15 min in an orbital shaker at room temperature. The homogenate was centrifuged to recover the liquid phase, and washed with 0.2 volume of 1% NaCl solution. The separated lower phase was recovered and concentrated by rotary evaporator. Samples were analyzed by GC (Shimadzu GC-2010 Plus) using DB-wax column (Agilent, 30 m in length, with 0.25 mm ID and 25 µm film thickness). The following temperature program was applied: 1 min at 40 °C, 15 min ramp to 280 °C, and constant at 280 °C for 10 min. 0.1 mg of nonadecanoic acid methyl ester was added as an internal standard, and the quantity of fatty acid ethyl ester was calculated by reference to the internal standard.

3. Results and Discussion

Optimization of enzyme concentration for hydrolysis of rice straw, rice husk, and water hyacinth

Initial experiments were done to select the optimal condition of each pretreatment method and to compare the efficiency of different pretreatment methods. Here, the concentration of commercial cellulase enzyme was optimized for the hydrolysis of pretreated samples. First, to find the optimal time for hydrolysis, unpretreated rice straw, rice husk, and water hyacinth were hydrolyzed with different loads of cellulase enzymes and incubation times (Fig. 2). The contents of released reducing sugars were increased linearly until 24 hr, and its increment rate reduced considerably afterward. Based on hydrolysis yield and time consuming, the incubation time of 48 hr was selected to use in comparative study to evaluate the efficiency of different pretreatment methods. It is also found that the hydrolysis yield of 20 FPU/g-substrate enzyme loading is increase significantly compared to 4 FPU/g-substrate (Fig. 2).

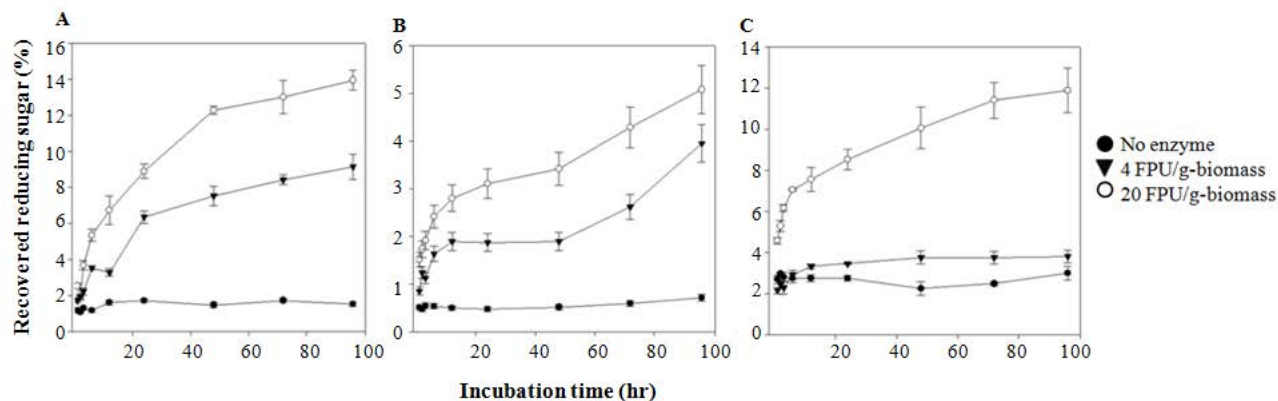


Fig. 2. Production of reducing sugars at different enzyme concentrations during hydrolysis of unpretreated (a) rice straw, (b) rice husk, and (c) water hyacinth samples by Celluclast 1.5L from *Trichoderma reesei*. Each experiments were performed triplicates.

Similar trends of hydrolysis were found in rice straw, rice husk, and water hyacinth digestion. However, the maximum reducing sugars released from rice straw, rice husk, and water hyacinth were different (13.95%, 5.07%, and 11.89% respectively). According to other studies as shown in Table 1 that reported the contents of cellulose, hemicellulose, and lignin in rice straw, rice husk, and water hyacinth (Table 1), the contents of cellulose and hemicellulose of these three types of biomass are not really different, but lignin content of rice husk (26-31%) is relatively high compared to rice straw (10-15%) and water hyacinth (10-16%). The lower contents of recovered reducing sugars from rice husk might caused by the inhibition of high lignin contents on cellulase enzyme activity as reported in other studies [11-13]. Clearly, without pretreatment the percent reducing sugar recovery no more than 13.95%. Therefore, this evidence suggested that it is necessary to perform pretreatment before hydrolysis. Furthermore, rice husk might need to be pretreated with the method that can remove lignin more than rice straw and water hyacinth.

Biomass	Cellulose (%)	Hemicellulose (%)	Lignin (%)	References
Rice Husk	25-35	18-21	26-31	[14, 15]
Rice Straw	35-40	25-30	10-15	[14, 16]
Water Hyacinth	20-31	22-33	10-16	[17, 18]

Table 1. The composition of cellulose, hemicellulose and lignin in rice straw, rice husk, and water hyacinth.

Effect of microwave pretreatment

Many pretreatment methods have been developed to find the suitable methods for each biomass types, including chemical, biological, and thermophysical pretreatment. In this study, we aimed to apply microwave irradiation for pretreatment process because it accelerates molecule collision to create thermal condition, which could be counted as thermophysical pretreatment [19]. Microwave irradiation has potential to be desirable pretreatment, because it is possible to optimize the operation conditions and has relatively short retention time compared to conventional heating. However, the economically energy consumption need to be evaluated to decide whether it is reasonable for practical biofuel production.

In this study, household microwave was used as a microwave irradiation generator. Based on the different compositions of each biomass types, we hypothesized that different powers of microwave

will suitable to each types of biomass. After microwave irradiation to rice straw, rice husk, and water hyacinth, the pretreated biomass was placed until its teperature cools down to room temperature, then proceed to saccharification reaction. As shown in Fig. 3, the results showed that the microwave power at 400, 200, and 200 watts gives the highest amount of recovered reducing sugars in rice husk, rice straw, and water hyacinth respectively (9.92%, 19.97%, and 16.65%).

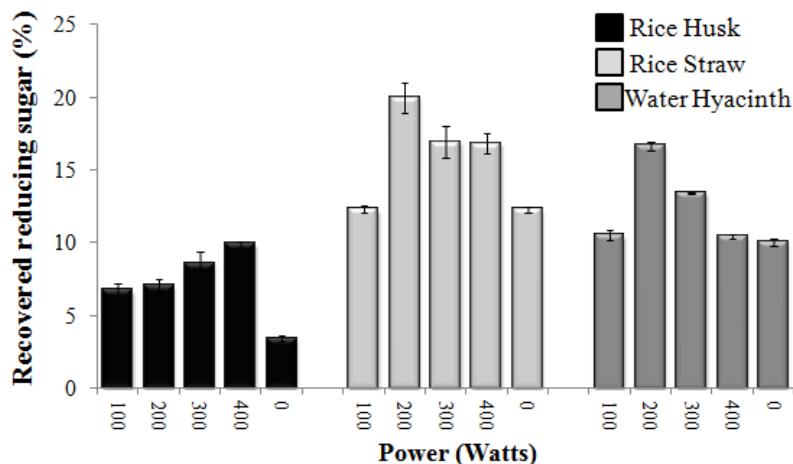


Fig. 3. Production of reducing sugars from microwave pretreated rice husk, rice straw, and water hyacinth. The powers of microwave were varied with 5 min exposure time. Each experiments were performed triplicates.

Effect of chemical pretreatment

Based on the results of microwave pretreatment, the enhancement of saccharification efficiency is not really high compared to unpretreated biomass control (Fig. 3). We therefore selected chemicals that were reviewed somewhere else to be used in pretreatment process [20]. In this study, sodium hydroxide (NaOH), hydrochloric acid (HCl), ammonium hydroxide (NH₄OH), and urea have been comparatively tested with rice straw, rice husk, and water hyacinth at different concentration. First, different concentration of each chemicals (0.5%-2.5% w/w for NaOH, 0.5%-2.5% w/w for HCl, 10%-30% w/w for NH₄OH, and 7.5%-17.5% w/w for urea) were tested to find the optimal concentration that gives the highest contents of recovered reducing sugars. After pretreatment by each chemicals, biomass were washed with distilled water, and saccharified by commercial cellulase enzymes. The reducing sugars released from saccharified biomass were measured to evaluate the efficiency of pretreatment.

As shown in Fig. 4, NaOH pretreatment gives the highest contents of recovered reducing sugars from rice straw, rice husk, and water hyacinth, compared to other chemicals. Here, the optimal concentration of each chemicals for treatment was also shown in Fig. 4. Comparing to NaOH, and HCl, NH₄OH and urea still have relatively lower efficiency although the high concentration of these chemicals was used. Surprisingly, comparing to results in Fig. 1, the sugar recovery from pretreated rice husk is increased up to similar level of water hyacinth, when NaOH, HCl, and NH₄OH were used. So, pretreatment of rice husk using these three chemicals is literally recommended.

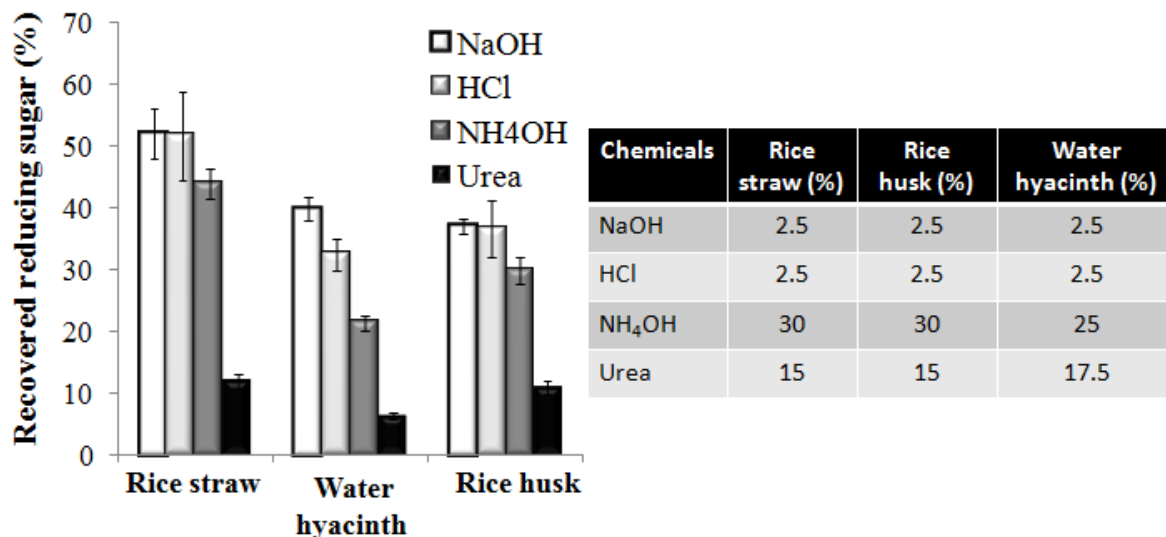


Fig. 4. Production of reducing sugars from four different chemicals pretreated rice husk, rice straw, and water hyacinth (Left panel). The optimal concentrations of different chemicals that enhance the highest saccharification efficiency of each biomass were presented (Right panel). Each experiments were performed triplicates.

Effect of sequential pretreatment

Based on the results of microwave, and chemical pretreatment, we selected the optimal condition of each pretreatments to combine in this experiments. First we pretreated rice straw, rice husk, and water hyacinth in 1% of NaOH for 24 hour as described in the materials and methods. We selected 1% NaOH for first step pretreatment because NaOH is the best chemicals among other tested chemical (Fig. 4). Additionally, although 2.5% concentration NaOH pretreatment has the highest efficiency, there are significant biomass loss during washing step (23.22%±4.5% of starting biomass weight) as it required more repeated washing compared to other concentration.

After 1% NaOH pretreatment, we directly exposed optimal-power microwave on pretreated biomass (200, 400, and 200 watts for rice straw, rice husk, and water hyacinth, respectively) for 5 min. Then sequential pretreated biomass were washed and saccharified. And contents of reducing sugar were measured as shown in Fig. 5. The results showed that sequential pretreatment of microwave and 1% NaOH have synergy effects on enhancement of saccharification. For example, in rice straw, 19.96%, 40.4% and 71.77% of biomass were changed to reducing sugars from microwave, 1% NaOH, and sequential pretreatment respectively. Likewise, the rice husk, and water hyacinth also get %reducing sugar up to 52.35% and 61.86%, respectively. Therefore, the result of this experiment suggested the pretreatment method that is applicable to different types of biomass. Although, the efficiency of this pretreatment method is not higher than other studies, but the cost of chemicals, and complexity of method are practical for further downstream process.

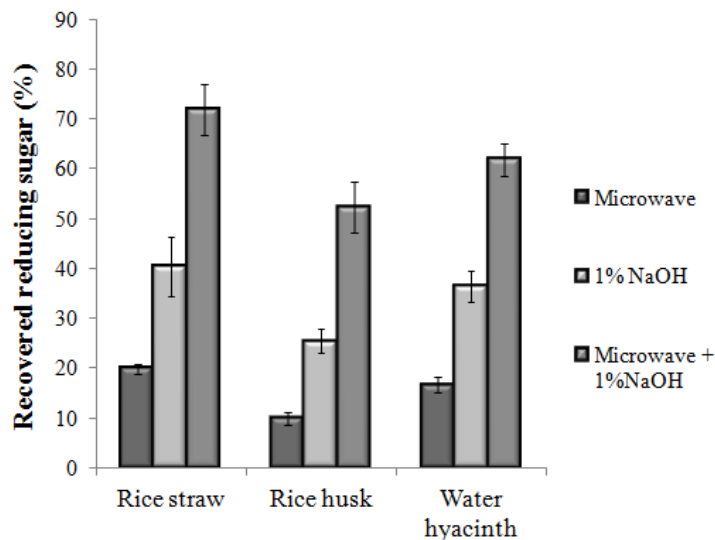


Fig. 5. Production of reducing sugars from sequential pretreated rice husk, rice straw, and water hyacinth. Each experiments were performed triplicates.

Fermentation of hydrolysate by Acinetobacter spp.

To study the feasibility of utilization of sugars derived from biomass, we applied the property of *Acinetobacter* bacteria that produce endogenous DGAT enzyme to catalyze the esterification reaction between fatty acid and ethanol to produce FAEE or biodiesel [2, 21]. First, the hydrolysate from saccharified pretreated rice straw was supplemented into minimal medium at different ratio to substitute the carbon source because rice straw hydrolysate has higher sugar content compared to rice husk and water hyacinth. After culturing the *A.baylyi* and *A.calcoaceticus* in medium for 20 hr, the cells were harvested, and their dry weights were measured. The FAEEs of cultures were extracted and quantified as described in materials and methods (Table 2).

Considering the dry weight yields, *Acinetobacter spp* cultured in nutrient rich media has the higher dry weight compared to cultures that used hydrolysated as carbon source. Interestingly, the higher amount of biodiesel was produced by cultures that used hydrolysates as carbon source. This observed results might be explained that the nutrient composition in nutrient rich media might not suitable for FAEE production. For example, if there is enough carbon and nitrogen source, bacteria prefer to undergo to cell proliferation, and will not accumulate lipid within their cells. On the other hand, in minimal media, it might not have enough nitrogen source to allow cell division, so cells accumulate lipid within the cells and those lipid become substrates of FAEEs.

Medium	Total dry weight (g/l)	Total biodiesel production (g/l)
<i>A.baylyi</i>		
Nutrient rice media	2.89±0.07	0.62±0.05
Minimal media + 50% hydrolysates	2.59±0.02	0.83±0.02
Minimal media + 25% hydrolysates	2.35±0.05	1.04±0.05
<i>A.calcoaceticus</i>		
Nutrient rice media	2.67±0.03	0.40±0.11
Minimal media + 50% hydrolysates	2.69±0.06	0.75±0.07
Minimal media + 25% hydrolysates	2.33±0.07	0.81±0.09

Table 2. The total dry weight and biodiesel production of *A.baylyi* and *A.calcoaceticus*. Each experiments were performed triplicates.

4. Conclusion

In this study, we developed the sequential pretreatment method and evaluated its efficiency to enhance saccharification of three different types of lignocellulosic biomass (rice straw, rice husk, and water hyacinth) by commercial cellulase enzymes. The synergistic effect of two different pretreatment methods was observed which giving up to 71.77% biomass recovery. Although the efficiency is not higher than other reports, but our sequential pretreatment method is simple and cheap. Additionally, we also studied the feasibility for utilization of lignocellulosic biomass hydrolysate as carbon source for *Acinetobacter* bacteria. Using minimal medium supplemented with 25% hydrolysates, *A.baylyi* culture can produce FAEEs up to 1,040±0.05 mg/l. This preliminary study supported the idea to produce biodiesel from lignocellulosic biomass to substitute the use of petroleum. However, further experiments are need to be done to analyze the hydrolysed compositions, so the optimization of medium composition will be possible to maximize the FAEE production. Additionally, the cost of pretreatment process, for example energy consumption, will be need to calculate to evaluate whether it is reasonable for production.

Acknowledgements

The authors would like to thank King Mongkut's University of Technology, North Bangkok (Research University Grant No. KMUTNB-GOV-56-12 and KMUTNB-NEW-55-07), The Institute for the Promotion of Teaching Science and Technology, Thailand (IPST) (Research Grant No. 022/2555), and RWTH Aachen University (Research Grant-Seed Fund Project) for financial support of this work.

References

1. Röttig A, Wenning L, Bröker D, S A: Fatty acid alkyl esters: perspectives for production of alternative biofuels. *Appl Microbiol Biotechnol* 2010, 85:1713–1733.
2. Stoveken T, Kalscheuer R, Malkus U, Reichelt R, A S: The wax ester synthase/Acyl Coenzyme A: Diacylglycerol acyltransferase from *Acinetobacter* sp strain ADP1: Characterization of a novel type of acyltransferase. *J Bacteriol* 2005, 187(4):1369-1376.
3. Wältermann M, Hinz A, Robenek H, Troyer D, Reichelt R, Malkus U, Galla H, Kalscheuer R, Stöveken T, P L: Mechanism of lipid-body formation in prokaryotes: how bacteria fatten up. *Mol Microbiol* 2005, 55():750-763.
4. Wältermann M, Stöveken T, P S: A: Key enzymes for biosynthesis of neutral lipid storage compounds in prokaryotes: properties, function and occurrence of wax ester synthases/acyl-CoA: diacylglycerol acyltransferases. *Biochimie* 2007, 89(2):230-242.
5. Chandel A, O S: Weedy lignocellulosic feedstock and microbial metabolic engineering: advancing the generation of 'Biofuel'. *Appl Microbiol Biotechnol* 2011, 89(5):1289-1303.
6. Gírio F, Fonseca C, Carvalheiro F, Duarte L, Marques S, R B-L: Hemicelluloses for fuel ethanol: A review. *Bioresour Technol* 2010, 101(13):4775-4800.
7. Agbor VB CN, Sparling R, Berlin A, Levin DB.: Biomass pretreatment: fundamentals toward application. *Biotechnol Adv* 2011, 29(6):675-685.
8. Miller G: Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Anal Chem* 1959 31(3):426-428.
9. Hongsawat P, Vangnai AS: Biodegradation pathways of chloroanilines by *Acinetobacter baylyi* strain GFJ2. *Journal of Hazardous Materials* 2011, 186:1300-1307.
10. Folch J, Lees M, Sloane GH: A simple method for the isolation and purification of total lipides from animal tissues. *J Biol Chem* 1957, 226(1):497-509.

11. Kumar R, Singh S, OV S: Bioconversion of lignocellulosic biomass: biochemical and molecular perspectives. *J Ind Microbiol Biotechnol* 2008, 35(5):377-397.
12. Miao Y, Chen JY, Jiang X, Z. H: Kinetic studies on the product inhibition of enzymatic lignocellulose hydrolysis. *Appl Biochem Biotechnol* 2012, 167(2):358-366.
13. Kim Y, Ximenes E, Mosier NS, Ladisch MR: Soluble inhibitors/deactivators of cellulase enzymes from lignocellulosic biomass. *Enzyme Microb Technol* 2011, 48(4-5):408-415.
14. Majeed K, Jawaid M, Hassan A, Bakar AB, Khalil HPS, Salema AA, Inuwa I: Potential materials for food packaging from nanoclay/natural fibres filled hybrid composites. *Material and design* 2013, 46:391-410.
15. Ang T, Ngoh GC, Chua AS, MG. L: Elucidation of the effect of ionic liquid pretreatment on rice husk via structural analyses. *Biotechnol Biofuels* 2012, 5(1):67.
16. Mohan P, Ramesh B, Reddy OVS: Biological pretreatment of rice straw by *Phenarochete chrysosporium* for the production of cellulases and xylanases using *Aspergillus niger* isolate. *Research Journal of Microbiology* 2012, 7(1):1-12.
17. Sornvoraweat B, Kongkiattikajorn J: Separated hydrolysis and fermentation of water hyacinth leaves for ethanol production. *KKU Res J* 2010, 15(9):794-802.
18. Gao J, Chen L, Yan Z, L. W: Effect of ionic liquid pretreatment on the composition, structure and biogas production of water hyacinth (*Eichhornia crassipes*). *Bioresour Technol* 2013, 132:361-364.
19. Banik S BS, Ganguly S.: Bioeffects of microwave--a brief review. *Bioresour Technol* 2003, 87(2):155-159.
20. Brodeur G, Yau E, Badal K, Collier J, Ramachandran KB, S R: Chemical and physicochemical pretreatment of lignocellulosic biomass: A review. *Enzyme Research* 2011, 2011(787532).
21. Fixter L, Nagi M, McCormack J, Fewson C: Structure, Distribution and Function of Wax Esters in *Acinetobacter calcoaceticus*. *Microbiology* 1986, 132(11):3147-3157.

*The Consideration of Heat Reduction Hourly Schedule on Front Surface of
Photovoltaic Module to Improve Efficiency*

Nuchida Suwapaet, Prapapit Boonla

Maharakham University, Thailand

0337

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The efficiency of the Photovoltaic (PV) are depended on many things, one of them is the accumulative heat on the front surface which related to the operating temperature. The attempt to improve PV efficiency was carried out by reducing the heat on the front surface. The Monocrystalline silicon photovoltaic was used in the experiment. There were two sets of system, control system and test system. The control system was the PV that operated in normal condition. The test system was the PV that operated with the heat reduction equipment in which spraying water on the front surface. The results showed that the test system had better output than the control system in overall. The output was considerably different during 11:00 to 14:00 hours. On the other hand, there were not much of the differences in the morning and late afternoon. The highest value of the improvement efficiency was 15%. It was shown that the time schedule of spraying water in order to reduce heat on the front surface of the PV could be arranged instead of having heat reduction system ran all day long.

Introduction

Solar energy is one of the most powerful energy in the world. There are many different applications that change the form of solar energy into other types. Solar cell or photovoltaic (PV) is the tool that transforms solar energy into electrical energy. The use of electricity has been increasing every year in everywhere in the world. For Thailand, the Electricity Generating Authority of Thailand (EGAT) had energy sales of $155,507.26 \times 10^6$ kWh in 2011 comparing to the energy sales of $97,412.45 \times 10^6$ kWh in 2001 [1]. The electricity production mainly uses natural gas as the fuel. From the overall energy resources for electricity generation in Thailand, renewable energy was used only 1.44% to produce electricity [2]. Since the renewable energy is considered to be unreliable resources due to the nature of it, the cost of electricity from this resource is high. Therefore, the improvement of conversion efficiency of the electricity production from renewable energy has been studied and implemented.

Solar energy is one of the renewable energy. The conversion efficiency of solar cell of photovoltaic depends on the material, the production technology, and operating conditions. Typical crystalline silicon photovoltaic has the efficiency of 15-22% [3]. There are many factors that could reduce the efficiency of PV such as high working temperature, dust, relative humidity and air velocity [4][5][6]. It was reported that the operating temperature caused a reduction of electrical power output of 0.4 – 0.5 % for mono and multi crystalline silicon PV [7].

There were many studies that tried to increase the efficiency of the PV by reducing the operating temperature. The use of natural air flow [8], cooling ducts [9], and water flow [7][10][11] were experimentally done to improve the efficiency of PV. Water is a good candidate for the reducing operating temperature operation. Not only water could reduce the heat but also could reduce the reflection of the radiation on the front surface of PV [7]. The increase of 10.3% in efficiency was obtained by using the water flow operation over the front surface of PV [7]. Another technique of using water cooling was water tricking configuration on the upper surface of the panel. It could increase about 15% in system output in peak radiation conditions [11]. The spraying water over the front surface of PV experiment was performed in order to investigate the possibility of improving the performance of PV [10]. The results showed that this system could improve the total efficiency of 1.35%. The experiment of passing water over the back of the module was performed by Wilson [12]. The result of this study was 12.8% increase in PV efficiency.

In this research, water was used as a coolant in order to reduce the operating temperature of the PV and then the efficiency of PV was examined. The heat would accumulate on the PV during the operation. Typically, the cooling system would be set to constantly run during the testing time. Thus, this study was aimed to investigate and recommend the cooling system time schedule. The efficiency of the PV was brought into account and reported. The experiment was carried out at Maha Sarakham, Thailand.

Methodology

The monocrystalline silicon photovoltaic module was used in the experiment. The experiment was set up at Maha Sarakham province, Thailand. The best condition of getting the maximum solar radiation at the location was having the PV faced south with 16 degree inclined from the horizon [13]. There were 2 set of PV in the experiment, control PV and test PV. The control PV was the PV that operated in normal condition and the test PV was the PV that installed the spraying water system. The water was sprayed over the front surface of PV in order to

reduce the operating temperature. Those PVs were placed on the steel frame and tested at the same location. Thermocouple type K was used to measure the temperature. The thermocouples were attached on the front surface of those PV modules. The attached areas of interest were spread out uniformly on the front surface.



Fig. 1 The front surface of control PV with attached thermocouples.



Fig. 2 The test PV with attached cooling system .

The testing time was 9:00 to 15:00 hours and the experiment was run from August to October, 2012. The resistant loads were connected in the circuit for measuring current and voltage. The module temperature data were collected and stored by data logger (Wisco AI2010). The operating current and the operating voltage of modules were also measured and recorded. All data were measured every 15 minutes.

Analysis

Power output of the PV was considered from the measured current and the measured voltage from the experiment.

$$P = I \cdot V \quad (1)$$

P = Power output (W)

I = Current (A)

V = Voltage (V)

Efficiency of the PV was considered from the power output from PV, the front surface area of PV and the solar radiation.

$$Efficiency = \left(\frac{P}{A \cdot G} \right) \times 100\% \quad (2)$$

P = Power output (W)

A = Area (m²)

G = Solar radiation (W/m²)

Results and discussions

The data was collected during August – October, 2012 for 30 days. All measured data were averaged over the testing period and presented in this study.

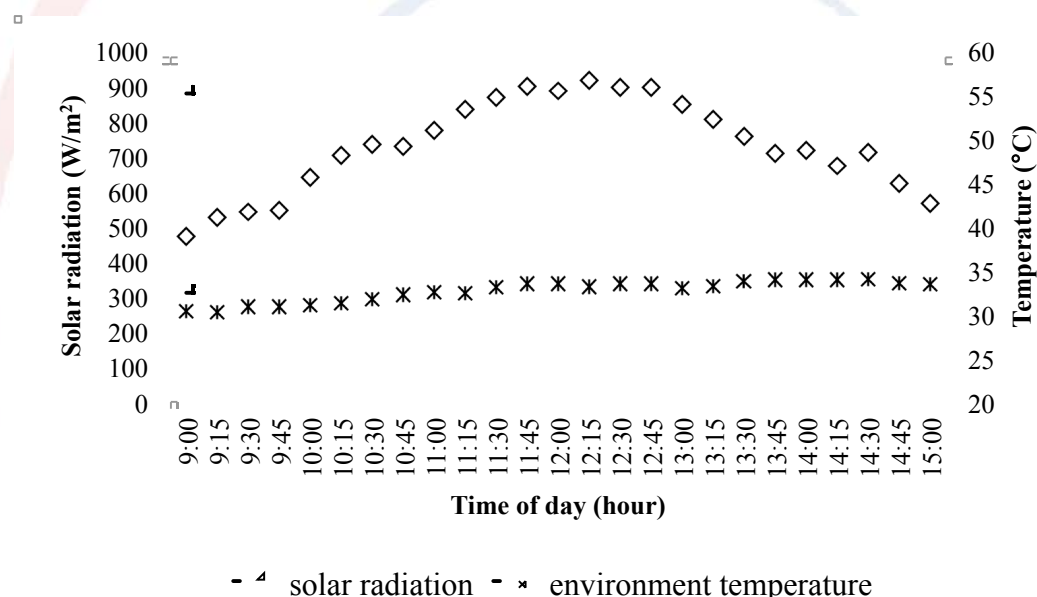


Fig.3 The relationship between daily solar radiation and environment temperature and time of day

The solar radiation and the average environment temperature were shown in Fig.3. For the testing period, the highest solar radiation value was 916.2 W/m² and the high solar radiation values were considerably occurred during 11:00 – 14:00 hours. The environment temperature was gradually increased during the day and it was ranged 30 °C – 35 °C.

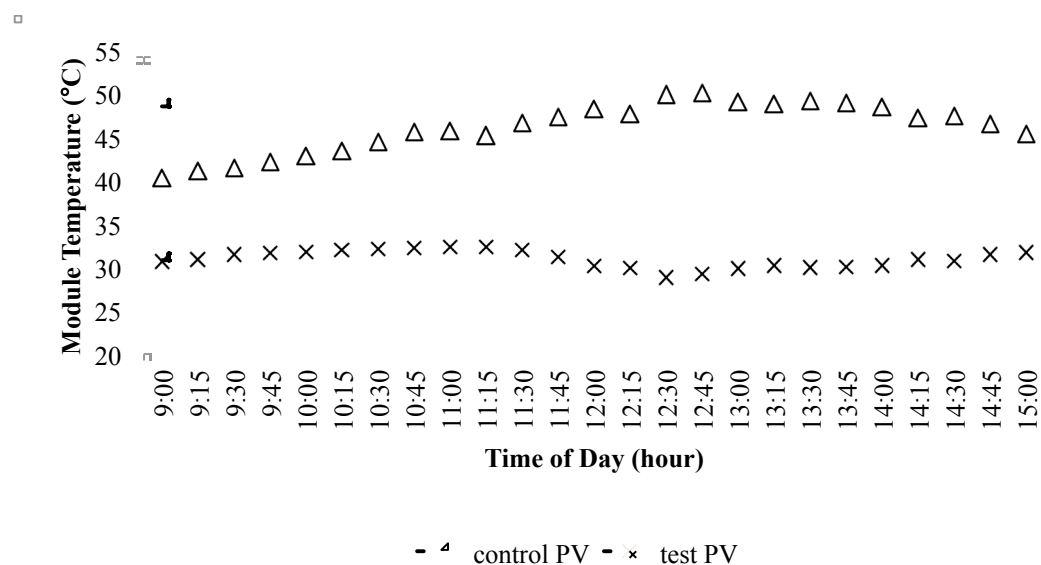


Fig.4 The module temperatures of the control PV and the test PV

In Fig.4, the module temperature of control PV and test PV were compared. The module temperature of the control PV was higher than that of the test PV for the entire testing time. The highest module temperature of the control PV and the test PV were 50.0°C and 32.4°C, respectively. When the sunlight hit the front surface of the PV, not only the PV started working but also the heat was accumulated. Therefore, the module temperature would increase. Since the test PV was installed the water spraying system, the water could reduce the heat on the front surface of the test PV and then the module temperature was decreased. During 11:00 – 14:00 hours, the module temperature of the control PV was high because the solar radiation was high (Fig.3) and also the heat was continuously accumulated since the beginning of the day. In contrast, the module temperature of the test PV was lower, comparing to the control PV. It was maybe because the water was continuously sprayed which gradually reduced the heat. Therefore, the module temperature of the test PV was slowly decreased. At the point that the module temperature of the test PV was close to the environment temperature along with the solar radiation value was high, the heat was accumulated again and then the module temperature started to increase.

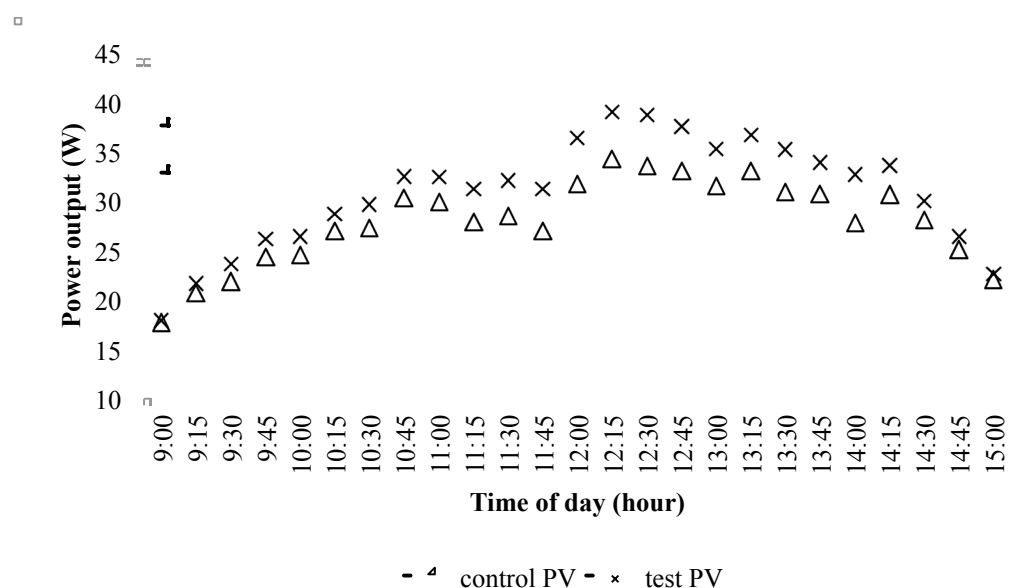


Fig.5 The power output of the control PV and the test PV

The power output of PV was calculated from the current and voltage in which produced from the PV (Eq.1). In Fig.5 showed that the power output of the test PV was higher than that of the control PV. It was also shown that reducing module temperature affected the ability to produce power output of the PV. With lower module temperature, the test PV could produce more power output. During 11:00 – 14:00 hours, the difference of the power output between the control PV and the test PV was considerably high comparing to the rest of the testing time. The average power output that the control PV and the test PV could produce during the testing time were 27.94 W and 30.83 W, respectively. In average, the test PV had the better result of 10.34% comparing to the control PV.

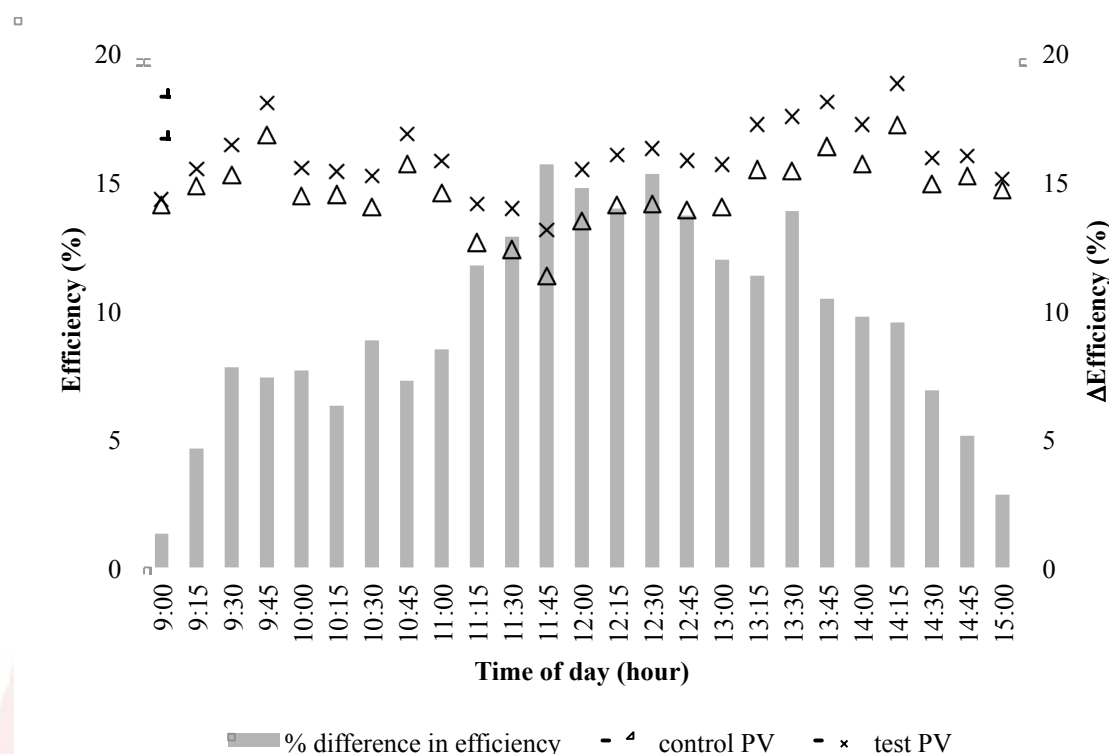


Fig.6 The comparison of the efficiencies and the difference in efficiency between the control PV and the test PV

With Eq. 2, the efficiencies of those PV were calculated. The comparison of the efficiency was made between the control PV and the test PV (Fig. 6). The difference in percentage described that the test PV had better output results. The efficiency of the test PV was improved because the module temperature was reduced. The highest improvement in efficiency that could be achieved was 15.7% during noon time. This number was higher comparing to the results of other techniques [7][10] and was slightly different comparing to the results of other similar water techniques [11]. In overall, it was confirmed that the temperature reduction system could effectively improve the efficiency of the test PV.

From Fig.6, the efficiency of the control PV and the test PV were in the range of 14% - 17% and 14% - 19%, respectively. The differences in efficiency between those PV were above 10% during 11:00-14:00 hours in which solar radiation values were high (Fig.3). The data also showed that the efficiencies between the control PV and the test PV weren't much different in the morning and late afternoon. Therefore, the consideration of setting up the time schedule for the heat reduction system could be implemented.

The PV cooling system could be scheduled to operate at the time that the difference in efficiency was above 10% according to Fig.6. Therefore, the cooling system could start to operate at 11:00 am and end at 14:00 hour instead of operating all day long. Additional observation from the experiment was also noted here. When the spraying water system started to run, the temperature of the test PV was reduced immediately and kept steady afterward (Fig.4). Hence, the investigation of efficiency improvement after implementing the heat reduction schedule during 11:00 – 14:00 hours on front surface of photovoltaic module will be carried out as the future work.

Conclusions

The cooling system for reducing the module temperature of the PV in order to improve the efficiency of the PV was implemented using spraying water technique. There were the control PV which operated at normal condition and the test PV which installed the cooling system. The water was sprayed over the front surface of the test PV while it was operating. The results showed that reducing module temperature affected the efficiency of the PV. The power output of the test PV was higher than that of the control PV. The highest efficiency improvement occurred during noon time of about 15%. The comparison between the control PV and the test PV showed that the cooling system could improve the efficiency in the range of 5% - 15% during the day. The improvement was peak from 11:00 to 14:00 hours. Thus, the schedule for the heat reduction system could be employed for that period of time instead of running the system all day.

Acknowledgement

The authors would like to thank the members of Bio-Energy and Renewable Resources Research Laboratory for constructing and installing all testing equipments and Solar Energy Lab & Research Unit for providing daily solar radiation data.

This work was financially supported by research grant of fiscal year 2012, Faculty of Engineering, Mahasarakham University, Thailand.

References

- [1] Electricity Generating Authority of Thailand, "Statistical data, Energy Sales," http://www.egat.co.th/en/index.php?option=com_content&view=article&layout=edit&id=79&Itemid=200, May 21, 2013.
- [2] Electricity Generating Authority of Thailand, "Annual Report 2011," http://www.egat.co.th/en/images/annual-report/2011/annual2011_eng_p20.pdf, May 21, 2012.
- [3] T.M. Razykov, C.S. Ferekides, D. Morel, E. Stefanakos. H.S. Ullal and H.M. Upadhyya, "Solar photovoltaic electricity: Current status and future prospects," *Solar Energy*, vol. 85, pp. 1580-1608, 2011.
- [4] M.E. Meral and F. Dincer, "A review of the factors affecting operation and efficiency of photovoltaic based electricity generation systems," *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 2176-2184, 2011.
- [5] F.A. Touati, M.A. Al-Hitmi and H.J. Bouchech, "Study of the effect of dust, relative humidity and temperature on solar PV performance in Doha: Comparison between mono-crystalline and amorphous PVs," *International Journal of Green Energy*, vol. 10, issue 7, pp. 680-689, 2013.
- [6] S. Mekhilef, R. Saidur and M. Kamalisarvestani, "Effect of dust, humidity and air velocity on efficiency of photovoltaic cells," *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 2920-2925, 2012.
- [7] S. Krauter, "Increased electricity yield via water flow over the front of photovoltaic panels," *Solar Energy Materials & Solar Cells*, vol.82, pp. 131-137, 2004.

- [8] J.K. Tonui and Y. Tripanagnostopoulos, "Performance improvement of PV/T solar collectors with natural air flow operation," *Solar Energy*, vol. 82, pp. 1-12, 2008.
- [9] B.J. Brinkworth and M. Sandberg, "Design procedure for cooling ducts to minimize efficiency loss due to temperature rise in PV arrays," *Solar Energy*, vol. 80, pp. 89-103, 2006.
- [10] M. Abdolzadeh and M. Ameri, "Improving the effectiveness of a photovoltaic water pumping system by spraying water over the front of photovoltaic cells," *Renewable Energy*, vol. 34, pp. 91-96, 2009.
- [11] S. Odeh and M. Behnia, "Improving photovoltaic module efficiency using water cooling," *Heat Transfer Engineering*, vol. 30, issue 6, pp. 499-505, 2009.
- [12] E. Wilson, "Theoretical and operational thermal performance of a 'wet' crystalline silicon PV modul under Jamican conditions," *Renewable Energy*, vol. 34, pp. 1655-1660, 2009.
- [13] A. Saengprajak, "Effect of high temperature on the open circuit voltage of PV modules used in Thailand," *Journal of Science and Technology Mahasarakham University*, vol. 28, No. 2, pp. 215-222, 2009.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is partially overlaid by a large, faint, circular graphic element that appears to be a stylized sun or a similar abstract shape, rendered in a light blue color.

Key Issues on Designing and Implementing Emissions Trading System in China

Ying Shen

University of Western Sydney, Australia

0341

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The mitigation of carbon emissions has been the subject of gradual policy development in the international community during recent years. China, as the world's most populous and largest developing country, is a large greenhouse gas (GHG) emissions source that grows rapidly in line with its industrialisation and urbanisation. Extensive air pollution within China today, however, is endangering the lives of countless citizens and sapping the nation's economic vitality. In response, the Chinese government is considering adopting appropriate environmental policy instruments to mitigate emissions, among which emissions trading system (ETS) is of great concern.

This article firstly makes a brief introduction to the status quo of China's emerging carbon market. In this context, two types of ETS are defined and a review of pilot programs on carbon emissions trading in part of China is provided. Before discussing the key elements on designing and implementing ETS in China, the methodology of a multi-criteria approach is explained in Section II, which is used to evaluate this market-based environmental policy instrument throughout the article. In order to develop a scientifically sound, economically rational and politically feasible ETS, key issues including the scope of cap's coverage, cap setting, system's point of regulation, allowance distribution methods as well as "cost-containment" mechanisms are identified and discussed in Section III. Finally, an outlook on ETS in China is provided as a brief conclusion on the basis of the above study.

Key Words: Emissions Trading System, Greenhouse Gas, Climate Change Mitigation, China

1. Introduction

The mitigation of carbon emissions has been the subject of gradual policy development in the international community during recent years. China, as the world's most populous and largest developing country, is a large greenhouse gas (GHG) emissions source that grows rapidly in line with its industrialisation and urbanisation. Extensive air pollution within China today, however, is endangering the lives of countless citizens and sapping the nation's economic vitality. In response, the Chinese government is considering adopting appropriate environmental policy instruments to mitigate emissions, among which emissions trading system (ETS) is of great concern.

The Outline of the Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China (2011-2015) puts forward the application of emissions trading, anticipating the "step by step establishment of carbon emissions trading markets" to ensure further GHG mitigations throughout the economy (NDRC 2011). Based on this Outline, carbon emissions trading has been concretized through specific pilot programs in part of China. When discussing the initiative pilot programs of carbon emissions trading in China, it is necessary to clarify two types of ETS. The first is voluntary emissions trading, which is established upon previous pilot programs conducted at local level. The second is pilot ETS spread out in four municipalities, two provinces and one local level city in China (Figure 1). Given that industries included into these pilot ETS programs are compulsory to comply with their commitments under the pilot ETS, the nature of pilot ETS could be considered as a mandatory nature compared to the voluntary emissions trading, although there is no official definition on it yet (Tuerk et al. 2013).

Approved Pilot Carbon Trading Schemes in China

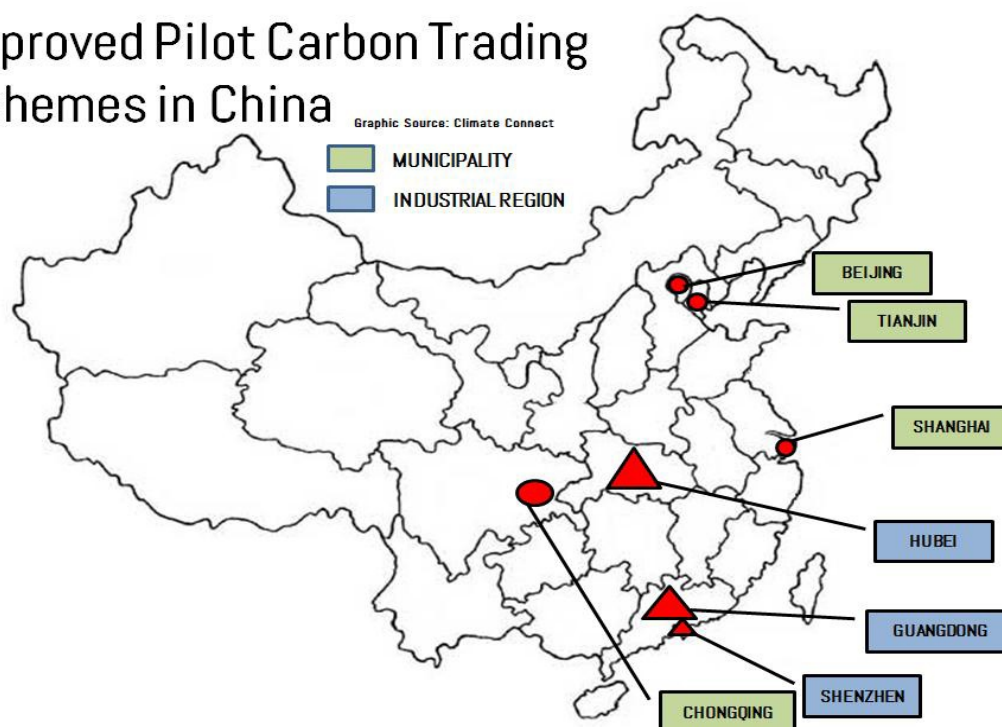


Figure 1 Pilot Carbon Trading Schemes in China (Source: Climate Connect)

Figure 1 clearly shows current pilot carbon trading schemes in China. Cities with green background are municipalities, including Beijing, Tianjin, Shanghai and Chongqing. Regions with blue background are industrial regions, among which two are provinces, including Hubei and Guangdong, and the other is a local level city Shenzhen located in Guangdong province. In the year 2011, a series of pilot programs for carbon emissions trading operating in a similar way to the EU ETS were initiated by the National Development and Reform Commission (NDRC) in these seven regions (NDRC 2012). In general, these seven regions aggregately account for 18 percent of China's population and 28 percent of its national gross domestic product (GDP), but their energy and carbon intensity are below China's national average level (Tuerk 2013). Given that ETS is usually a learning-by-doing process and that learning costs during the early stage might be relatively high due to high uncertainties of economic growth and development, the primary cause why these regions are selected as pilot regions to conduct pilot ETS is not their energy and carbon intensity, but their capacity to pay for the high learning costs (Tuerk 2013). It is generally recognized that choosing richer regions as pilot regions firstly can minimize national wide learning costs in the long run, when other regions, especially poorer regions, can run ETS later upon the experience and lessons learned from these pilot regions (Tuerk 2013).

Although these seven designated regions are selected to conduct pilot ETS programs at local level, their development are not synchronous, which are divided into three groups. The first group is considered as first movers of pilot ETS in China, including Beijing, Shanghai and Guangdong. Beijing is the first pilot region announcing that its pilot ETS implementation plan has been formulated in March 2012, even though this implementation plan has not been published yet (*Progress on pilot ETS programs in seven provinces and cities* 2013).¹ Following Beijing, Shanghai (Shanghai Municipal People's Government 2012) and Guangdong (People's Government of Guangdong Province 2012) set out and published their implementation plans in July 2012 and September 2012, respectively. Following first movers, Tianjin (General Office of Tianjin Municipal People's Government 2013) and Hubei (General Office of the Government of Hubei Province 2013) published their pilot ETS implementation plans in February 2013 successively. Up to now, there are only two pilot regions, *i.e.* Shenzhen and Chongqing, without official implementation plans, where local pilot ETS implementation plans are still under drafting and preparation.

2. Research Methodology

In terms of research methodology, the methodology of a multi-criteria approach is clarified before discussing the key elements on designing and implementing ETS in China. The multi-criteria approach used in this study is founded on the premise that various criteria are needed to evaluate a policy (Venmans 2012). Indeed, evaluation is by nature normative and therefore a variety of specific criteria must be utilized as a basis for these normative judgements (Mickwitz 2003). There are all sorts of evaluation criteria, and different authors use different criteria to assess environmental policies (Mickwitz 2003, Harrington et al. 2004, Konidari & Mavrakakis 2007, Baldwin 2008, Mundaca & Neij 2009, Wang et al. 2009, IPCC 2007, Stechow et al. 2011,

¹ Since there is no public access to Beijing's pilot ETS implementation plan, materials and data used in this thesis are based on secondary data, which is provided by people having internal materials.

Goers et al. 2010, and Stavins 2008). Based on the practical aims of China's ETS, this study follows the criteria proposed by the 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC 2007), which distinguishes four principal criteria for evaluating environmental policy instruments.

The first and most important criterion is environmental effectiveness, which means the extent to which a policy achieves its intended environmental target or realizes positive environmental outcomes (IPCC 2007). For market-based environmental policy instrument, which aims at achieving the environmental goal through an economic-incentive manner, the second important criterion is cost-effectiveness, which indicates the extent to which the policy can meet its objectives at a minimum cost to society (IPCC 2007). A well designed policy scores also high in terms of distributional considerations, which presents the incidence or distributional consequences of a policy, including dimensions such as fairness and equity (IPCC 2007). The last but not least is institutional feasibility, showing the extent to which a policy instrument is likely to be viewed as legitimate, obtain acceptance, adopted and implemented by public society (IPCC 2007). These above mentioned four criteria are used to evaluate the ETS throughout this topic.

3. Key Issues on Designing and Implementing ETS in China

A scientifically sound, economically rational and politically feasible instrument for reducing carbon emissions is supposed to be well designed and properly implemented. In developing a carbon ETS in China, some key issues must be identified before designing and implementing such a market-based environmental policy instrument.

3.1 Scope of the Cap's Coverage

In the first place, the scope of the cap's coverage, or what emission sources and types of GHG emissions will be subjected to the overall cap, must be determined by the policymakers. The GHG ETS is designed to achieve the goal of carbon emissions reduction, thereby realizing the ultimate goal of mitigating climate change. Thus anthropogenic carbon dioxide (CO₂) emissions (*i.e.*, emissions produced by human activities) are the major focus of this environmental policy instrument, which arise from a broad range of activities involving the use of different fuels in many different economic sectors. Although CO₂ makes a significant contribution to the global warming, some non-CO₂ GHG, such as Methane (CH₄), Nitrous Oxide (N₂O) and Ozone (O₃), have impacts on the GHG concentrations (Blasing 2012) that should not be ignored. For example, biological sequestration and reductions in non-CO₂ GHG emissions can contribute substantially to minimizing the cost of limiting GHG concentrations (Reilly et al. 2003, Stavins & Richards 2005, and Stavins 2008). Therefore, some non-CO₂ GHG emissions might also be controlled and reduced under the same framework as CO₂ in a multi-gas ETS.

In addition to the types of GHG emissions, the ETS may vary by the number and type of sectors covered. For example, the EU ETS covers only electric utilities and heavy industry. Some other systems ignore households, agriculture, and small entities. Therefore, how to set sectoral boundary is also required to be determined by policymakers.

3.2 Cap Setting

Setting reasonable and feasible emissions targets, *i.e.* emissions caps, is one of the essential elements of the ETS, since the targeted emissions mitigation of this policy over the horizon of time is among the most important determinants of policy cost and its climate benefits (Paltsev et al. 2007).

When discussing cap setting, two types of caps need to be identified. One is absolute caps, which imply an absolute level of emissions during a defined period (Goers et al. 2012). The other is relative caps, which are defined by a certain activity, *e.g.* emissions per unit of output (Goers et al. 2012). Compared to absolute caps, relative caps provide more flexibility and certainty regarding the costs, while score lower in environmental effectiveness. Most countries and regions with existing ETS have adopted absolute caps, which are equivalent to their commitments under the Kyoto Protocol. However, during the first commitment period of the Kyoto Protocol, China has no binding emissions reduction targets under the Kyoto Protocol as a developing country. Therefore, the Chinese Government has not considered setting an absolute cap for its overall GHG emissions. This situation may be changed later, given that a legally binding agreement covering all countries is supposed to be prepared until 2015 and to enter into force by 2020, which has been confirmed by the United Nations Climate Change Conference (UNCCC) held in Doha in 2012 (Goers et al. 2012). In this context, China's policymakers need to reconsider this issue.

Due to the long-term nature of the climate problem, it is difficult to estimate when emissions reductions actually occur, which has significant flexibility. Phased-in targets, including short-term targets, medium-term targets and long-term targets, are introduced into the policies to deal with this "when flexibility".

Generally speaking, short-term targets taking stringent action too quickly may be associated with many costs due to the sacrifice of a continued high economic growth rate. However, these costs can be avoided by setting annual emission targets that gradually increase in stringency, without sacrificing environmental benefits (Wigley et al. 1996), as premature retirement of existing capital stock and production and siting bottlenecks arising in the context of rapid capital stock transitions can be avoided (Stavins 2008). In addition, gradually phased-in targets provide time to merge advanced technologies into long-term investments (Jaffe et al. 1999). Therefore, a climate policy's cost can be reduced by setting gradually phasing emissions targets.

By contrast to short-term targets, long-term targets are more likely to address the climate problem in lower costs due to the long-term nature of the climate problem and the need for technology change to bring about lower-cost emissions reductions. Developing advanced low-carbon and other relevant technologies themselves take a long time, and the adoption of these technologies will depend on the predictability of future carbon prices, which are influenced by the cap's constraints (Stavins 2008). Thus, it is essential that the ETS policy incorporate medium-term targets to long-term targets rather than short-term targets, making caps constitute a long-term trajectory.

Considering the relationship of games between economic development and climate change mitigation, a gradually increasing trajectory of emissions reductions over time, especially setting long-term gradually phasing emissions targets, is a reasonable and

feasible means to achieve a win-win goal, sacrificing neither economical nor environmental benefits.

3.3 System's Point of Regulation

A related decision regards the system's point of regulation is a primary determinant of an ETS's cost on ensuring the achievement of the national emission targets. A cap on energy-related CO₂ emissions can be enforced by requiring fossil fuel suppliers to surrender allowances for the carbon content of their fuel sales ("upstream regulation"), or by demanding final emitters to surrender allowance for their emissions ("downstream regulation") (Jaffe & Stavins 2008). More precisely, an upstream point of regulation requires first sellers of fossil fuels to hold allowances (Stavins 2008), whereas a downstream point of regulation is exactly the opposite, requiring firms or gasoline stations to hold allowances. These two different points of regulation, however, have different impacts on the system's cost of achieving a particular national emissions target.

Generally speaking, an upstream point of regulation tends to create an economy-wide scope of coverage, which provides the greatest certainty that national emission targets will be achieved, whereas a downstream point of regulation is apt to limit the scope of coverage to a subset of emission sources, which leads to emissions uncertainty (Stavins 2008). It is obvious that an economy-wide cap effectively covers all sources of CO₂ emissions throughout the economy, thus is the principle element on ensuring the achievement of the national emission targets. For one thing, variations in emissions from unregulated sources may cause national emissions to deviate from expected targets (Stavins 2008). For another, limiting the scope of coverage to a subset of emission sources can cause "leakage", since market adjustments resulting from a regulation may lead to increased emissions from unregulated sources outside the cap which will partially offset reductions under the cap (Stavins 2008). Therefore, in order to ensure the achievement of the national emission targets, an economy-wide cap should be created, which can be realized by employing an upstream point of regulation.

Apart from ensuring the achievement of a particular national emissions target, an economy-wide cap with broad coverage of emission sources can also reduce the cost of achieving such a target (Stavins 2008). First, the broader the cap is, the more low-cost emissions reduction opportunities are provided, which can contribute to achieving the national emissions target (Stavins 2008). Second, given uncertainties in emissions reduction costs across sectors, an economy-wide cap can provide significant flexibility to meet the emission targets with lower costs (Stavins 2008). Third, an economy-wide cap can bring about incentives for innovation that is conducive to cost saving in all sectors of economy (Stavins 2008). Thus, an upstream regulation should be employed to create such an economy-wide coverage.

In contrast with a downstream regulation, a key advantage of an upstream regulation is that it lowers an ETS's administrative costs through its effect on the number of sources that must be regulated. Apparently, the system's administrative costs to regulators and firms will increase if the number of regulated sources rises. An upstream point of regulation makes an economy-wide ETS possible to cap almost all CO₂ emissions through regulation of limited upstream entities, making it

administratively feasible.² Furthermore, an upstream program eliminates the regulatory need for facility-level GHG emissions inventories, which would be essential for monitoring and enforcing an ETS that is implemented downstream at the point of emissions (Stavins 2008). Therefore, an upstream point of regulation should be adopted to save the ETS's administrative costs.

3.4 Allowance Distribution

Policymakers must determine how to allocate allowances and these allocation decisions will have significant distributional consequences. Allowances can be freely distributed without charge to any persons, firms or other organizations in the economy, or they can be auctioned, or be allocated through employing a hybrid of the two methods. Theoretically speaking, the choice between auctioning allowances and freely distributing allowances does not have impact on firms' production and emission-reduction decisions, since firms face the same emissions cost regardless of the distribution approaches (Stavins 2008). When using an allowance that was freely received, a firm loses the opportunity to sell that allowance. Realizing this "opportunity cost", it will decide to use the allowance instead of investing emissions reduction technologies which will increase the cost. Consequently, in many respects, this allocation choice (freely allocating allowances) will not influence a cap's aggregate costs. However, these different approaches may affect an ETS's overall cost at different levels in practice.

In terms of auctioning, since it generates government revenue that can be put towards innumerable uses, it is recognized that auctioning has the potential to reduce a climate policy's economy-wide costs. One important example is that government revenues raised by selling emissions allowances (auction revenue) may sufficiently offset the need to raise revenues through distortionary taxes on beneficial activities such as capital (corporate income, dividends or capital gains) and labor (earned income) (Smith et al. 2002). In this context, the GHG ETS would yield not only an environmental dividend but also an economic one. Bovenberg and Goulder's studies show that "recycling" auction revenue through reducing personal income tax rates could offset 40 to 50 percent of the economy-wide social costs that a cap would impose if allowances were freely allocated (Bovenberg & Goulder 2003). Thus, the economy could be improved while also improving environmental conditions through auctioning allowances under an ETS (Smith et al. 2002).

Compared to auctioning, free distribution of allowances forgoes opportunities to reduce the costs of the existing tax system or fund other socially beneficial policies due to the absence of the opportunity to sell the allowances, thus will not influence a cap's overall costs in many respects. However, it can affect the distribution of a climate policy's economic impacts by redistributing a cap's economic burdens. Free allocations can be issued to the most influenced entities to mitigate impacts and compensate the most burdened sectors and individuals, contributing to the establishment of consensus on an ETS that achieves significant emissions reduction target. Given that free allocations may generate more costs compared to auctioning, it is important to consider how to distribute allowances freely in order to achieve

² For example, in US, an economy-wide ETS was possible to cap nearly all US CO₂ emissions through regulation of just 2,000 upstream entities in the year 2005. *See* Stavins 2008.

specific compensation goals. Two dimensions are often concerned when discussing this problem. For one thing, it is crucial to consider what kind of entity is entitled to be distributed allowances freely. Since free distribution aims to redistribute a cap's economic burdens and compensate financial losses of affected sectors and individuals, this allocation choice should be applied to the most affected and burdened entities rather than entities that are not influenced or less influenced by the climate policy. For another, it is important to decide what share of allowances needs to be freely allocated to affected entities. Studies indicate that freely allocating all allowances in perpetuity to affected firms would significantly overcompensate them for their financial losses in aggregate (Goulder 2001, Smith et al. 2002, and Bovenberg & Goulder 2003). Therefore, it is not recommended to freely allocate all allowances to affected firms at the beginning and the share of allowances that are freely allocated is suggested to diminish steadily over time.

Considering the important differences in the implications of free allocation and an auction, there seems to be an "equity-efficiency" trade-off in the allocation decision. Although free allocation of any amount of allowances would reduce the potential efficiency improvements from revenue-recycling which could be realized by auctioning, it could provide an opportunity to address the distribution of an ETS's economic impacts, thereby compensating affected entities for equity losses. Faced with the dilemma between equity and efficiency, the best alternative is to start with a combination of the two approaches, wherein part of the allowances are freely allocated to affected entities that are burdened by the ETS and the rest are initially auctioned. In order to give equity-value compensation to affected entities, the share of allowances that are freely allocated should diminish over time until there is no free distribution into the program, since the private sector, including industries with long-lived capital assets, will have an opportunity to adjust to the carbon constraints (Bovenberg & Goulder 2003). The particular time-path of the numerical division between the share of allowances that is freely allocated and the share that is auctioned need to be analyzed by the economists, being consistent with the principle of targeting free distributions to burdened sectors in proportion to their relative burdens. Considering the complicated and changeful economic situation, it is feasible and practical to distribute the allowances more generous in the early years of the program, moving towards a rigorous allocation of the allowances steadily over the time.

3.5 "Cost-Containment" Mechanisms

A key concern about uncertainty regarding compliance costs is often expressed as concern about the level and volatility of allowance prices, deriving from the possibility of unexpectedly and unacceptably significant cost increases. In response to this concern, much attention has been given to the opportunity of including "cost-containment" mechanisms in the ETS to reduce cost uncertainty, such as allowance banking and borrowing, safety-valve provisions, and credits (offsets) mechanism.

Allowance banking and borrowing are often used to reduce some of the undesirable consequences of cost uncertainty by giving firms the flexibility to shift their emission reductions obligations across periods, when confronting unexpectedly and temporarily high or low costs, instead of undertaking costly reductions. Banking of allowances allows firms to undertake extra emission reductions (over-comply) earlier and save ("bank") unused allowances for use in future years, adding greatly to the cost

effectiveness of previous ETS (Stavins 2003). However, banked allowances would be exhausted eventually if costs remain high over extended periods. This problem may be particularly acute and severe in a cap's early years, when relatively few allowances have been banked in the face of unexpectedly high costs. Therefore, allowance banking is not a useful form of cost protection in an earlier year. On this occasion, borrowing of allowances, which allows firms to under-comply their emission reductions obligations and use ("borrowing") allowances that will be issued in future years by shifting the deficit forward to the obligations in subsequent periods, is introduced to an ETS to demonstrate compliance in a cap's early years. Compared to banking that is allowed by many ETS, provision for borrowing is less common due to its default risk. When undertaking this cost-containment mechanism, it is necessary to establish credible mechanisms, ensuring that the use of borrowed allowances can be offset by future emission mitigations.

Although allowances banking and borrowing can be used to abate long-term cost uncertainty, the possibility of drastic short-term volatility of allowance prices may ask for bringing a sensible cost-containment mechanism into an ETS. Such an insurance mechanism is called "safety valve", which places a ceiling on the allowance prices and provides firms the option of purchasing additional allowances at this predetermined price (the safety-valve "trigger price") in the face of unexpectedly high costs (Stavins 2008, Jaffe & Stavins 2008). In this context, no firms would undertake emission mitigations more costly than the trigger price, which is an upper bound of the allowance prices (Jacoby & Ellerman 2004). Therefore, the "safety valve" put a ceiling on the compliance costs (abatement costs) as well. The trigger price is set at a sufficiently high level to avoid any impacts on normal allowances trading unless allowance price demonstrates factually dramatic spikes (Stavins 2008). Whether the safety valve could be triggered is controlled by joint selection of the number of allowances issued (the "cap") and the safety valve price (the predetermined fee) (Paltsev et al. 2007). Generally speaking, in the absence of the safety valve, the tighter the cap is, the higher the expected allowance price is, and vice versa (Paltsev et al. 2007). It is worth noting that this predetermined fee should be set at the maximum incremental emission-reduction cost that the society is willing to endure, otherwise this insurance mechanism would be less likely to be triggered (if the predetermined fee is set relatively high in relation to the expected allowances price), or it is better thought of as an emissions tax with allocated exemptions (if the predetermined fee is set relatively low in relation to the expected allowances price) (Paltsev et al. 2007).

Another cost-containment measure is credits (offsets) mechanism, which allows regulated entities to offset some of their emissions with credits from emissions mitigation mechanisms that are outside the ETS's scope of coverage, thereby achieving compliance obligations (Jaffe & Stavins 2008). The credits should be issued for selective use in this cost-containment mechanism, such as non-combustion uses of fossil fuels in some petrochemical feedstock and fuel exports that generate no emissions in process (Stavins 2008). Other emissions mitigation mechanisms, such as carbon capture and storage (CCS) (Stavins 2008) and biological carbon sequestration through afforestation and retarded deforestation (Stavins 2008) are supposed to be included into the credits mechanism as well.

3.6 Other Issues Concerning the Design and Implementation of ETS

In addition to the above mentioned key elements, some issues need to be considered when designing and implementing an ETS in China as well.

First of all, robust, transparent, consistent and accurate monitoring and reporting of GHG emissions are essential for the effective operation of the ETS. Monitoring systems that allow for credible measurement, reporting and verification of emissions trading activities are among the most critical elements for the successful implementation of any ETS. Generally speaking, monitoring, reporting and verification (MRV) works are conducted by a designated third party, and local firms are usually prioritized.

Secondly, when a national wide ETS is established, possible linkage will be considered as an alternative bottom-up approach to keep the idea of emissions trading on a global scale alive, which is not achieved yet by the international society through a top-down approach (Goers et al. 2012). The benefits of linking ETS between different countries and districts are obvious. It can not only reduce the overall costs of compliance in concerned systems while improving the overall economic efficiencies of the ETS, but also provide internationally competing companies with a wider regulatory framework due to a single price of carbon (Goers et al. 2012). Two types of linkage are available when discussing this issue. The first is linking China's ETS with other countries and regions, such as linking China's carbon market with the EU or Australia. The second is linking ETS with other scheme type, such as emission reduction credit system. Since the issue of possible linkage is usually discussed after the establishment of the ETS, therefore no further study is conducted in this study.

Another two issues which need to be considered when evaluating the effectiveness of the ETS are the competitiveness and the hidden peril of carbon leakage. The competitiveness of industries included into the ETS is often associated with carbon leakage, since one of the channels for carbon leakage is competitiveness leakage channel. The impacts of carbon pricing on firm's production costs are closely connected with the competitiveness of energy-intensive and trade-exposed ETS industries. When facing emissions limitations from the ETS, these industries may lose competitiveness. As a result, they will change their operation and investment decisions, for example increase emission-intensive production abroad, generating carbon leakage outside the region of the ETS.

4. Outlook on ETS in China

It is anticipated that a national wide ETS is expected to be established from 2015 after the pilot ETS programs in China between 2013 and 2015. It is obvious that the pilot ETS is conducted under a nation-wide bottom-up approach. However, a lot of questions need to be addressed before establishing such a national wide ETS in China, causing more uncertainties for China's future carbon market.

Firstly, It is obvious that the pilot ETS is conducted under a nation-wide bottom-up approach. However, a lot of questions need to be addressed before establishing such a national wide ETS in China, causing more uncertainties for China's future carbon market.

Secondly, the experience learning period of pilot ETS in seven regions from 2013 to 2015 is relatively short, making policymakers lack enough time to accumulate sufficient information. It is obvious that current pilot ETS programs at the local level are still immature, given that detailed provisions are insufficient in implementation plans of pilot regions, which needs to be further refined by policy makers. In this context, policy makers will be confronted with substantial challenges due to the lack of experience with sophisticated requirements of the ETS in terms of emissions data, administrative capacity, and solid regulatory frameworks, which are integral to a robust ETS (Tuerk et al. 2013).

Thirdly, from an international perspective, the downturn of EU's carbon market serves as a signal to participating enterprises that low-carbon technologies may not bring in expected profit, discouraging their enthusiasm in creating emissions quotas. Therefore, the ETS may be resisted by industry sectors and stakeholders, making launching a national wide ETS become infeasible.

Regardless of these above mentioned uncertainties and difficulties, the nature of the national wide ETS needs to be further clarified by the government. Policymakers need to determine whether this national wide ETS is voluntary or it is mandatory like pilot ETS programs in the seven regions, which will directly influence the linkage with other countries and regions. They also need to identify whether there is a transitional period for previous pilot regions. The articulation point between pilot ETS programs and the national wide ETS needs to be further explored by the Chinese Government in the near future.

References

Baldwin, R 2008, 'Regulation Lite: The Rise of Emissions Trading', *Regulation and Governance*, vol. 2, pp. 193-215.

Blasing, TJ 2012, *Recent Greenhouse Gas Concentrations*, CDIAC (Carbon Dioxide Information Analysis Center), viewed 26 June 2013, <http://cdiac.ornl.gov/pns/current_ghg.html>.

Bovenberg, AL & Goulder, LH 2003, 'Confronting industry-distributional concerns in U.S. climate-change policy', Discussion Paper (Les Séminaires de l'IDDRI no. 6), Institute on the Economics on the Environment and Sustainability.

General Office of the Government of Hubei Province 2013, *Circular of General Office of the Government of Hubei Province on Printing and Distributing the Implementation Plan for Pilot Carbon Emissions Trading Programs in Hubei Province*, Hubei Environmental Protection Bureau, viewed 26 June 2013, <http://www.hbepb.gov.cn/zwgk/zcwj/szfwj/201303/t20130304_59436.html> (available in Chinese version only).

General Office of Tianjin Municipal People's Government 2013, *Circular of General Office of Tianjin Municipal People's Government on Printing and Distributing the Implementation Plan for Pilot Carbon Emissions Trading Programs in Tianjin*, Tianjin Municipal People's Government, viewed 26 June 2013,

<http://www.tj.gov.cn/zwgk/wjgz/szfbgtwj/201303/t20130304_188946.htm>
(available in Chinese version only).

Goers, S, Wagner, AF & Wegmayr, J 2010, 'New and old market-based instruments for climate change policy', *Environmental Economics and Policy Studies*, vol. 12, no. 1, pp. 1-30.

Goers, SR, Pflüglmayer, B & Luger, MJ 2012, 'Design Issues for Linking Emissions Trading Schemes: A Qualitative Analysis for Schemes from Europe, Asia and North America', *Journal of Environmental Science and Engineering*, vol. 1, pp.1322-34.

Goulder, LH 2001, 'Confronting the Adverse Industry Impacts of CO₂ Abatement Policies: What Does it Cost?', in MA Toman (ed), *Climate Change Economics and Policy: An RFF Anthology*, Resources for the Future, pp. 125-33.

Harrington, W, Morgenstern, RD & Sterner, T 2004, 'Overview: Comparing Instrument Choices', in W Harrington, RD Morgenstern & T Sterner (eds), *Choosing Environmental Policy: Comparing Instruments and Outcomes in the United States and Europe*, Resource for the Future, Washington, DC.

IPCC 2007, *Climate Change 2007: Climate Mitigation*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Jacoby, HD & Ellerman, AD 2004, 'The Safety Valve and Climate Policy', *Energy Policy*, vol. 32, no. 4, pp. 481-91.

Jaffe, AB, Newell, RG & Stavins, RN 1999, 'Energy-Efficient Technologies and Climate Change Policies: Issues and Evidence', KSG Working Paper (John F. Kennedy School of Government, Harvard University, Faculty Research Working Papers Series), Climate Issues Brief No. 19, Washington, DC, Resources for the Future.

Jaffe, J & Stavins, RN 2008, 'Linkage of Tradable Permit Systems in International Climate Policy Architecture', NBER (National Bureau of Economic Research) Working Paper Series No. 14432.

Konidari, P & Mavrakakis, D 2007, 'A multi-criteria evaluation method for climate change mitigation policy instruments', *Energy Policy*, vol. 35, no. 12, pp. 6235-57.

Mickwitz, P 2003, 'A Framework for Evaluating Environmental Policy Instruments: Context and Key Concepts', *Evaluation*, vol. 9, no. 4, pp. 415-36.

Mundaca, L & Neij, L 2009, 'A multi-criteria evaluation framework for tradable white certificate schemes', *Energy Policy*, vol. 37, no. 11, pp. 4557-73.

NDRC 2011, *The Outline of the Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China*, National Development and Reform Commission, viewed 26 June 2013,

<<http://www.ndrc.gov.cn/fzgh/ghwb/gjjh/P020110919592208575015.pdf>> (available in Chinese version only).

NDRC 2012, *China's Policies and Actions for Addressing Climate Change*, National Development and Reform Commission, viewed 26 June 2013, <<http://qhs.ndrc.gov.cn/zcfg/W020121122588539459161.pdf>>.

Paltsev, S, Reilly, JM, Jacoby, HD, Gurgel, AC, Metcalf, GE, Sokolov, AP & Holak, JF 2007, 'Assessment of U.S. Cap-and-Trade Proposals', NBER (National Bureau of Economic Research) Working Paper Series No. 13176.

People's Government of Guangdong Province 2012, *Implementation Plan for Pilot Carbon Emissions Trading Programs in Guangdong Province*, People's Government of Guangdong Province, viewed 26 June 2013, <http://zwgk.gd.gov.cn/006939748/201209/t20120914_343489.html> (available in Chinese version only).

Progress on pilot ETS programs in seven provinces and cities 2013, viewed 22 April 2013, <<http://www.tangongye.com/news/NewShow.aspx?id=12074>> (available in Chinese version only).

Reilly, J, Jacoby, H & Prinn, R 2003, 'Multi-gas Contributors to Global Climate Change: Climate Impacts and Mitigation Costs of Non-CO₂ Gases', Arlington, VA, Pew Center on Global Climate Change.

Shanghai Municipal People's Government 2012, *Opinions of Shanghai Municipal People's Government on the Implementation of Pilot Carbon Emissions Trading Programs in Shanghai*, www.shanghai.gov.cn, viewed 26 June 2013, <<http://www.shanghai.gov.cn/shanghai/node2314/node2319/node12344/u26ai32789.html>> (available in Chinese version only).

Smith, AE, Ross, MT & Montgomery, WD 2002, 'Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations', Working Paper, Charles River Associates, Washington, D.C.

Stavins, RN & Richards, KR 2005, *The Cost of US Forest-based Carbon Sequestration*, Arlington, VA, Pew Center on Global Climate Change, January.

Stavins, RN 2003, 'Experience with market-based environmental policy instruments', in KG Mäler & JR Vincent (eds), *Handbook of Environmental Economics, Volume 1: Environmental Degradation and Institutional Responses*, Elsevier Science and Technology, pp.355-435.

Stavins, RN 2008, 'A Meaningful U.S. Cap-and-Trade System to Address Climate Change', *Harvard Environmental Law Review*, vol. 32, pp.293-361.

Stavins, RN 2008, 'Addressing climate change with a comprehensive US cap-and-trade system', *Oxford Review of Economic Policy*, vol. 24, no. 2, pp. 298-321.

Stechow, C, Watson, J & Praetorius, B 2011, 'Policy incentives for carbon capture and storage technologies in Europe: A qualitative multi-criteria analysis', *Global Environmental Change*, vol. 21, no. 2, pp. 346-57.

Tuerk, A, Mehling, M, Klinsky, S & Wang, X 2013, *Emerging Carbon Markets: Experience, Trends, and Challenges*, Climate Strategies, viewed 26 June 2013, <<http://www.climatestrategies.org/research/our-reports/category/63/370.html>>.

Venmans, F 2012, 'A literature-based multi-criteria evaluation of the EU ETS', *Renewable and Sustainable Energy Reviews*, vol. 16, pp. 5493-5510.

Wang, JJ, Jing, YY, Zhang CF & Zhao, JH 2009, 'Review on multi-criteria decision analysis aid in sustainable energy decision-making', 13(9) *Renewable and Sustainable Energy Reviews*, vol. 13, no. 9, pp. 2263-78.

Wigley, TML, Richels, R & Edmonds, JA 1996, 'Economic and Environmental Choices in the Stabilization of Atmospheric CO₂ Concentrations', *Nature*, vol. 379, no. 18, pp. 240-43.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is partially overlaid by a large, faint, circular graphic composed of several overlapping, curved lines in shades of blue and red, creating a sense of motion or a globe.

Modeling of a Single-chamber Microbial Fuel Cell Using Glycerin as an Energy Source

Bunpot Sirinutsomboon, Napatsanun Wongsamajan, Katanyuta Sirikhum

Thammasat University, Thailand

0342

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

A bio-electrochemical system of microbial fuel cell (MFC) can operate on wastewater and various organic substances. One possible energy source is crude glycerin waste from biodiesel production. Similar to any process, MFC needs accurate computational models for prediction and optimization of the cell performance. We proposed a comprehensive computational modeling of a membrane-less single-chamber MFC, in which bacteria consumed glycerin as a primary nutrient. The simulated cathode was a layer of silicone, which prevented water leakage, but allowed oxygen molecules to diffuse through to take part in the reduction reaction. Bulk liquid in the chamber contained glycerin being consumed during the operation. Glycerin molecules diffused through the biofilm, which deposited on the anode surface, and were oxidized by the bacteria dispersive within the film. The biofilm was assumed to be conductive; therefore electrons generated from the oxidation reaction within the film could migrate toward the anode surface. We developed the simulation program to accept inputs such as initial amount of glycerin, thickness of the biofilm layer, and dimensions of the MFC chamber. Some outputs of the program include profiles of concentrations of glycerin and oxygen as a function of time and location, and the MFC output voltage as a function of time.

Keywords microbial fuel cell, single chamber, air cathode, glycerin, simulation

Introduction

A properly designed system of electrochemical cell can operate using a liquid culture of bacteria. Such system is called microbial fuel cell (MFC) (Logan et al., 2006). An MFC can treat wastewater containing organic matters, which bacteria can consume as a mean of wastewater treatment, while simultaneously producing electricity. Crude glycerin as a by-product of biodiesel production process has a potential to be used by an MFC without glycerin purification process (Feng et al., 2011). Utilization of crude glycerin by large-scale MFCs can synergistically boost the biodiesel production industry.

MFCs typically come with two chambers of anode and cathode, separated by a proton exchange membrane (PEM). Our interest is, however, a membrane-less single-chamber MFC (Liu and Logan, 2004). One side of a cathode electrode of the MFC is in contact with the liquid, while the other side is directly exposed to air. In this manner, oxygen in the air can passively diffuse through the cathode and involve in the reaction of oxygen reduction. An intensive energy task of liquid aeration is not required, thus saving cost and energy. A PEM can obstruct the flow of the protons from the anode chamber to the cathode. A study (Liu and Logan, 2004) showed that an air-cathode MFC produced higher power output in absence of the membrane. PEMs are also generally quite expensive; therefore we are interested in an MFC without a PEM. A membrane-less single-chamber MFC has a simple configuration and is inexpensive to build. Figure 1 shows a conceptual diagram of the MFC having glycerin ($C_3H_8O_3$) as a primary source of energy.

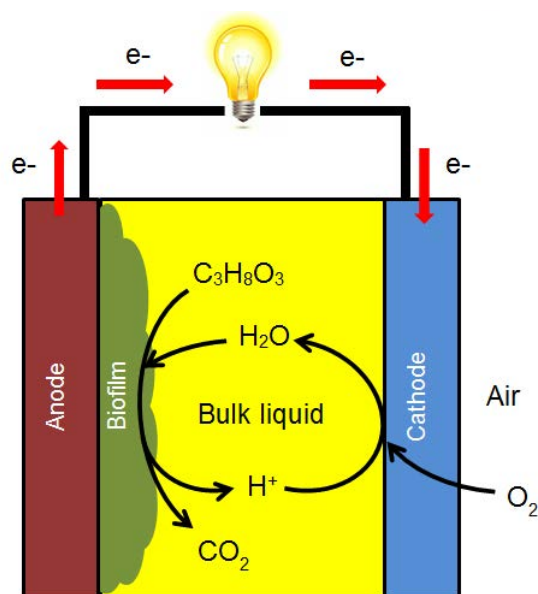
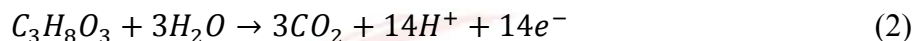


Figure 1. A conceptual diagram of membrane-less single-chamber MFC.

As in any simulation, the aim is to have a mathematical model that can predict the output and performance of the MFC for future modifications and optimization of the system. The model requires knowledge in electrochemistry, reaction kinetics, and mass balances. It also includes diffusion of oxygen across the cathode, and diffusion of chemical species across the diffusion layers and the biofilm that deposits on the anode. Some attempts have been done to develop simulation models of biofilm on anode (Merkey and Chopp, 2012) and two-chambered MFCs (Zeng et al., 2010). No work for a comprehensive simulation of single-chambered MFCs has been published. To develop a computational program for such simulation is our goal.

Methods

For our MFC, the cathodic reaction was the reduction of oxygen (Logan et al., 2006), as shown in Equation 1, and the anodic reaction was the oxidation of glycerin (Selemba et al., 2009), as shown in Equation 2. The two equations were considered when deriving the equations for the rates of consumption or production of the chemical species in our system.



Our program was roughly divided into two sequential segments; cathode and biofilm/anode. Each segment has a number of equations to be solved and their calculated outputs will be used by the subsequent segment. The program was developed using Visual Basic.

Cathode

The concentration of oxygen in the silicone layer, assumed to be the main component of the cathode, was calculated using Fick's second law of diffusion (Zielke, 2006), as shown in Equation 3. The concentration was a function of both time and location in the silicone layer.

$$\frac{\partial}{\partial t} [O_2]_{\text{cat}} = D_{O_2, \text{sil}} \frac{\partial^2}{\partial y^2} [O_2]_{\text{cat}} \quad (3)$$

where

$[O_2]_{\text{cat}}$ = concentration of oxygen in cathode, mmol dm^{-3}

$D_{O_2, \text{sil}}$ = diffusivity of oxygen in silicone, $\mu\text{m}^2 \text{min}^{-1}$

y = location in silicone, μm

The cathode voltage was then calculated using the cathodic reaction and the Nernst equation, as shown in Equation 4 (Logan et al., 2006). Only oxygen molecules that diffused through the silicone layer could be reduced to yield water molecules. The reaction was assumed to occur only at the cathode/liquid interface and oxygen was assumed to be ideal gas.

$$E_{\text{cat}} = E_{\text{cat}}^o - \frac{RT}{\gamma_{e^-/O_2} F} \ln \left(\frac{1}{(R \times 10^{-2}) T [O_2]_{\text{cat/liq}} [H^+]_{\text{cat/liq}}^4} \right) \quad (4)$$

where

E_{cat} = cathode voltage, V

E_{cat}^o = standard cathode voltage, V

R = gas constant, $\text{J mol}^{-1} \text{K}^{-1}$

T = temperature, K

γ_{e^-/O_2} = electron equivalence of oxygen, $\text{mmol-electron mmol-oxygen}^{-1}$

F = Faraday's constant, C mol^{-1}

$[O_2]_{\text{cat/liq}}$ = concentration of oxygen at cathode/liquid interface, mol dm^{-3}

$[H^+]_{\text{cat/liq}}$ = concentration of hydrogen ion at cathode/liquid interface, mol dm⁻³

It was proposed that the rate of oxygen reduction at the cathode follows the Monod equation and the Butler-Volmer equation (Torres et al., 2010; Zeng et al., 2010). We thus incorporated the two equations into Equation 5.

$$r_{O_2} = k_{O_2} \frac{[O_2]_{\text{cat/liq}}}{K_{O_2} + [O_2]_{\text{cat/liq}}} \exp \left[-\alpha_{\text{cat}} \gamma_{e^-/O_2} \frac{F}{RT} (E_{\text{cat}} - E_{\text{cat}}^o) \right] \quad (5)$$

where

r_{O_2} = rate of oxygen reduction per area, mmol dm⁻² min⁻¹

k_{O_2} = rate constant of oxygen reduction per area, mmol dm⁻² min⁻¹

$[O_2]_{\text{cat/liq}}$ = concentration of oxygen at cathode/liquid interface, mmol dm⁻³

K_{O_2} = half velocity constant for oxygen, mmol dm⁻³

α_{cat} = electron-transfer coefficient of cathode

Biofilm/Anode

Glycerin was assumed to be the main nutrient consumed by the bacteria, which resulted in the anodic reaction shown in Equation 2. Since the bacteria were localized and dispersed throughout the biofilm, assumed to conduct electrons, we considered the biofilm to be part of the anode (Kato Marcus et al., 2007; Merkey and Chopp, 2012; Torres et al., 2010). The rate of glycerin consumption was the same as the rate of exogenous respiration by the bacteria and it was described by the Nernst-Monod equation (Kato Marcus et al., 2007; Merkey and Chopp, 2012), as shown in Equation 6. The active biomass referred to the live bacteria.

$$r_{\text{exo}} = \frac{\rho_b \mu_b X_b}{Y_b \gamma_{\text{COD/gly}}} \cdot \frac{[Gly]_{\text{bio}}}{K_{Gly} + [Gly]_{\text{bio}}} \cdot \frac{1}{1 + \exp\left(-\frac{F}{RT} \eta\right)} \quad (6)$$

where

r_{exo} = rate of exogenous respiration in biofilm, mmol dm⁻³ min⁻¹

ρ_b = density of active biomass, mg-VS dm⁻³
(VS = volatile solids, a measure of biomass)

μ_b = specific growth rate of active biomass, min⁻¹

X_b = volume fraction of active biomass (unitless) = $\frac{\text{volume of active biomass}}{\text{bulk volume}}$

Y_b = active biomass growth yield, mg-VS mg-COD⁻¹

$\gamma_{\text{COD/gly}}$ = COD equivalence of glycerin, mg-COD mmol-glycerin⁻¹

$[Gly]_{\text{bio}}$ = concentration of glycerin in biofilm, mmol dm⁻³

K_{Gly} = half velocity constant for glycerin, mmol dm⁻³

η = $E_{\text{ano}} - E_{K_{\text{ano}}} =$ local potential in biofilm, V

E_{ano} = anode voltage, V

$E_{K_{\text{ano}}}$ = Half-max-rate anode voltage, V

In addition to the exogenous respiration, from which the bacteria obtained most energy from, the bacteria performed endogenous respiration by oxidizing their own cellular mass for additional energy. The rate of endogenous respiration was described by Equation 7 (Kato Marcus et al., 2007; Merkey and Chopp, 2012).

$$r_{\text{endo}} = b_{\text{endo}} \rho_b X_b \frac{1}{1 + \exp\left(-\frac{F}{RT} \eta\right)} \quad (7)$$

where

r_{endo} = rate of endogenous respiration in biofilm, mg-VS $\text{dm}^{-3} \text{min}^{-1}$

b_{endo} = endogenous decay coefficient of active biomass, min^{-1}

Based on the steady-state electron balance and Ohm's law, we calculated the local potential in the biofilm using Equation 8 (Kato Marcus et al., 2007; Merkey and Chopp, 2012).

$$\kappa_{\text{bio}} \frac{\partial^2 \eta}{\partial z^2} - \frac{F}{\tau v} (\gamma_{e^-/\text{Gly}} r_{\text{exo}} + \gamma_{e^-/b} r_{\text{endo}}) = 0 \quad (8)$$

where

κ_{bio} = biofilm conductivity, $\text{mS } \mu\text{m}^{-1}$

z = location in biofilm, μm

τ = time conversion = 60 sec min^{-1}

v = volume conversion = $10^{15} \mu\text{m}^3 \text{dm}^{-3}$

$\gamma_{e^-/\text{Gly}}$ = electron equivalence of glycerin, $\text{mmol-electron mmol-glycerin}^{-1}$

$\gamma_{e^-/b}$ = electron equivalence of active biomass, $\text{mmol-electron mg-VS}^{-1}$

(assuming $\text{C}_5\text{H}_7\text{O}_2\text{N}$ for VS (Kato Marcus et al., 2007))

The anode voltage was calculated using the anodic reaction and the Nernst equation, as shown in Equation 9 (Logan et al., 2006). The voltage value was applied as a boundary condition for calculation of Equation 8. Carbon dioxide was assumed to be ideal gas.

$$E_{\text{ano}} = E_{\text{ano}}^o - \frac{RT}{\gamma_{e^-/\text{Gly}} F} \ln \left(\frac{[\text{Gly}]_{\text{ano/bio}}}{((R \times 10^{-2}) T [\text{CO}_2]_{\text{ano/bio}})^3 [\text{H}^+]_{\text{ano/bio}}^{14}} \right) \quad (9)$$

where

E_{ano}^o = standard anode voltage, V

$[\text{Gly}]_{\text{ano/bio}}$ = concentration of glycerin at anode/biofilm interface, mol dm^{-3}

$[\text{CO}_2]_{\text{ano/bio}}$ = concentration of carbon dioxide at anode/biofilm interface, mol dm^{-3}

$[\text{H}^+]_{\text{ano/bio}}$ = concentration of hydrogen ion at anode/biofilm interface, mol dm^{-3}

The open-circuit voltage of the MFC was determined using Equation 10 (Logan et al., 2006).

$$E_{OCV} = E_{cat} - E_{ano} \quad (10)$$

where

E_{OCV} = open-circuit voltage of MFC, V

In the biofilm, the concentration of glycerin was a function of both time and location. We derived a mass balance of glycerin in the biofilm, as shown in Equation 11, by considering both the anodic reaction and the diffusion of glycerin from the bulk liquid through the biofilm layer. In a similar fashion, we derived mass balances of hydrogen ion and carbon dioxide, as shown in Equations 12 and 13, respectively.

$$\frac{\partial}{\partial t} [Gly]_{bio} = D_{Gly,bio} \frac{\partial^2}{\partial z^2} [Gly]_{bio} - r_{exo} \quad (11)$$

where

$D_{Gly,bio}$ = diffusivity of glycerin in biofilm, $\mu\text{m}^2 \text{min}^{-1}$

$$\frac{\partial}{\partial t} [H^+]_{bio} = D_{H^+} \frac{\partial^2}{\partial z^2} [H^+]_{bio} + 14r_{exo} \quad (12)$$

where

$[H^+]_{bio}$ = concentration of hydrogen ion in biofilm, mmol dm^{-3}

D_{H^+} = diffusivity of hydrogen ion in water, $\mu\text{m}^2 \text{min}^{-1}$

$$\frac{\partial}{\partial t} [CO_2]_{bio} = D_{CO_2,bio} \frac{\partial^2}{\partial z^2} [CO_2]_{bio} + 3r_{exo} \quad (13)$$

where

$[CO_2]_{bio}$ = concentration of carbon dioxide in biofilm, mmol dm^{-3}

$D_{CO_2,bio}$ = diffusivity of carbon dioxide in biofilm, $\mu\text{m}^2 \text{min}^{-1}$

All the parameters applied in the above equations were obtained from various literatures. Some assumptions were made, since not all aspects of MFC have been thoroughly studied yet. Numerical values of the parameters are shown in Table 1.

Table 1. Parameters in the simulation of the MFC.

Symbol	Description	Value	Unit	Reference
α_{cat}	electron-transfer coefficient of cathode	0.084	unitless	calculated, [1]
$\gamma_{COD/Gly}$	COD equivalence of glycerin	112	mg-COD mmol-glycerin ⁻¹	calculated
$\gamma_{e^-/b}$	electron equivalence of active biomass	0.177	mmol-electron mg-VS ⁻¹	[2]
$\gamma_{e^-/Gly}$	electron equivalence of glycerin	14	mmol-electron mmol-glycerin ⁻¹	calculated
γ_{e^-/O_2}	electron equivalence of oxygen	4	mmol-electron mmol-oxygen ⁻¹	calculated
κ_{bio}	biofilm conductivity	5×10^{-5}	mS μm^{-1}	[3]
μ_b	specific growth rate of active biomass	4.792×10^{-4}	min ⁻¹	[3]
ρ_b	density of active biomass	5×10^4	mg-VS dm ⁻³	[3]
b_{endo}	endogenous decay coefficient of active biomass	5.556×10^{-5}	min ⁻¹	[3]
$D_{CO_2,bio}$	diffusivity of carbon dioxide in biofilm	6.91×10^4	$\mu\text{m}^2 \text{min}^{-1}$	[4]
$D_{Gly,bio}$	diffusivity of glycerin in biofilm	1.41×10^4	$\mu\text{m}^2 \text{min}^{-1}$	[4]
D_{H^+}	diffusivity of hydrogen ion in water	5.58×10^5	$\mu\text{m}^2 \text{min}^{-1}$	[5]
$D_{O_2,sil}$	diffusivity of oxygen in silicone	9.6×10^4	$\mu\text{m}^2 \text{min}^{-1}$	[6]
E_{ano}^o	standard anode voltage	0.0126	V	calculated, [7]
E_{cat}^o	standard cathode voltage	1.229	V	[8]
$E_{K_{ano}}$	Half-max-rate anode voltage	-0.448	V	[3]
F	Faraday's constant	96,485	C mol ⁻¹	[2]
k_{O_2}	rate constant of oxygen reduction per area	5.48×10^{-6}	mmol dm ⁻² min ⁻¹	calculated, [1]
K_{Gly}	half velocity constant for glycerin	0.0536	mmol dm ⁻³	assumed same as acetate, [3]
K_{O_2}	half velocity constant for oxygen	4×10^{-3}	mmol dm ⁻³	[1]
R	gas constant	8.3145	J mol ⁻¹ K ⁻¹	[2]
X_b	volume fraction of active biomass	0.5	unitless	assumed
Y_b	active biomass growth yield	0.049	mg-VS mg-COD ⁻¹	[3]

References: [1] - Zeng et al. (2010), [2] - Kato Marcus et al. (2007), [3] - Merkey and Chopp (2012), [4] - Stewart (2003), [5] - Torres et al. (2008), [6] - Zhang and Cloud (2006), [7] - Thauer et al. (1977), and [8] - Logan et al. (2006).

Numerical approximation

Several equations above are differential equations, and finding the solutions normally involves a numerical approximation method. The selected numerical technique was the implicit finite difference method (Zielke, 2006). For instance, we transformed Equation 3 into the following equation.

$$\frac{[O_2]_{i,j} - [O_2]_{i,j-1}}{t_j - t_{j-1}} = D_{O_2, \text{sil}} \left\{ \frac{[O_2]_{i+1,j-2} [O_2]_{i,j} + [O_2]_{i-1,j}}{(z_i - z_{i-1})^2} \right\} \quad (14)$$

where

i = index indicating location i

j = index indicating time j

We rewrote Equation 14 into an equation of vectors and matrices that contained the values of the concentration of oxygen at every location in the silicone layer. For example, if we partition the layer to consist of 4 locations inside, Equation 14 then becomes Equation 15. The subscript t indicates that all the concentrations in the vector are at time t .

$$\frac{1}{\Delta t} \left(\begin{pmatrix} [O_2]_1 \\ [O_2]_2 \\ [O_2]_3 \\ [O_2]_4 \end{pmatrix}_t - \begin{pmatrix} [O_2]_1 \\ [O_2]_2 \\ [O_2]_3 \\ [O_2]_4 \end{pmatrix}_{t-\Delta t} \right) = \frac{D_{O_2, \text{sil}}}{(\Delta z)^2} \left(\begin{bmatrix} -2 & 1 & 0 & 0 \\ 1 & -2 & 1 & 0 \\ 0 & 1 & -2 & 1 \\ 0 & 0 & 1 & -2 \end{bmatrix} \begin{pmatrix} [O_2]_1 \\ [O_2]_2 \\ [O_2]_3 \\ [O_2]_4 \end{pmatrix}_t - \begin{pmatrix} [O_2]_0 \\ 0 \\ 0 \\ [O_2]_5 \end{pmatrix} \right) \quad (15)$$

where

Δt = $t_j - t_{j-1}$ = time interval

Δz = $z_i - z_{i-1}$ = distance interval

We could also rewrite Equation 15 into an abbreviated form, as shown in Equation 16.

$$\frac{1}{\Delta t} \left(\underline{[O_2]}_t - \underline{[O_2]}_{t-\Delta t} \right) = \frac{D_{O_2, \text{sil}}}{(\Delta z)^2} \left(\mathbb{A} \underline{[O_2]}_t - \underline{a} \right) \quad (16)$$

We then rearranged Equation 16 into the form of $\mathbb{B} \underline{x} = \underline{b}$, as shown in Equation 17. Since the matrix \mathbb{B} was a tridiagonal matrix, we applied an algorithm for solving a tridiagonal system by elimination (Conte and de Boor, 1980) to solve for the vector \underline{x} , which was $\underline{[O_2]}_t$ in our case.

$$\left(\mathbb{I} - \frac{\Delta t D_{O_2, \text{sil}}}{(\Delta z)^2} \mathbb{A} \right) \underline{[O_2]}_t = \underline{[O_2]}_{t-\Delta t} + \frac{\Delta t D_{O_2, \text{sil}}}{(\Delta z)^2} \underline{a} \quad (17)$$

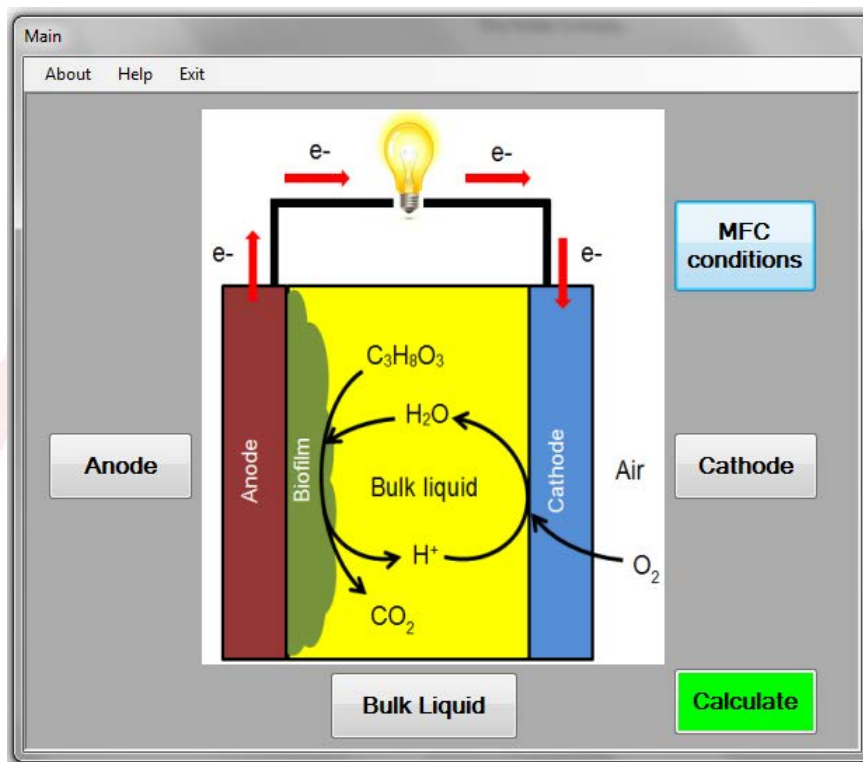
where

\mathbb{I} = identity matrix

Results and discussions

We developed a simulation program of the MFC with a user-friendly interface. The program accepted inputs including initial amount of glycerin, operation time, pH, temperature, and biofilm thickness. A program user can also modify values of some parameters, if more

accurate values are acquired. Figure 2 show some screen captures of the program. The program displayed the results in two formats; tables of data and plots. The results included various variables of the system, for example, concentration of oxygen in cathode layer, concentration of glycerin and pH in bulk liquid, concentration of glycerin in biofilm layer, cathode and anode voltages, and MFC open-circuit voltage.



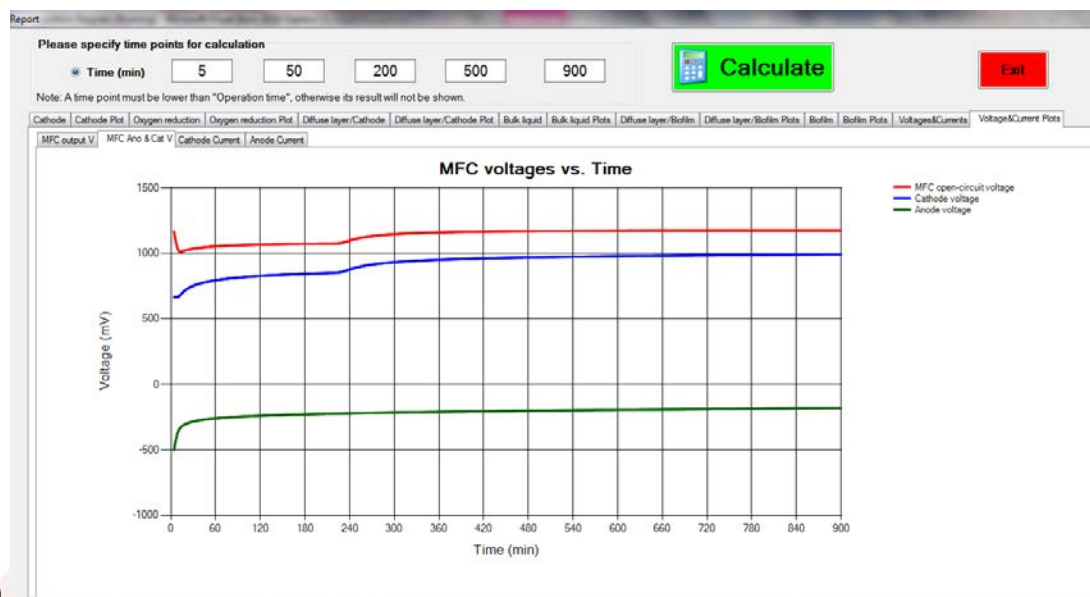
(A)

Bulk liquid variables		
Initial amount of glycerin	1	g
Initial pH	7	
Diffuse layer thickness	50	um

Bulk liquid constants		
Diffusivity of carbon dioxide in water	115000	um ² /min
Diffusivity of hydrogen ion in water	558000	um ² /min
Diffusivity of glycerin in water	56400	um ² /min
Electron equivalence of glycerin	14	mmol-electron/mmol-glycerin
COD equivalence of glycerin	112	mg-COD/mmol-glycerin
Half velocity constant for glycerin	0.0536	mmol/dm ³

Save

(B)



(C)

Figure 2. Examples of screen captures of the MFC simulation program: (A) the main window, (B) the input window of bulk liquid, and (C) the result window.

Plots of concentration of oxygen in the cathode layer at different times are shown in Figure 3. Thickness of the layer was set at 1000 μm . Oxygen concentration in the air was assumed to be in excess and thus constant. The liquid was depleted of oxygen since it was completely consumed in the reduction reaction. As shown in the plots, the concentration reached saturation in the first few minutes and remained constant throughout the MFC operation.

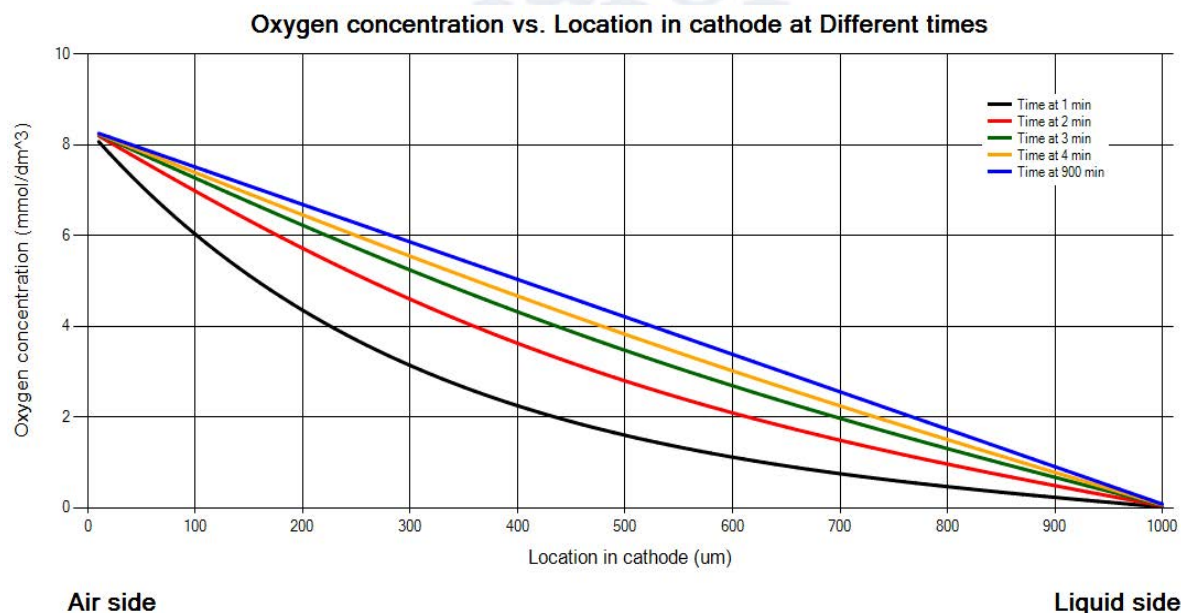


Figure 3. Plots of oxygen concentration in cathode layer at different times.

Plots of glycerin concentration and pH in the bulk liquid are shown in Figures 4 and 5, respectively. The MFC operation time was set at 15 hours (900 min). The glycerin concentration decreased, due to being consumed by the bacteria, quickly in the first hour and at a slower rate afterwards. The pH also decreased due to the accumulation of hydrogen ions, and thus the system became more acidic.

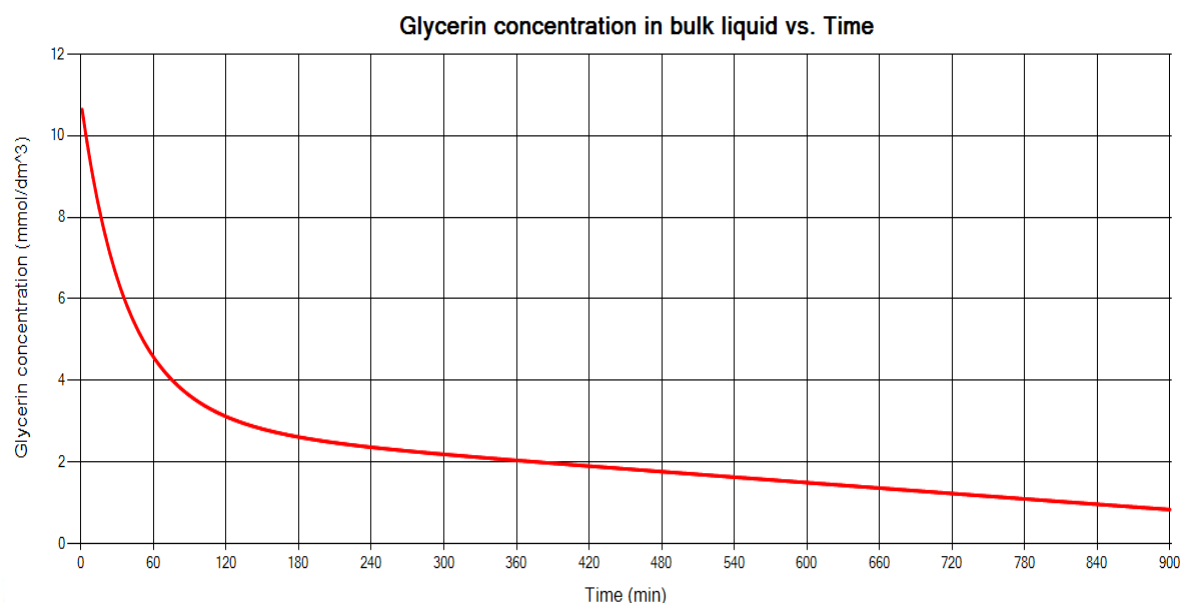


Figure 4. A plot of glycerin concentration in bulk liquid over time.

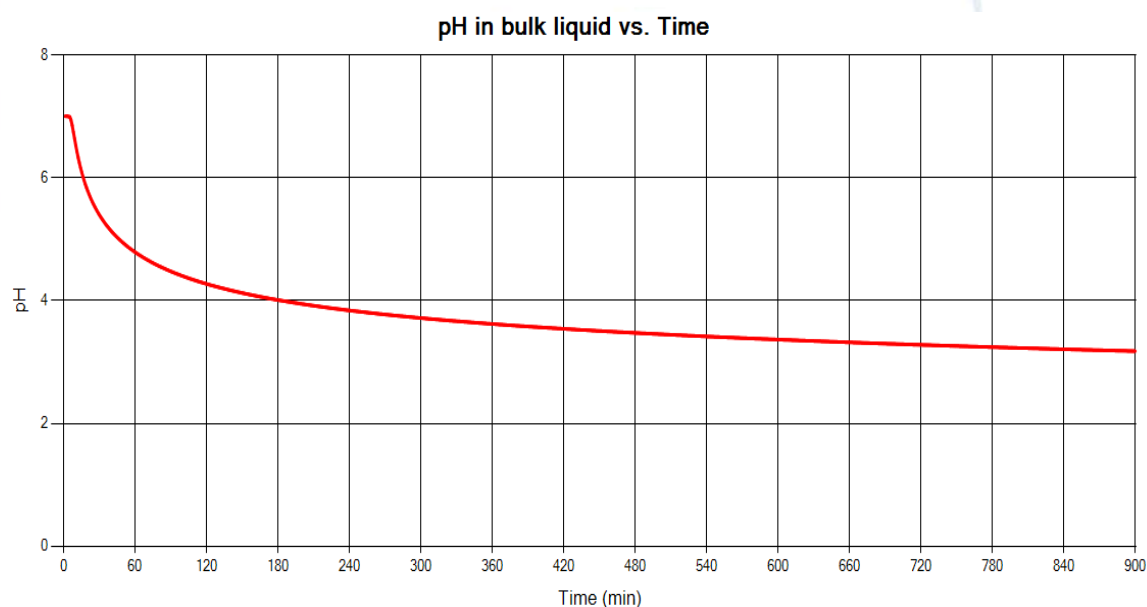


Figure 5. A plot of pH in bulk liquid over time.

Plots of glycerin concentration and local potential in the biofilm layer are shown in Figure 6 and 7. Thickness of the layer was set at 60 μm . The glycerin concentration increased in the early period due to diffusion of glycerin from the bulk liquid into the biofilm layer. The concentration, however, subsequently decreased since glycerin was consumed by the bacteria. The potentials quickly increased in the early period and at a slower rate afterwards. The potentials close to the anode were slightly higher than those close to the bulk liquid. As a result, the generated electrons flowed toward the anode with the higher potential, and the current flowed in the opposite direction.

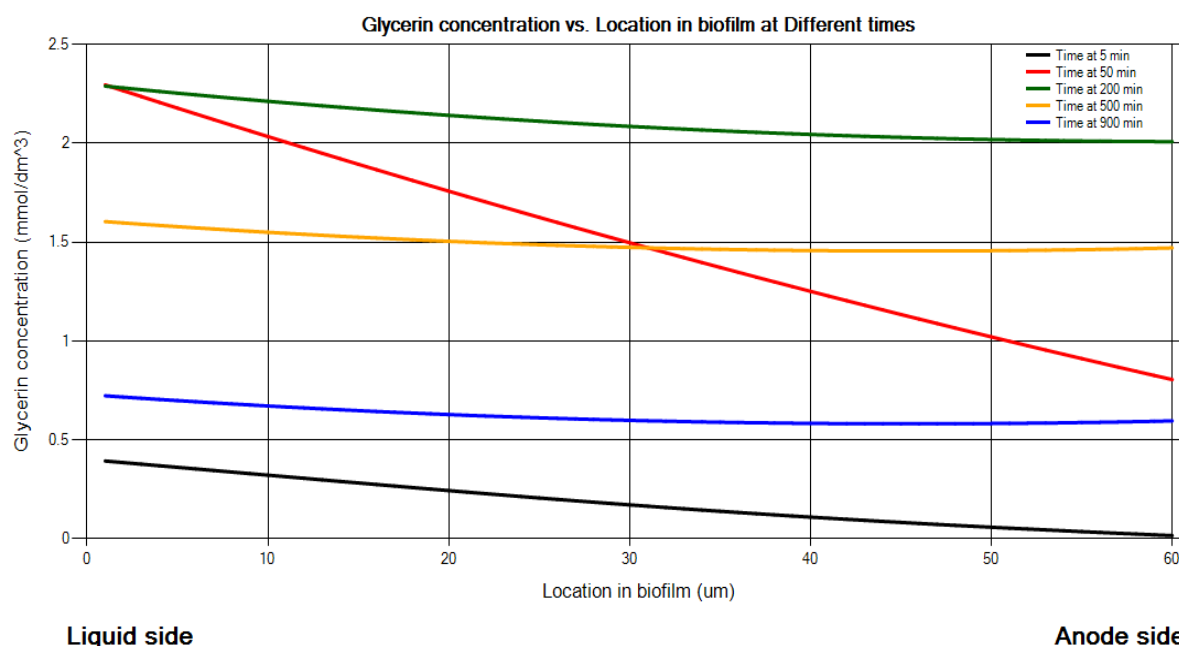


Figure 6. Plots of glycerin concentration in biofilm layer at different times.

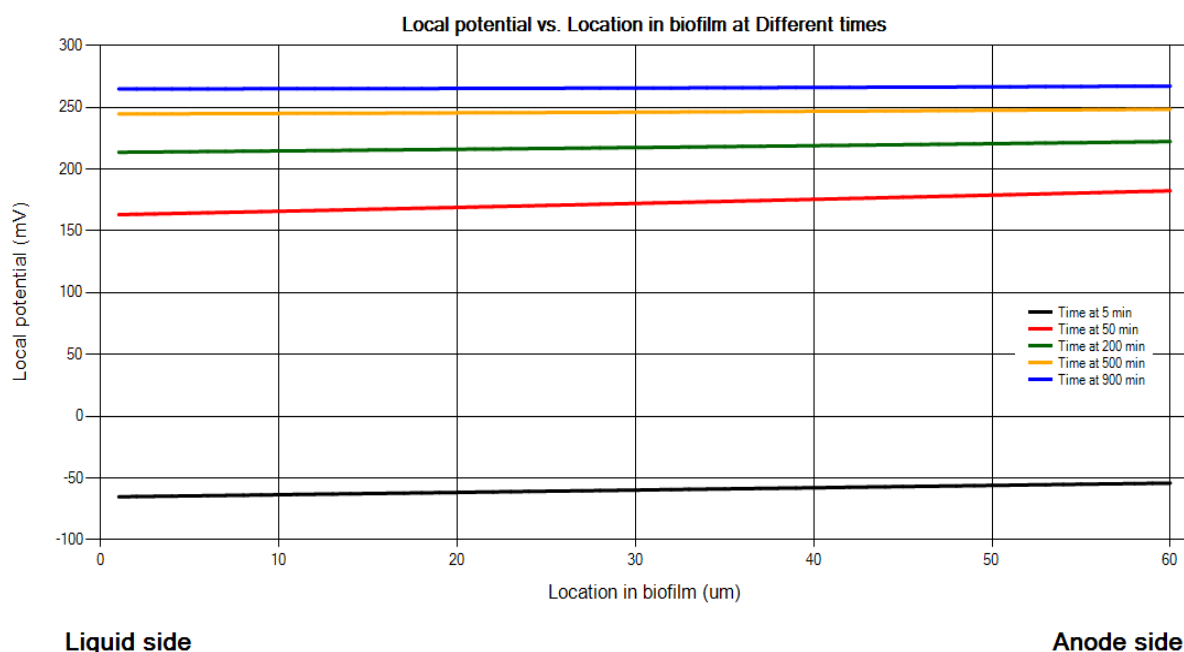


Figure 7. Plots of local potential in biofilm layer at different times.

Plots of cathode, anode, and MFC open-circuit voltages of the system are shown in Figure 8. The cathode voltage increased over time, since more hydrogen ions accumulated in the system and participated in the reduction reaction. The anode voltage also increased over time, since the glycerin concentration decreased, therefore the rate of electron generation decreased. Fewer number of electrons means the anode becomes more positive; thus a higher voltage. Compared to the anode voltage, the cathode voltage increased at a faster rate in the first half

of the operation time, but in the end both voltages became steady. As a result, the open-circuit voltage slightly increased in the first half, but became steady in the end.

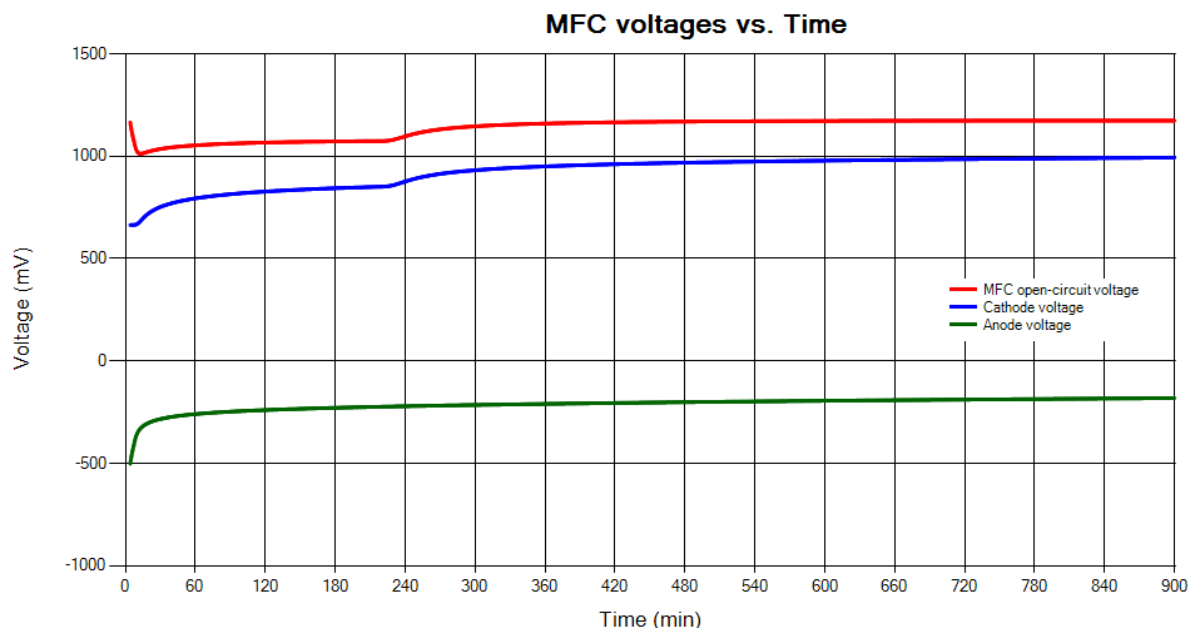


Figure 8. Plots of cathode, anode, and MFC open-circuit voltages over time.

The simulation program was able to compute and provide the voltages and the concentration profiles of chemical species in the MFC, and the trends seemed to agree with our expectations. Further development of the program involves calculation of the current and power density of the system. In addition, model validation with experimental data is necessary and more accurate model parameters are desirable, before the program could be used in practical optimization and prediction of the MFC performance.

References

- Conte, S. D., and de Boor, C. (1980) The solution of linear system by elimination. *Elementary Numerical Analysis* (pp. 147-157): McGraw-Hill.
- Feng, Y., Yang, Q., Wang, X., Liu, Y., Lee, H., and Ren, N. (2011) Treatment of biodiesel production wastes with simultaneous electricity generation using a single-chamber microbial fuel cell. *Bioresource Technology*, 102(1), 411-415.
- Kato Marcus, A., Torres, C. I., and Rittmann, B. E. (2007) Conduction-based modeling of the biofilm anode of a microbial fuel cell. *Biotechnology and Bioengineering*, 98(6), 1171-1182.
- Liu, H., and Logan, B. E. (2004) Electricity generation using an air-cathode single chamber microbial fuel cell in the presence and absence of a proton exchange membrane. *Environmental Science & Technology*, 38(14), 4040-4046.
- Logan, B. E., Hamelers, B., Rozendal, R., Schröder, U., Keller, J., Freguia, S., Aelterman, P., Verstraete, W., and Rabaey, K. (2006) Microbial fuel cells: methodology and technology. *Environmental Science & Technology*, 40(17), 5181-5192.
- Merkey, B. V., and Chopp, D. L. (2012) The performance of a microbial fuel cell depends strongly on anode geometry: a multidimensional modeling study. *Bulletin of Mathematical Biology*, 74(4), 834-857.

- Selembo, P. A., Perez, J. M., Lloyd, W. A., and Logan, B. E. (2009) High hydrogen production from glycerol or glucose by electrohydrogenesis using microbial electrolysis cells. *International Journal of Hydrogen Energy*, 34(13), 5373-5381.
- Stewart, P. S. (2003) Diffusion in biofilms. *Journal of Bacteriology*, 185(5), 1485-1491.
- Thauer, R. K., Jungermann, K., and Decker, K. (1977) Energy conservation in chemotrophic anaerobic bacteria. *Bacteriological Reviews*, 41(1), 100-180.
- Torres, C. I., Kato Marcus, A., and Rittmann, B. E. (2008) Proton transport inside the biofilm limits electrical current generation by anode-respiring bacteria. *Biotechnology and Bioengineering*, 100(5), 872-881.
- Torres, C. I., Marcus, A. K., Lee, H.-S., Parameswaran, P., Krajmalnik-Brown, R., and Rittmann, B. E. (2010) A kinetic perspective on extracellular electron transfer by anode-respiring bacteria. *FEMS Microbiology Reviews*, 34(1), 3-17.
- Zeng, Y., Choo, Y. F., Kim, B.-H., and Wu, P. (2010) Modelling and simulation of two-chamber microbial fuel cell. *Journal of Power Sources*, 195(1), 79-89.
- Zhang, H., and Cloud, A. (2006, November 6 – 9). *The permeability characteristics of silicone rubber*. Paper presented at the Global Advances in Materials and Process Engineering, Dallas, Texas.
- Zielke, E. A. (2006). Numerical analysis of a one dimensional diffusion equation for a single chamber microbial fuel cell using a linked simulation optimization (LSO) technique. *E521: Advanced Numerical Methods*.

iafor

Adapting the Design Principles of Business Dashboards for Visualizing Status and Trends of River Water Quality - A Case Study of Yogyakarta Province, Indonesia

Fahmi Machda, Firdan Machda

PT. Machda Furyco, Indonesia

0357

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Monitoring of river water quality is an essential part of environmental management activities. It is generating new data periodically, which are hard to keep track of with multiple pages of traditional reports or spreadsheets. A dashboard that can show a graphical presentation of the current status and historical trends of river water quality is needed to enable environmental managers to make right decisions at a glance. In this paper, we present the adaptation results of design principles of business dashboard to develop a web-based dashboard for river water quality. This adaptation includes use of officially published data by the environmental management agency of Yogyakarta Province Government of Indonesia. Google Map API is used to provide web mapping on the dashboard. Dynamic bar charts are used to visualize time series data. A slider is provided to show historical trends and progress. The approach of Web 2.0 is implemented to enable users to collaborate with each other to update data on the dashboard. Besides the capability to help users glean insights and make right decisions quickly on the sustainability and management of river water quality from a single interactive web-page screen, this dashboard is also a collaborative medium for multiple users to put and visualize river data together at one place.

keywords: River Water Quality, Environmental Management, Dashboard, Web-Mapping

1. INTRODUCTION

Rivers are important natural resources particularly for agriculture, fisheries, recreational use, amenity value and as sources of drinking water (Department of the Environment – Northern Ireland, 2001). Maintaining the quality of the rivers will contribute significantly for the quality of the environment. Monitoring is an important part of it. It generates data periodically which are very useful for assessing the quality of an environment. It is also useful for evaluating the environmental performances such as the effectiveness of projects, programs or activities for river management. Proper evaluation will be achieved with a good insight of the data and will lead to good of river management. On the other hand, improper evaluation without good understanding of data will lead to the destruction of the river.

The data are necessary to be processed, presented, and publicly reported at least for two fundamental functions (The Ministry of The Environment - Japan, 2007). The first is an external function as a communication tool between the river management authority and society. It includes disclosing information based on the social accountability of organizations, providing useful information for stakeholders making decision, and promoting environmental initiatives between the organization and society. The second is an internal function which promotes ideas within the organization. It includes establishing or revising the environmental policy, objectives and action plans of the organization. It also is able to motivate and encourage the environmental activities of managements and employees. All of these functions play a very important role in promoting voluntary initiatives there.

Reporting publicly the environmental data also give benefits (Natural Heritage Trust - Australia, 2000) such as creation of market opportunities; indirect improvement in internal environmental performance; increased confidence of investors, insures and financial institutions; improvement of relationships with local communities, regulators, and non government organization, greater control of environmental disclosure, and increased staff commitment.

The Environmental Agency of Yogyakarta Province has reported and published publicly the Summaries of Water Quality Monitoring and Analysis from 2007 – 2012 (Badan Lingkungan Hidup Daerah Istimewa Yogyakarta, 2013). The summaries generally contains multiple pages of tables (Fig. 1). It is hard to keep track of the data with this kind of reports. Additional visualization is necessary to make sense of the data because research shows that data visualization can improve significantly the insights and accelerate time-needed to the insight (Eckerson, 2011).

REKAPITULASI HASIL PEMANTAUAN DAN ANALISA PERHITUNGAN METODE STORET UNTUK PENENTUAN STATUS MUTU
 KUALITAS AIR SUNGAI CODE TAHUN 2012

A. Lokasi Pemantauan: Jembatan Boyong, Pakem, Sleman
 B. Koordinat: S: 07° 37' 26.9"
 E: 110° 24' 52.1" C-01

No.	Parameter	Satuan	Baku Mutu Kelas I*	Hasil Pemantauan					Perhitungan Storet			
				Februari	Juni	Oktober	Mas	Storet	Min	Skor	Rata-rata	Skor
1	Suhu	°C	26.5	26.1	24.7	26.5	25.7	26.1				
2	pH		6-8.5	6.9	7.2	5.1	7.2	6.4				
3	Residu Terlarut	mg/L	1000	98	99	116	116	0	98	0	104.3	0
4	Residu Teruspensi	mg/L	0	907	69	9	907	-1	9	-1	325.0	-3
5	Oksigen terlarut (DO)	mg/L	6	7	8	28	28	0	7	0	14.3	0
6	BOD ₅	mg/L	2	1	2	9	-2	1	0	0	4.0	-6
7	COD	mg/L	10	6	8	20	-2	6	0	0	11.3	-6
8	Klorin bebas	mg/L	0.03	0.13	0.11	0.03	0.13	-2	0.03	0	0.0900	-6
9	Nitrat (NO ₃ -N)	mg/L	10	0.1	0.5	0.7	0.7	0	0.3	0	1	0
10	Nitrat	mg/L	0.06	0.06	0.02	0.03	0.06	-2	0.02	0	0.036667	0
11	Fluorida	mg/L	1.5	0.001	0.001	0.001	0.001	0	0.001	0	0.001	0
12	Sulfida (H ₂ S)	mg/L	0.002	0.554	0.018	0.001	0.154	-2	0.018	-2	0.086	-10
13	Deterjen	mg/L	200	33	24	25	75	0	24	0	4.4	0
14	Fenol	mg/L	1	0.1	0.1	0.2	99	-2	0.1	0	13.1	-6
15	Fosfat (PO ₄)	mg/L	0.2	0.7	0.1	0.7	-2	0.1	0	0.33	-6	
16	Stanad (CN)	mg/L	0.02	0.001	0.001	0.009	0.009	0	0.001	0	0.00	0
17	Minyak & lemak	mg/L	1000	0	0	0	0	0	0	0	0	0
18	Kadmium (Cd)	mg/L	0.01	0.005	0.001	0.001	0.005	0	0.001	0	0.002333	0
19	Seng (Zn)	mg/L	0.05	0.009	0.1	0.002	0.1	-2	0.002	0	0.037	-2
20	Krom heksavalen	mg/L	0.05	0.1	0.09	0.02	0.1	-2	0.02	0	0.07	-6
21	Tembaga (Cu)	mg/L	0.02	0.7	0.1	0.04	0.2	-2	0.04	-2	0.113333	-6
22	Warna	mg/L	100	155	0	29	155	-1	20	0	71.66667	0
23	Boron	mg/L	1	0.001	0.8	0.1	0.0	0	0.001	0	0.300333	0
24	Timbal (Pb)	mg/L	0.03	0.5	0.06	0.01	0.5	-2	0.01	0	0.19	-6
25	Bakteri kol. Total	PTV/100ml	100	9000	7000	1000	9000	-3	4000	-3	6667	-15
26	Bakteri Total Koli	PTV/100ml	1000	2000	7000	1000	2000	-3	7000	-3	13000	-17

Skor: -117

Status Mutu Air Dengan Metode Storet sesuai KepMen LH No. 115 Tahun 2003 tentang Pedoman Status Mutu Air: Status Mutu: **cemar berat**

(1) Kelas A: Baik sekali, skor = 0 → memenuhi baku mutu (3) Kelas C: Sedang, skor = 11 s/d 30 → cemar sedang
 (2) Kelas B: Baik, skor = 1 s/d 10 → cemar ringan (4) Kelas D: Buruk, skor > 31 → cemar berat
 *) Peraturan Pemerintah Nomor 82 Tahun 2001

Fig. 1 The format of River Water Quality Monitoring and Analysis Summaries of Yogyakarta Province, Indonesia

The initiative to visualize the river water quality status is not new. For example, Environmental Protection Agency (EPA) of Ireland has an accessible web-based data visualization screen (EPA of Ireland, 2013) for its rivers (Fig. 2). This data visualization shows five types of river status dots, among others are High (blue), Good (green), Moderate (yellow), Poor (orange), and Bad (red) from all spots of The republic of Ireland. Those dots can be clicked and will give the information about the name of the monitoring station.

Another example is Statewide River Water Quality Assessment (Fig. 3) by The Government of Western Australia (Department of Water - Western Australia, 2013). This data visualization shows spots of river monitoring as blue dots. Those blue dots can be clicked and will give you text based summary about the location such as the location name, the parameters, and the trends on the right panel of the browser.

Those visualizations are mainly based on maps and give the actual status of those spots. Confusion is there since it visualizes too broad areas for local authority and society. It is hard to give the real impact for the river stakeholders with this kind of visualizations. The visualization are not actionable since they are not clear about the metrics if it is on-target or off-target.

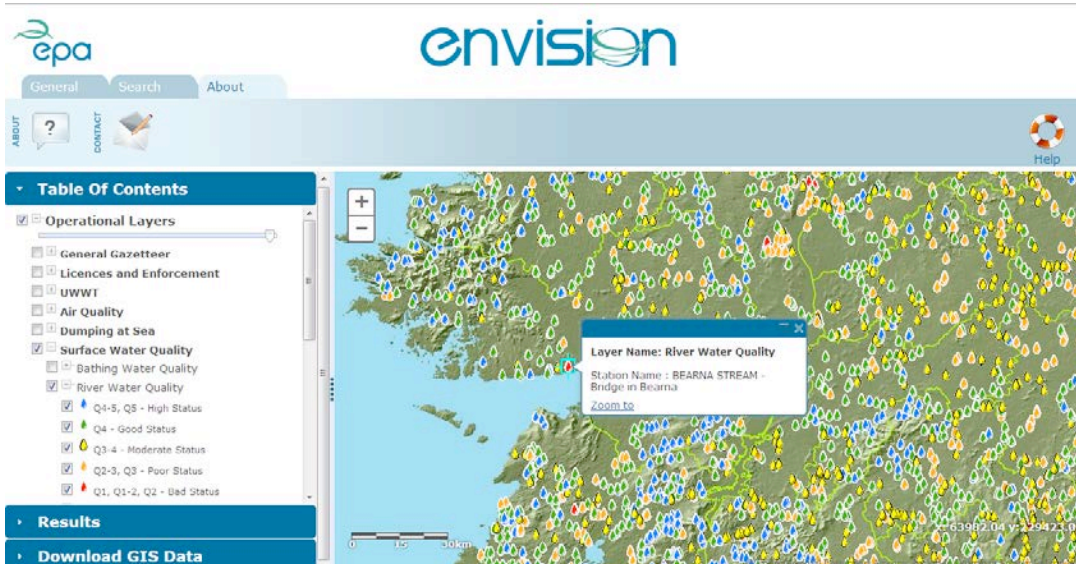


Fig. 2 The layout of Envision by EPA of the Republic of Ireland

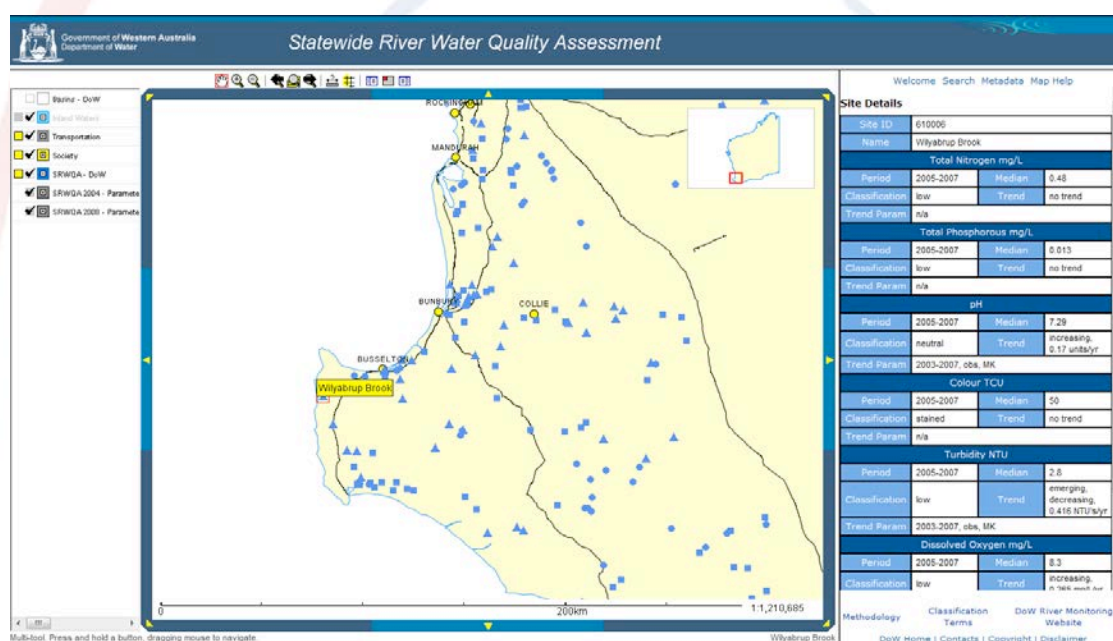


Fig. 3 The layout of Statewide River Water Quality Assessment by Department of Water, Government of Western Australia

For this reason, we are trying to come up with a new design for visualizing status and trends of river water quality that is user-friendly, non-confusing, high impact, and actionable particularly for the River Stakeholders of Yogyakarta Province. This new design tries to complement the public river water quality report so the dashboard can help it to give its purpose and benefits better.

2. METHODS

2.1 Design Principles

This web-application is designed as a dashboard which is a visual display of the most important information needed to achieve one or more objective which fits entirely on a single screen so it

can be monitored at a glance (Few, 2011). Business dashboard design principles (Juice, 2009) are used to make the river dashboard (Table 1).

Table 1. Business Dashboard Design Principles Implementation

Principles	Description	Implementation
Actionable	It is clear what is the source of the problem when the metric goes off-target	The dashboard focuses on showing the river status only whether it is on-target or off-target
Common interpretation	People in the organization recognize the metrics	The dashboard should use the metrics that are already understood and used by the local Environmental Authority
Transparent, simple calculation	How the metric is generated is shared and easy to understand	The dashboard assess the water quality in a very simple way. It is to present visually if the quality is on-target or not
Accessible, credible data	The data can be acquired with modest effort from a source that people trust	The dashboard should use the sample data which are officially published for public by local Environmental Authority.

2.2 Water Quality Parameter and Data Sample

The parameter of the water quality in this application uses the standards defined by the President of Indonesia (Presiden Indonesia, 2001) which are classified to some classes (Table 2). Each class has its own usages (Table 3) which are defined by the Governor of Yogyakarta Province (Gubernur Yogyakarta, 2008). The data sample for this application comes from the Water Quality Reports of three rivers in Yogyakarta Province which are Code, Winongo and Gadjahwong River from 2007 to 2012 including the standard of water quality in each monitoring location (Badan Lingkungan Hidup Yogyakarta, 2013).

Table 2. The Parameter of Water Quality

Parameter	Units	Class 1		Class 2		Class 3	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
pH	-	6	8.5	6	8.5	6	8.5
Total Dissolved Solid	mg/L	0	1000	0	1000	0	1000
Total Suspended Solid	mg/L	0	0	0	50	0	400
DO	mg/L	6	9	5	9	4	9
BOD5	mg/L	0	2	0	3	0	6
COD	mg/L	0	10	0	25	0	50
Free Chlorine	mg/L	0	0.03	0	0.03	0	0.03
Nitrate (NO ₃ ⁻)	mg/L	0	10	0	10	0	10
Nitrite (NO ₂ ⁻)	mg/L	0	0.06	0	0.06	0	0.06
Fluoride	mg/L	0	1.5	0	1.5	0	1.5
Sulfide (H ₂ S)	mg/L	0	0.002	0	0.002	0	0.002
Detergent	µg/L	0	200	0	200	0	200
Phenol	µg/L	0	1	0	1	0	1
Phosphate (PO ₄ ³⁻)	mg/L	0	0.2	0	0.2	0	0.2
Cyanide (CN)	mg/L	0	0.02	0	0.02	0	0.02
Oils and Fats	µg/L	0	1000	0	1000	0	1000
Cadmium (Cd)	mg/L	0	0.01	0	0.01	0	0.01
Zinc (Zn)	mg/L	0	0.05	0	0.05	0	0.05
Chromium (VI)	mg/L	0	0.05	0	0.05	0	0.05
Copper (Cu)	mg/L	0	0.02	0	0.02	0	0.02
Color	mg/L	0	100	0	100	0	100
Boron (B)	mg/L	0	1	0	1	0	1
Lead (Pb)	mg/L	0	0.03	0	0.03	0	0.03
Fecal Coliform	MPN/100ml	0	100	0	1000	0	2000
Total Coliform	MPN/100ml	0	1000	0	5000	0	10000

Table 3. Water Quality Classification

Usage	Class 1	Class 2	Class 3
Drinking	ü	X	X
Water-based Recreational facilities	ü	ü	X
Freshwater Fish breeding, Livestock, and Irrigation	ü	ü	ü

2.3 Database Schema

The database of this web-application is designed to visualize river data. There are four tables which relates to each other for the visualization feature. The tables are “baku_mutu”, “parameter”, “data_sungai”, and “lokasi” (Fig. 4). For preventing repeated data, we implement One to Many relations on the “parameter” table to “baku_mutu” table, “data_sungai” table to “parameter” table and “lokasi” table to “data_sungai” table.

The “baku_mutu” table stores the data of the water quality threshold standards for each parameter. This table has the value of “parameterid” which is referencing to the primary key of the “parameter” table . The “parameter” table stores the name and the units of the parameters.

Table of “data_sungai” stores the actual value of water in a specific date, a specific location, the “parameterid” value for referencing to the table of “parameter”, and the target of what water quality class should be achieved in that location. The location value of “data_sungai ” table is referencing to the table of “lokasi” which stores the name of the river, the name of the monitoring location, the latitude, and the longitude.



Fig. 4. Database schema of the river dashboard application

3. APPLICATION AND DISCUSSION

3.1 Dashboard Designs

The river dashboard we developed combines a map and bar-charts. The map is used to show the distribution of monitoring locations. Google Map API is chosen since it can show the contour of an area. Google Map API is also able to show the satellite image of an area that will give useful information for the users. On the map, points are dynamically generated from the selected year. Users can select the year by dragging the slider on top of the map. The points also show the results of water quality assessment in each year, when it is on-target, the points will be green otherwise the points will be red. The total numbers of the green and red dots are displayed on a summary box on on top-right of the map.

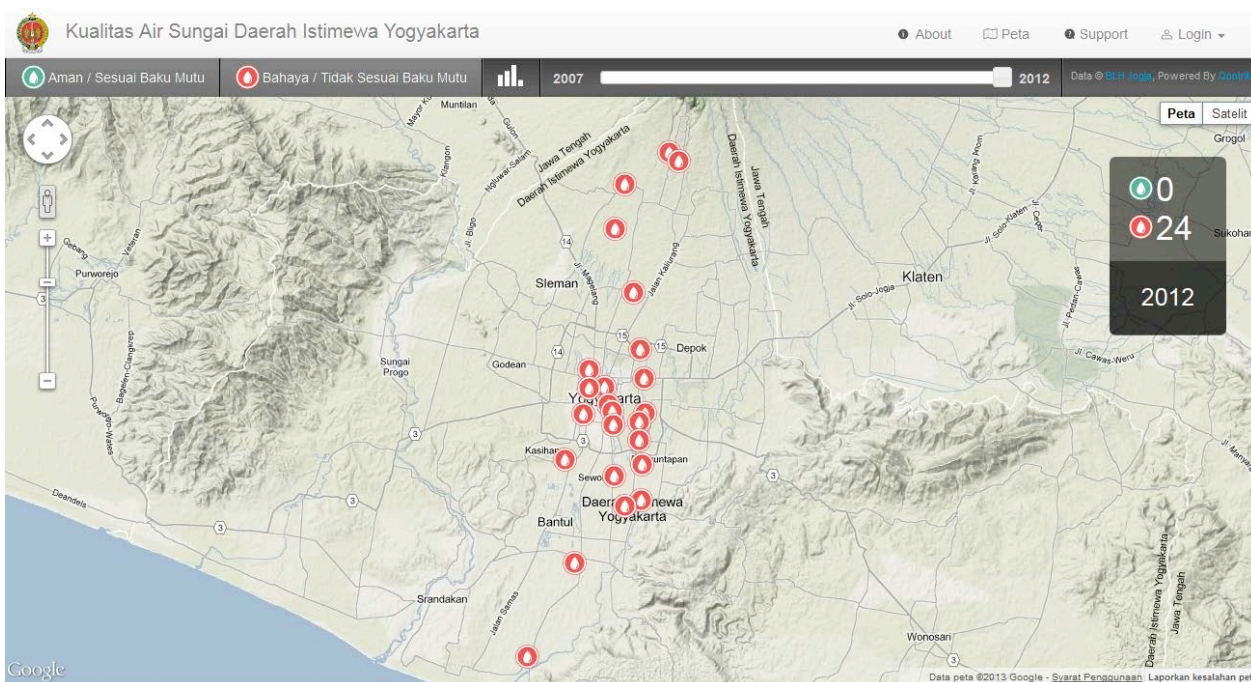


Fig. 5. The main interface of the dashboard that include main navigation, a map, points, a summary box, and a slider

Bar charts are used to visualize the numbers of monitoring locations and the value of each water quality parameter monthly. On top of the map, a button on the left side of the slider can be clicked to show the monthly river water quality data and assessment. The points on the map can be clicked to show the value of the parameters in that location. The value of the parameter are shown per month as bar charts. The slider under the bar-charts can be dragged to select the year.

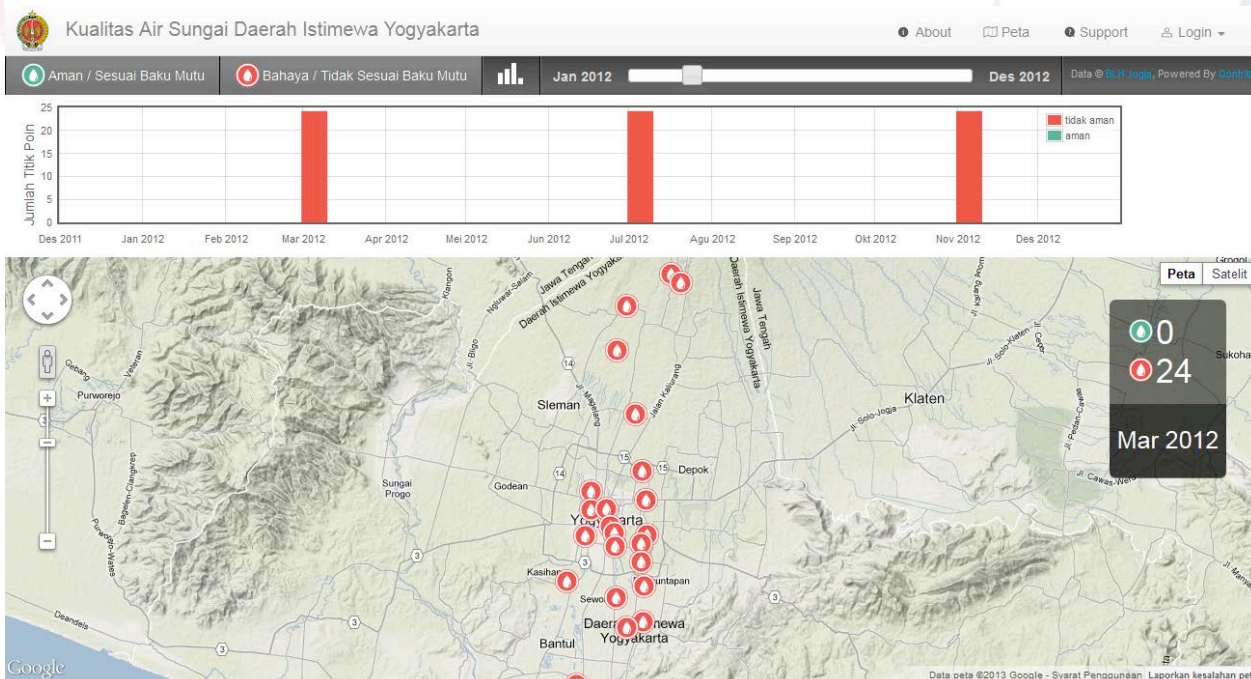


Fig. 6. The monthly review interface of the dashboard showing the numbers of the green and red points per month in a selected year

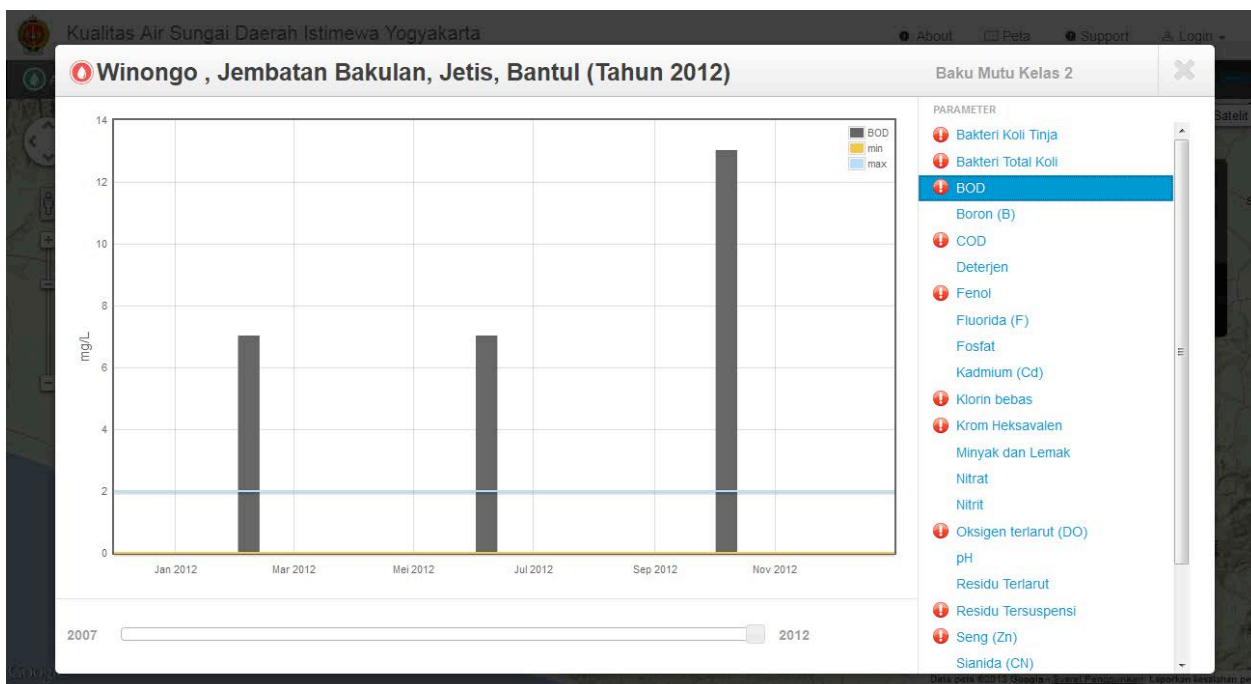


Fig. 6. The monthly review interface of the dashboard showing the value of each parameter per month in a selected location and year

Through this design, this river water quality dashboard is able to visualize water quality assessment automatically. The performance of a local river management authority can also be monthly or yearly reviewed. This dashboard also has a narrower targeted users which are local river authority and local society in a region so the information on the dashboard is more actionable.

These features differentiate this application in comparison to other web-based river data visualization application such as Envision of the Environmental Protection Agency of Ireland and Statewide Water Quality Assessment system of the Department of Water, Western Australia Government.

3.2 Data Collaboration and Management

The approach of Web 2.0 is implemented to this application by making this dashboard as a gateway rather than an endpoint of the river data visualization. A definition of Web 2.0 is the philosophy of mutually maximizing collective intelligence and added values for each participant by formalized and dynamic information sharing and creation (Wijaya, 2009). This application allows users to create and share river data in a collaborative environment to update and manage the dashboard. There are three levels of users in the dashboard which are “Sp-Admin”, “Admin”, and “Tim”. Each level has its own role for the dashboard. The interface of the web-page for this feature shows the list of the uploaded files and the list of the registered users (Fig. 7). This dashboard can handle the Open Office (.ods) and Microsoft Excel (.xls) files.

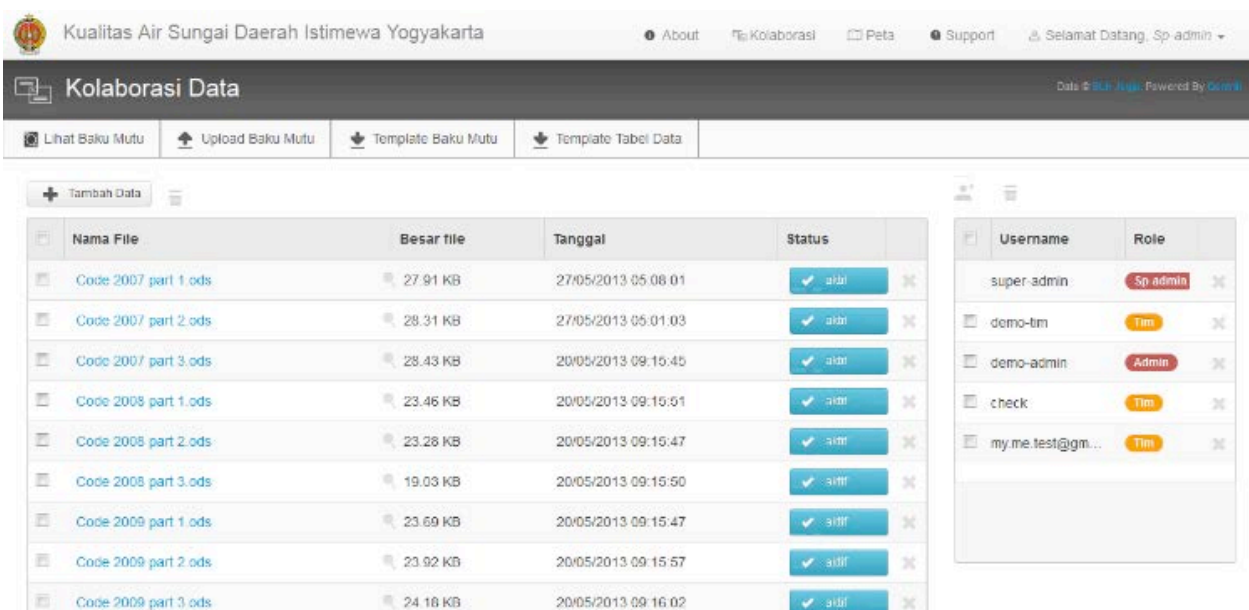


Fig.7 The interface for the collaborative environment of the dashboard

Table 4. Users Role

Role	Sp-Admin	Admin	Tim
Deleting “Admin” users	ü	X	X
Deleting “Tim” users	ü	ü	X
Activating the Data to be visualized and visible by public	ü	ü	X
Uploading the Water Quality Parameter Standards	ü	ü	ü
Uploading River Data	ü	ü	ü

3.3 Findings

After putting all the sample data to the dashboard, we can easily review the performance of the river management in Yogyakarta Province. We can find through the map and the bar charts on the dashboard (accessible at <http://riverdemo.qontrib.com>) that there is no significant improvement of the three rivers in six years from 2007 to 2012. BOD and COD remain off-target from 2007 to 2012. Even the monitoring locations for these three rivers in 2011 and 2012 are fewer than in the previous years. There are 24 locations in 2012 and 2011. There are 28 locations in 2010, 2009, 2008, and 2007. The frequency in 2012 is also fewer than in the other years. In the year 2012, there were three times of monitoring activities. But previously from 2007 to 2011, there were four times in each year. We also found the inconsistency when the monthly monitoring took place.

The current form of the reports published by the Environmental Authority of Yogyakarta Province uses 119 pages for putting all the data of the three rivers. This dashboard simplify the reports to be a single interactive web-screen and full of data visualization which is easier to understand. Through these findings we can see that there is a lot to improve in the efforts to manage the rivers. We also can conclude that the effectiveness of the current efforts is not enough.

5. CONCLUSION

This dashboard of river water quality simplify significantly the reports of three rivers monitored in six years and automatically assess if the water quality is on-target or off-target in each year. This dashboard stores, combines, and visualizes river water quality data. At this point, the dashboard is able to relate data instantly. It is also able to visualize its value and distribution on dynamic bar charts and Google Map. This implication is useful to look at data in a more meaningful way so we can easily review the performance of the river management. The functions that facilitate an easier way to update the dashboard will make this application as a gateway rather than an endpoint so it will help the continuous improvement of the river management from years to years.

ACKNOWLEDGEMENT

We thank the Environmental Authority (*Badan Lingkungan Hidup*) of The Yogyakarta Province Government for providing publicly the river water quality data on its accessible website at <http://blh.jogjaprov.go.id/kualitas-air/>.

REFERENCES

- Badan Lingkungan Hidup Daerah Istimewa Yogyakarta. (n.d) *Kualitas Air* [Online] Available: <http://blh.jogjaprov.go.id/kualitas-air/> [Accessed: May. 29, 2013]
- Department of Water Western Australia Government. (n.d). *Statewide River Water Quality Assessment*, [Online] Available: <http://www.water.wa.gov.au/idelve/srwqa/> [Accessed: May 29, 2013]
- Eckerson, Wayne and Mark Hammond. (2011). *Visual Reporting and Analysis – Seeing is Knowing*. [Online]. Available: http://www.datavisualization.fr/files/tdwi_bpreport_q111_vra_web.pdf [Accessed: May. 29, 2013]
- Environment and Heritage Service Department of the Environment – Northern Ireland. (May 2001). *A River Water Quality Monitoring Strategy For Northern Ireland*. [Online]. Available: http://www.doeni.gov.uk/niea/river_monitoring.pdf [Accessed: May. 29, 2013]
- EPA of Ireland. (n.d). *Envision*. [Online] Available: <http://gis.epa.ie/Envision/> [Accessed: May 29, 2013]
- Few, Stephen. (2006). *Information Dashboard Design*, Sebastopol, CA: O'Reilly Media, 2006, [E-book]. Available: <http://shop.oreilly.com/product/9780596100162.do>
- Gubernur Daerah Istimewa Yogyakarta. (2008). *Peraturan Gubernur Daerah Istimewa Yogyakarta Nomor 20 Tahun 2008 Tentang Baku Mutu Air Di Provinsi Daerah Istimewa Yogyakarta* [Online], Available: <http://www.birohukum.jogjaprov.go.id/index.php/produk-hukum/provinsi-diy> [Accessed: May 29, 2013]
- Juice, Inc. (November 2009). *A guide to creating dashboards people love to use*. [Online]. Available: http://www.juiceanalytics.com/wp-content/uploads/2010/11/Guide_to_Dashboard_Design.pdf [Accessed: May 29, 2013]
- Natural Heritage Trust – Environment Australia. (March 2000). *A Framework for Public Environmental Reporting, An Australian Approach*. [Online]. Available: <http://www.enviroreporting.com/others/Australian%20PER%20Guidelines.pdf> [Accessed: May. 29, 2013]
- Presiden Republik Indonesia. (2001). *Peraturan Pemerintah Republik Indonesia Nomor 82*

Tahun 2001 Tentang Pengelolaan Kualitas Air Dan Pengendalian Pencemaran Air [Online], Available: <http://www.sjdih.depkeu.go.id/fulltext/2001/82TAHUN2001PPLamp.pdf> [Accessed: May 29, 2013]

The Ministry of The Environment Government of Japan. (June 2007). *Environmental Reporting Guidelines (Fiscal Year 2007 Version)*. [Online]. Available <http://www.env.go.jp/en/policy/economy/erg2007.pdf> [Accessed: May. 29, 2013]

Wijaya, Senoaji, Marco R. Spruit, and Wim J. Scheper. (2009). *Webstrategy Formulation: Benefiting from web 2.0 concepts to deliver business values,* in *Web 2.0, The Business Model*. Eds. Spinger, 2009, pp 103-132. [E-book]. Available: SpringerLink.

The logo for iafor (International Association for Business and Economics) is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is surrounded by two large, overlapping, semi-transparent circular arcs. The outer arc is light blue and the inner arc is light red, creating a stylized circular frame around the text.

iafor

The Effect of Accounting Information System Implementation on Accounting Information Quality and Its Impacts on Managerial Performance

Yaman Suryaman*¹, Sri Mulyani NS*², Sri Mulyani*²

*¹Garut University, Indonesia, *² Padjadjaran University, Indonesia

0372

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The local government financial management paradigm has been changed over few years in Indonesia. This is shown by the implementation of local financial information system which integrates each agency of local government. In turns, it is expected that local managerial can increase their performance through this mechanism.

This research aims to study and analyze the effect of accounting information system implementation on accounting information quality and its impact on managerial performance. This research applied descriptive verification method in 26 districts/cities in West Java Province that included head of local treasuries, mayor assistants of financial affairs and local inspectorates

The results showed that implementation of accounting information system implementation has significant effect on managerial performance through accounting information quality.

Keywords: accounting information system implementation, accounting information quality, managerial performance

A. Backgrounds

One manifestation of the efforts to make government accountable is being accountability in managing and reporting public resources. Reporting financial statements is a form of financial performance achievement. Submission of financial accountability reports is executed in time and reliable. Besides that, financial statements also need to be equipped with adequate disclosure of the information that may influence the decision. (Mahmudi, 2006).

Demands for accountability of public agencies at the central and regional levels is a phenomenon that occurs in the development of the public sector in Indonesia today. Accountability can be defined as a form of obligation to account for the success or failure of the mission of the organization in achieving goals and objectives periodically (Stanbury, 2003). In this regard the creation of public accountability should be implemented in the system and standards of government accounting to be able to create good governance. Good Governance is often defined as the responsibility of development and management in line with the principles of democracy and the market efficiency, avoiding misallocation of investment funds, the prevention of corruption both politically and administratively, and run budget discipline.

The local financial accounting information systems refers to Government Regulation 56 year 2005, Government Act 13 years 2006 and Government Act 59 year 2007. In this provision, local governments are required to submit Financial Information periodically to the Ministry of Finance, and specifically for the budget, budget changes, and budget realization report Semester I delivered in softcopy and hardcopy. The benefits of the application of the accounting information system based on government accounting standards are intended to enhance the accountability and reliability of the government's financial management through the formulation and development of government accounting standards.

Accounting Information Systems at the Local Government Information Systems concerning especially the local finance, it is necessary to support the creation of accountability and transparency in the local financial management. With the support of better financial accounting information system, the local government is expected to have a variety of competitive advantages. Regarding local financial information systems, it is necessary to support the creation of accountability and transparency in the local financial management.

The current reality of the accounting information quality in the local government, the usefulness of the audited financial statements potentially will not be used as a basis for decision making. There are several aspects that can lead local financial statements useless. In practice, few government officials who understand accounting. The users of audited financial statements are only a few officers who able to understand it. This, in turn, will affect not to use this information as a basis for decision-making. Do not use financial statements means the report does not contain any usefulness.

Managerial performance of local government may be reflected in the financial statements of local governments. Still poor local government financial statements based on examination of the National Audit Board (BPK) is evidence of the poor performance of managerial government. National Audit Board has conducted the examination of financial statements of the 499 local governments, the results of the investigation National Audit Board provides an opinion on the quality of the financial statements which is prepared by local governments.

Table 1
Opinion Progress of Local Government Financial Report Year 2005- 2010

Financial Statement	O P I N I O N								Total
	Unqualified	%	Qualified	%	Disclaimer	%	Adverse	%	
2005	18	5%	307	85%	13	3%	24	7%	362
2006	3	1%	327	70%	28	6%	105	23%	463
2007	4	1%	283	60%	59	13%	123	26%	469
2008	13	3%	323	67%	31	6%	118	24%	485
2009	15	3%	330	66%	48	10%	106	22%	504
2010	32	9%	271	76%	12	3%	43	12%	358

Sources: Audit Board of the Republic of Indonesia, 2011

The table above presents the development of local financial statements from 2005 up to 2010. From the table it can be seen that opinions of local financial statements of 2010 showed an increase in the number of administrative regions receiving unqualified opinions and a qualified opinion compared to previous years. Meanwhile, the number of local governments which get disclaimer opinions and adverse opinions showed a decline from 2006-2009 except for 2005 an increase in the number of adverse opinions.

It generally describes the improvement of the quality of financial statements presented by the government even though it has not been a significant improvement (in percentage), the condition is at least provide hope for the realization of good governance implementation in Indonesia.

Although the element of control over the local government has not been optimal. It can be seen from the settlement of follow-up on audit findings were not available so they found repeated findings (Audit Board, 2011). There are still quite a lot of red card for local financial statements based on Audit Board report. It shows the inability of local governments to account for the use of funds.

Some of the results of previous research that examines the implementation of accounting information systems for improving the quality of financial reporting. According to research by Xu et al., (2003) which states that the main factors affecting the quality of financial reporting is the people, systems, and the organization itself. This was confirmed by Fariziah Choirunisah (2008) to produce quality financial reporting information required qualified human resources. Other than that put forward by Aruwa (2005) that in the preparation of financial reporting should be tailored to the needs of the users, so that the financial statements are useful. Klai and Omri (2011) mentions the quality of the financial statements is affected also by management mechanisms.

The quality of financial statement information is determined by the process of producing those statements. The quality of accounting information is the output of the implementation

of the accounting information system, accounting information systems is essential for the quality of information (Xu et al, 2003). Similarly Solikin and Kustiawan (2002) states that the public will demand accountability requires transparency of local government officials in generating accounting information quality of accounting information is accurate, relevant, and timely.

Performance measurement is an important component because it will provide feedback on the plan that has been implemented (Chow, Ganulin, Haddad, and Williamson, 1998). Wood (1998) revealed that the functions of performance measurement can explain the (1) evaluation of how the program is run , (2) as a comparison of the services provided, (3) as a communication media with the public. In addition, the demands of local government performance measurement needs to be done because of the fact that it is still poor the performance of local government in Indonesia that can be seen by the statement of the Chairman of the Audit Board of Indonesia (BPK RI), Anwar Nasution (www.antaraneews.com, 2007), that still poor transparency and accountability of local government so that it affects the poor performance of local government. Based on the description it can be concluded that the local performance measurement is an important thing to do. This statement is consistent with Greiling (2005) which revealed that one of the key success of the reforms in the public sector is by measuring performance.

This study was designed to examine how the effect of implementation of accounting information systems on the quality of accounting information and its impact on managerial performance of local government. The choice of accounting information systems as an independent variable because, accounting information systems is paramount to determine how the quality of accounting information (Susanto, 2008). So that further research will be investigated how the close relationship the local financial accounting information system with accounting information quality of local government districts / cities in West Java province in improving managerial performance.

The benefits of the application of the accounting information system based on government accounting standards are intended to enhance the accountability and reliability of the government's financial management through the formulation and development of government accounting standards. Therefore, the investigators analyzed the application of local financial accounting information system that affect managerial performance through quality information as an intervening variable.

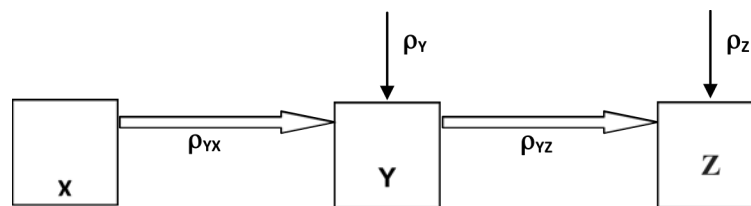
B. Research Methods

This study is located in the Province of West Java. The research is a descriptive research. In this case the description of the accounting information system, the quality of accounting information and managerial performance of the local governments in the district and city in the province of West Java. Verificative Research basically aims to test the truth of a hypothesis which is carried out through data collection in the field. In this research will be tested how much influence the accounting information systems, the quality of accounting information for managerial performance of the local governments.

The type of relationship among the variables are studied in this research in the form of a causal relationship. According Sugiyono (2007) the causal relationship is, if X then Y. Because this study examined variables on the independent variables (independent variable) and two variable (dependent variable) then in this study measured the effect of the implementation of accounting information systems on quality of accounting information and the quality of accounting information on managerial performance.

Target population in this study in 26 districts / cities in West Java. Respondents in this study is the Head of the finance, local secretary and inspectorate. The procedure of data collection in this research using questionnaire. While the data analysis technique used is path analysis. Therefore, the relationship between variables is described as follows:

Figure 1.
Research Model



- X = Independent Variable (Accounting Information System)
- Y = Dependent Variable (Accounting Information Quality)
- Z = Dependent Variable (Managerial Performance)
- ϵ = epsilon
- ρ_{yx} = coefficient of the effect of X variable to Y variable
- ρ_{zy} = coefficient of the effect of Y variable to Z variable
- $\rho_{z\epsilon}$ = coefficient of the effect of (ϵ) other variables to Z variable
- ► = Casuality relationship

C. Results and Discussion

The results in variable accounting information systems, the quality of accounting information and financial performance can be described as follows:

Table 2
Local Accounting Information System (X)

No	Indicator	Mean Score	Criteria
1	Input Facilities	3,00	Fair
2	Central Processing Facilities	3,23	Fair
3	Output Facilities	3,31	Fair
Hardware Dimension		3,18	Fair
1	Multi task and multi user on application	3,35	Fair
2	Quality application software	3,35	Fair
3	Easiness in operating	3,46	Easy
4	Integrated in operating	3,15	Fair
5	Security Level	3,23	Fair
6	Operating Manual	3,31	Fair
Software Dimension		3,31	Fair
1	Involvement	3,08	Fair
2	Ability in using input data facilities	3,27	Fair
3	Ability in using alat processing data	3,31	Fair
4	Skills in operating software	3,04	Fair
Operator Quality Dimension		3,17	Fair
1	Documenting Budget Subsystem	3,19	Fair
2	Documenting Treasury Subsystem	3,46	Good
3	Documenting Verification Subsystem	3,19	Fair
Procedure of Documenting Dimension		3,28	Fair
1	Data recovery	3,31	Fair
2	Integrated	3,15	Fair
3	Data security system	3,19	Fair
4	Multi user	3,35	Fair
5	Data Authorisation System	3,19	Fair
6	Data Processing System	3,23	Fair
Database Dimension		3,24	Fair
1	Server availability	2,85	Fair
2	Work station	3,04	Fair
3	Network card	3,00	Fair
4	Switching hub	2,92	Fair
5	Communication Network	3,15	Fair
Communication Network Dimension		2,99	Fair
Grand Mean		3,20	Fair

In Table 2, it can be seen that the calculation of the grand mean score of the responses regarding the accounting information systems are at intervals of 3.20 from 2.6 to 3.4. It can be concluded that the accounting information system in most districts / cities in West Java is fairly good. Similarly, when viewed by the dimensions, it appears that the average score of the responses to the six dimensions included in the fair category.

Table 3
Accounting Information Quality (Y)

No	Indicator	Mean Skor	Criteria
1	The financial statements are presented is easy to be understood	3,38	Fair
2	The government's performance in the financial statements accountability is easier to be understood	3,35	Fair
Understandable Dimension		3,37	Fair
1	The information generated in the financial statements used as a tool of evaluation and correction of the past activities	3,19	Fair
2	The information generated in the financial statements used as a tool of evaluation and correction of the activities	3,27	Fair
3	Submission of financial statements is timeline	3,00	Fair
4	Disclosure of accounting information in financial statements can influence decision making	3,15	Fair
Relevant Dimension		3,15	Fair
1	Do all adjustment records of its expenditure / spending	2,85	Poor
2	The results of an audit conducted by the inspectorate did not differ with the results of an audit conducted by the National Audit Board	3,42	Good
3	Presentation of any information in the financial statements intended for public needs	3,50	Good
Reliability Dimension		3,26	Fair
1	The financial statements present and classify items in the financial reports	3,54	Good
2	The accountability report indicates a tendency of financial budget realization financial and financial performance position	3,46	Good
Accountability Dimension		3,50	Good
Grand Mean		3,28	Fair

In Table 3 it can be seen that the calculation of the grand mean score of the responses regarding the quality of financial reporting in the interval of 3.28 is 2.6 to 3.4. It can be concluded that the quality of accounting information in most districts / cities in West Java is fairly good. Similarly, when viewed by the dimensions, it appears that the average score of the responses to the three dimensions included in the category of pretty, but the average score of the responses can be compared to the dimensions included in either category.

Table 4
Managerial Performance

No	Indicator	Mean Skor	Criteria
1	Planning	2,96	Fair
2	Investigating	3,31	Fair
3	Coordinating	3,35	Fair
4	Evaluating	3,31	Fair
5	Supervising	3,50	Good
6	Staffing	3,46	Good
7	Negotiating	3,42	Good
8	Representing	3,38	Fair
Grand Mean		3,34	Fair

Based on the distribution of district / city for each item in the dimension statement contained in Table 4 it can be seen that most of the leadership in the planning are rarely set goals, policy action plans, work scheduling, budgeting, designing and programming procedures. However, in most investigations of leaders often collect and transmit information to record, report and accounts, measure results, conduct research and analysis work. Later in the coordination of the many leaders frequently exchanging information within an organization to coordinate and customize the program. Similarly, in the evaluation, most leaders are evaluating and assessing the work plans, reports and job performance were observed in the unit / sub-unit, assessing financial statements, employee assessment and inspection activities.

Furthermore, in control, most of the leaders are often direct, lead, train and develop, explain the rules of employment, providing work tasks, and handle complaints from subordinates that existed at unit / sub-unit as well as rotation or moving staff, promote employees on the unit / sub-units within the setting staff. Besides, the leaders also often perform procurement, purchasing and contracts for goods / services required on a unit / sub-unit with outsiders as well as representing the organization to attend meetings related to external parties, official invitations, speeches to civic events, promote the general purpose office / agencies.

In accordance with the hypothesis of the proposed research, the data will be further tested using path analysis (path analysis). The analysis examines causal pathways that are structurally independent of the variable on the dependent variable by considering the relationship between the independent variables. The results of computational pathway analysis using statistical software LISREL 8.70

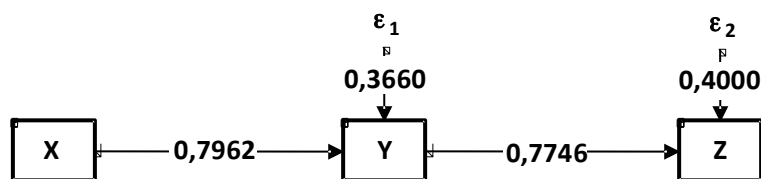
Based on the path coefficients obtained from the processed accounting information systems and the quality of accounting information on managerial performance as follows.

Table 5
Path Coefficient Independent Variables on the Quality of Accounting Information and on Managerial Performance

Sub-Structure	Jalur	Coefisien	T _{count}	R ²
First	X → Y	0,7962	6,4477	0,6340
Second	Y → Z	0,7746	6,0005	0,6000

Then the results of further studies on the effects between variables can be described as follows.

Figure 1
Diagram of Path Analysis



Based on the path coefficients obtained by processing accounting information system implementation on the quality of accounting information is 0.7962. It means that quality of accounting information is influenced by the implementation of accounting information systems. The other effects that are not observed at 0.3660. Then the quality of accounting information has an effect on managerial performance at 0.7746. It means that managerial performance is influenced by the quality of accounting information. For other influences that affect managerial performance is not examined at 0.4000.

D. Conclusions and Recommendations

1. Conclusion

From the results of this study concluded the following:

1. Implementation of Accounting Information Systems positively influence the Quality of Accounting Information
2. Accounting Information Quality has a positive effect on Managerial Performance

2. suggestion

Based on the findings and conclusions, suggestions can be expressed as follows:

1. That the quality of accounting information is influenced by the implementation of local accounting information systems and resulted in increased managerial performance. For those local governments to design and utilize appropriate accounting information system that can generate reports for quality accounting information so that indirectly the local government managerial performance can be improved.
 2. Although this study showed good results, but the desire to achieve a better condition of course is the ideal of every local government, for local government is expected to implement better accounting information system.
 3. For researchers, it is advisable to explore other factors such as user satisfaction, the size of the organization, training and education of the implementation of accounting information systems. This is confirmed by the results of studies in which there are 33.63%. Other variables that affect managerial performance in this study.
3. *Limitation*
- a) The analyzed data in this study is limited to data collected from 26 districts / cities in West Java so it takes quite a long time in the data collection it is caused by the bureaucracy is quite difficult and requires a long time in terms of the permit.
 - b) Financial Accounting Information Systems is the same government that used the resulting pattern of relations among local governments is the same so it does not look obvious fundamental differences relating to Financial Accounting Information Systems in each region
 - c) The results depend on the honesty of the respondents to answer the questionnaire and to minimize the dishonesty of the investigators to directly assist when filling out the questionnaire and conducted interviews.

Reference

- Afiah, NN, 2009. *Akuntansi pemerintahan, Implementasi Akuntansi Keuangan Pemerintah Daerah*. Kencana. Jakarta
- Akbar, Bahrullah, 2010. *Pusat Kajian dan Informasi Keuangan Daerah*
- Alkabi, 2004, *The role of Accounting Information System in Improving Managerial Performance in Commercial Banks in The UAE*. Al Yamouk University, Jordan
- Alqatan, 2002. *The Effect of Using Accounting Information on the Managerial Performance in Industrial Shareholding Companies in Jordan*. Al Albeit University, Jordan
- Anthony, Robert N.; Welsch, Glenn A.; Reece, James S 1985. *Fundamentals of Management Accounting Fourth Edition*, R D Irwin Illinois USA.
- Arikunto, S 1998. *Prosedur Penelitian Suatu Pendekatan Praktek PT*. Rineka Cipta Jakarta.
- Aruwa, Sulaiman A.S, 2005. *The Quality of The Information Content of Published Government Financial Statement*. Department of Economics and Management Science, Nigerian Defence Academic, Kaduna
- Bastian, I, 2006a. *Akuntansi Sektor Publik, Suatu Pengantar*, Erlangga Jakarta
- 2006b. *Sistem Perencanaan dan penganggaran Pemerintah Daerah di Indonesia*, Penerbit Salemba Jakarta.
- Bodnar, George H., Hopwood, William S, 2003. *Sistem Informasi Akuntansi, Buku 2*. Joseph W. Wilkinson, Michael J. Cerullo, *Accounting Information System, Essential Concepts and Applications*, Third Edition, John Wiley & Sons Inc. U S A.
- Choirunisah Fariziah, 2008. "Faktor-faktor yang Mempengaruhi Kualitas Informasi Laporan Keuangan yang Dihasilkan Sistem Akuntansi Intansi
- Chow CW, Ganulin D, Teknika O, Haddad K, Williamson J, 1998. *The Balanced Scorecard: A Potent Tool For Energizing And Focusing Healthcare Organization Management*. Journal of Heathcare Management/ american college of healtcare executives
- Davey, K.J, 1988. *Pembiayaan Pemerintah Daerah: Praktek-praktek Internasional dan Relevansinya bagi Dunia Ketiga*, UI – Press, Jakarta.
- Davis. GR and MH Olson. 1985. *Management Information Systems: Conceptual Foundations, Structure, and Development, 2nd Edition*, New York: McGraw-Hill
- Devas, Nick. & Maris, Masri. 1989. *Keuangan Pemerintah Daerah di Indonesia*, Penerbit UI Press, Indonesia.
- Halim, A, 2007. *Akuntansi Sektor Publik Akuntansi Keuangan Daerah*. Edisi Tiga. Salemba Empat, Jakarta

- Hendriyadi, Sigit, 2011. *Perbandingan Indikator Kinerja Keuangan Pemerintah Kabupaten/Kota Di Jawa Tengah Antara Tahun 2008 – 2009*, Fakultas Ekonomi Universitas Diponegoro
- Heny Susantih dan Yulia Saftiana, 2011. *Perbandingan Indikator Kinerja Keuangan Pemerintah Propinsi Se-Sumatera Bagian Selatan*, Jurnal SNA
- Ismail Mohamad, Sjahruddin Rasul dan Haryono Umar. 2004. *Konsep dan Pengukuran Akuntabilitas*, Jakarta: Penerbit Universitas Trisakti
- Jones, R. dan M. pendlebury, 2000. *Public Sector Accounting, Fifth edition* Pitman publishing .London.
- Jogiyanto, Hartono, 2007. *Analisis & Desain Sistem Informasi: Pendekatan Terstruktur Teori dan Praktek Aplikasi Bisnis*. PT. Andi. Yogyakarta
- Keban, Yeremias T. 2004. *Enam Dimensi Strategis Administrasi Publik, Konsep, Teori dan Isu*. Penerbita gava Media
- Klai Nesrine, omri Abdelwahed, 2011. “*Corporate Governance and Financial Reporting Quality: The Case of Tunisian Firms*”.
- Konthong K. And P. Ussahawaitchakit, 2009, *Management Accounting Information System Effectiveness and Business Value Creation: An Empirical Study of Thai Listed Firms. Review of Business Research*
- Kren, L. 1997. *The Role Of Accounting Information In Organizational Control: The State Of the Art. In V. Arnold, & S. G. Sutton (Eds.), Behavioral Accounting Research, Foundations And Frontiers*. American Accounting Association: USA.
- Kuncoro, M, 2003. *Metode Riset untuk Bisnis dan Ekonomi*, Erlangga Jakarta.
- Lillrank, P. New Research The Quality of Information. 2003. *International Journal of Quality and Reliability Management*. Volume 20. Number 6.
- Mamesah.D.J. 1995, *Sistem Administrasi Keuangan Daerah*. PT.Gramedia Pustaka Utama, Jakarta.
- Mardiasmo 2002. *Otonomi dan Manajemen Keuangan Daerah*, CV. Andi offset, Yogyakarta
- Mardiasmo. 2004. *Otonomi dan Manajemen Keuangan Daerah*. Penerbit Andi. Yogyakarta.
- , 2004. *Akuntansi Sektor Publik, Edisi Pertama*. Penerbit Andi Yogyakarta.
- Mahmudi. 2007. *Manajemen Kinerja Sektor Publik*. Edisi Kedua, UPP STIM YKPN Yogyakarta
- , 2007. *Analisis Laporan Keuangan Pemerintah Daerah*. UPP STIM YKPN Yogyakarta
- Nordiawan D 2006. *Akuntansi Sektor Publik*, Salemba Empat, Jakarta
- Nugroho, AB. 2005. *Strategi Jitu Memilih Metode Statistika Dengan SPSS*, Andi Offset Yogyakarta.

Raymond, *McLeod.Jr1995.Sistem Informasi Manajemen Jilid I, Edisi Bahasa. Indonesia, Jakarta :SalembaEmpat.*

Republik Indonesia, Undang-Undang RI No.22 tahun 1999.Tentang Pemerintah Daerah.

-----, Undang-Undang RI. No 25 tahun 1999, tentang Perimbangan Keuangan antara Pusatdan Daerah.

-----,Undang-Undang RI. No 17tahun2003, tentang Keuangan Negara.

-----,Undang-Undang RI No.32 tahun 2004. Tentang Pemerintah Daerah

-----,Undang-Undang RI. No 33 tahun 2004, tentang Perimbangan Keuangan antara Pusatdan Daerah.

-----,Undang-Undang RI. No 15 tahun2004, tentang Pemeriksaan Keuangan Negara.

-----,Peraturan Pemerintah. No 105tahun2000, tentang Pengelolaan dan Pertanggungjawaban Keuangan Daerah.

-----,Peraturan Pemerintah. No 58tahun2005, tentang Pengelolaan Keuangan Daerah.

-----,Peraturan Pemerintah. No 24tahun2005, tentang Karakteristik Kualitatif Laporan Keuangan.

-----,Peraturan Pemerintah. No 8tahun2006, tentang Laporan Keuangan dan Kinerja Organisasi.

-----,Peraturan Pemerintah. No 65tahun2010, tentang Sistem Informasi Keuangan Daerah

-----,Government Act. No 13tahun2006, tentang Pedoman Pengelolaan Keuangan Daerah

-----,Government Act. No 59tahun2007, tentang Perubahan atas Government Act No. 13 tahun 2006

Reksoprayitno, Soediyono, 1992. *Analisa Makro :Pengantar Analisis Pendapatan Nasional*, Edisi Kelima, Penerbit Liberty, Yogyakarta.

Romney and Steinbart, 2007. *Accounting Information Systems 10th Edition*, Pearson Education 2007.

Sekaran, Uma, 2010. *Research Methods fo Business; A Skill Building Approach.5th Edition*. John Wiley & Sons Inc. New York

Sugiyono,2007. *Metode Penelitian Bisnis*. Alfabeth, Bandung.

Sajady, M. Dastgir, Nejad Hashem, 2008. *Evaluation of The Effectiveness of Accounting Information Systems*, International Journal of Information Science and Technology.

Thansi, 2004. *Hubungan Kualitas Informasi Akuntansi Keuangan Syariah Dengan Kinerja Keuangan Baitulmal Wattamwil (Bmt)Di Kota Bandung*, tesis pada Universitas Padjadjaran Bandung

- Simpson, John and Weiner, Edmund, 1989. *The Oxford English Dictionary* Second Edition, Oxford University Press
- Susanto, Azhar, 2008, *Sistem Informasi Akuntansi, Struktur-Pengendalian-Resiko-Pengembangan*. Lingga Jaya, Bandung
- Sri Mulyani NS. 2008. *Analisis dan Perancangan Sistem Informasi Manajemen Keuangan Daerah*. Penerbit Abdi Sistematika. Bandung
- Standbury, M, Reilley, MJ & Rosenmen Kd 2003. Work-Related Amputation Michigan, 1997. *American Journal of Industrial Medicine*, 44(4), 359-367.
- Sutarbi, Tata, 2005. *Sistem Informasi Manajemen*. Yogyakarta PT. Graha Ilmu
- Susantih, Heny dan Saftiana, Yulia., 2011, *Perbandingan Indikator Kinerja Keuangan Pemerintah Propinsi Se-Sumatera Bagian Selatan*, Jurnal SNA
- Syamsi, Ibnu, 1986. *Pokok-Pokok Kebijakan, Perencanaan, Pemrograman, dan Penganggaran Pembangunan Tingkat Nasional*, Penerbit Rajawali, Jakarta.
- Urquía et, al, 2011, *The impact of Accounting Information Systems (AIS) on performance measures: empirical evidence in Spanish SMEs* The International Journal of Digital Accounting Research Vol. 11, pp. 25 - 43
- Weygant and Kieso, 2007, *Accounting Principles*, Eight Edition John Wiley & Son, Inc, New York
- Wilkinson, J. W., Cerullo, M. J., Raval, V. and Wong-On-Wing, B. 2000. *Accounting Information Systems: Essential Concepts and Applications*, John Wiley and Sons, New York
- Coy et all, 2002; "Public Accounting: A new Paradigm for collage and university annual Report; Critical perspectives on accounting, Vol.12, PP, 1-31.
- Hooks et all (2002); The information gap In annual report accounting, auditing and accountability journal, Vol 15 no.4, PP.93-109.
- Laudon and Laudon 2002. *Management Information Systems*. Prentice hall.
- Xu Hongjiang, Nord Jereta Horn, Nord G Daryl, Lin Binshan, 2003, "Key Issues of Accounting Information Quality Management: Australian Case Studies
- Zimmerman, 1997. *Economic value added and divisional performance measurement: capturing synergies and other issues*, Journal applied corporate finance. Po; 98-109.
- Sofyan Syafri Harahap. 2007. *Teori Akuntansi*. Jakarta: PT Raja Grafindo Persada.
- Ikhtisar Hasil Pemeriksaan BPK Semester II Tahun 2010. Melalui <http://www.bpk.go.id> [13/03/2011]
- Peta Kapasitas Fiskal Kabupaten/Kota/ Tahun 2010. Melalui <http://www.sjdih.depkeu.go.id> [13/10/2011]

*Bioenergy Potential Assessment of Wastewater Sludge and Forestry Waste in Taiwan:
Financial Analysis and Life Cycle Assessment*

Y. D. Huang^{*1}, H. H. Huang^{*1}, C. P. Chu^{*1}, Y. J. Chung^{*1} and K. T. Wu^{*2}

^{*1}Sinotech Engineering Consultants, Taiwan, ^{*2}National Chung-Hsing University,
Taiwan

0389

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Final disposal of enormous wastewater sludge in Taiwan becomes an environmental issue since most landfill sites will be closed in the next decade. The low heat value and high ash content of sludge restrict its energy application using thermochemical processes. Co-firing of sludge with the abundant forestry wastes like wood chips in Taiwan seems a feasible alternative. The heat value of mixture can be elevated accordingly. The existence of woody materials mitigates the typical operation problems like sand sintering and clogging in commercial fluidized reactors due to the sludge ashes.

This study conducts the financial analysis and life cycle assessment of the co-firing process, pyrolysis and gasification, based on the running data in a commercial cogeneration power plant in Taichung (central Taiwan), along with the pilot-scale tests of pyrolysis (at 500°C) and gasification (at 800°C). In the scenario, the sludge and wood chips are conveyed from one wastewater treatment plant in Taichung and an experimental forest in Nantou, respectively, to the cogeneration power plant. The results show that among the three processes, the conventional co-firing in the cogeneration power plant is the most economically feasible, though the environmental impacts are highest, mainly from the aspects of greenhouse effects and acid rain. The pyrolysis costs less than the gasification, and the derived environmental impacts are also fewer than gasification.

Keyword: Biomass; sugi; sludge; pelleting; gasification; pyrolysis; SimaPro; environmental impacts; ash in the sludge

1. Introduction

Converting biomass to bioenergy can decrease the dependence on fossil fuels. Also the bioenergy is nearly “carbon neutral” and emit less greenhouse gas (GHG) into the atmosphere. Vascular plants can build up carbohydrate from carbon dioxide and water in the presence of sunlight and in the process absorbing energy through the photosynthesis—carbon fixation (Figure 1). The relevant technologies are categorized into: (1) physical processes; (2) thermo-chemical processes; and (3) biological processes. Thermochemical ways are more mature than biochemical ways. The most widely applied procedure is the direct combustion of biomass, or co-firing with coals, a thermochemical converting technology. Moreover, both gasification and pyrolysis are considered as potential opportunities for recovering valuable material and energy from waste. Gasification can convert biomass into syngas, where pyrolysis converts them into liquid biofuel. The advantages of gasification and pyrolysis for greater flexibility in terms of energy production and material recycling remain evident, though the pretreating requirement may be more stringent [1-3]. Dewatering and drying are the most essential pretreatment to reduce the moisture content. Usually crushing, milling and pelleting are necessary to save the energy consumption of logistics.

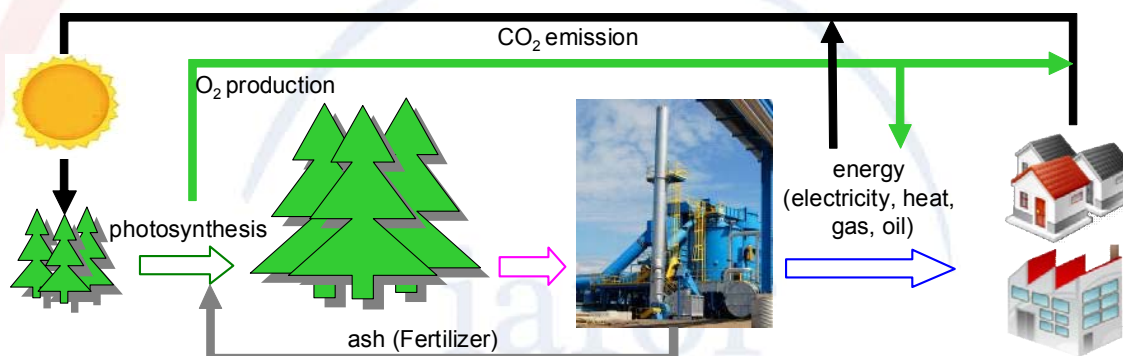


Figure 1 Carbon neutral characteristics of biofuels from vascular plants

On the other hands, final disposal of enormous wastewater sludge in Taiwan becomes an environmental issue. Since most landfill sites will be closed in the next decade, the dewatered sludge may soon face the dilemma that there is nowhere to go. According to our estimation, sludge for disposal will increase up to 2,000 tons per day after year 2030 in Taiwan while the total sewage is 6 million cubic meters per day (Figure 2).

Using sewage sludge as a biofuel could be feasible using the currently commenced incinerators. Other alternatives, like pyrolysis and gasification, are also possible, though the technology is not mature (Figure 3). However, due to the low connection of domestic sewage of households in Taiwan, the organics in the influent of wastewater treatment plants are generally insufficient. It leads to the low heat value in the sludge, as well as the high ash content in sludge (Table 1). It also restricts the energy application using thermochemical processes of sludge. In Taiwan, most applied resource utilization of sludge is for the raw materials of “construction materials”, though the organics in the sludge also raise some other problems in application. Figure 4 depicts a typical decision-making protocol in Taiwan for sludge resource utilization.

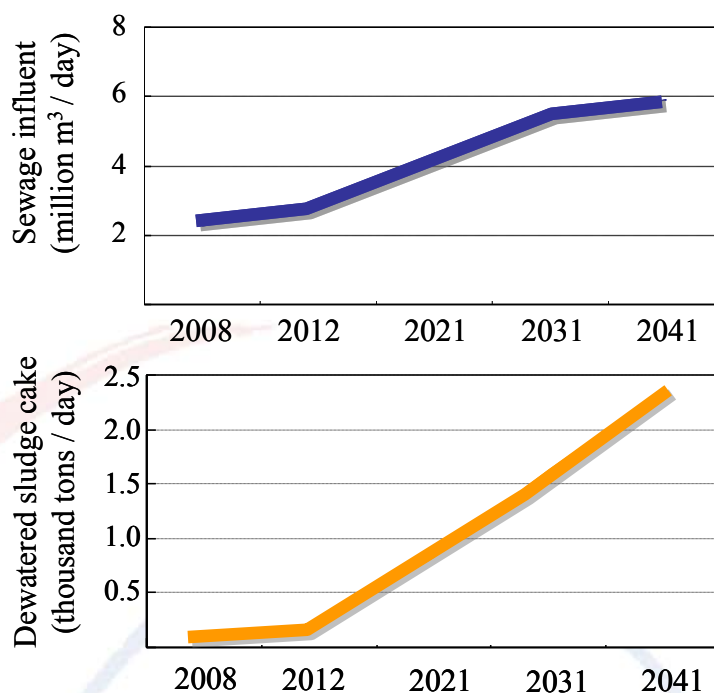


Figure 2 The estimated growth of sewage and sludge in Taiwan

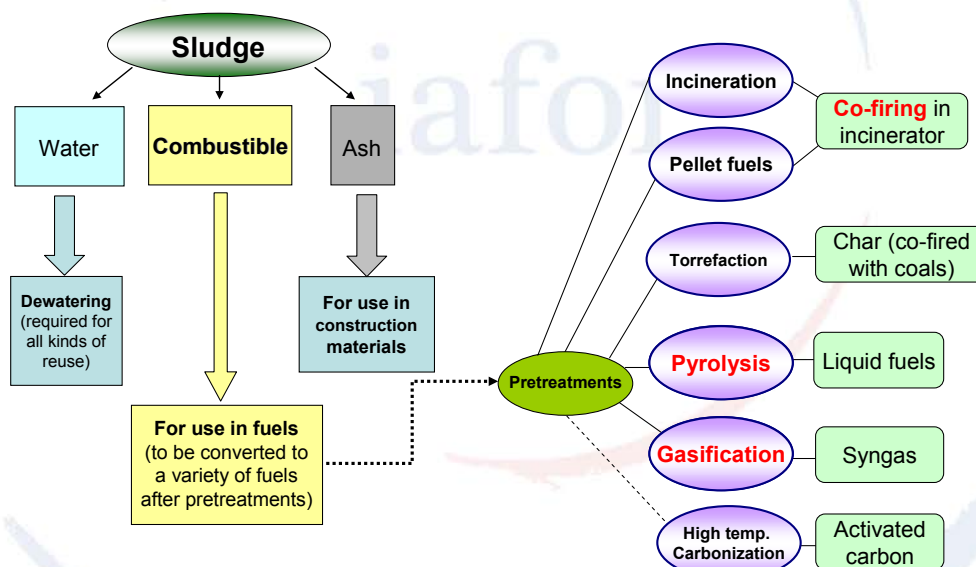


Figure 3 The possible energy application of sludge

Table 1 Thermal properties and composition of sludge in Taiwan

Items	Typical measured values in Taiwan	
Composition of sludge after drying	Moisture: 4.7~8.5 % Combustibles: 41.6~60.0 % Ash: 31.5~53.7%	
Low-level heating value	1,600~3,700 kcal / kg	
Elemental composition	C: 27.5 %	H: 4.4 %
	N: 3.45 %	S: 0.6 %
	Na: 417 mg / kg	K: 2,421 mg / kg
	Ca: 3,418 mg / kg	Mg: 1,075 mg / kg
	Si: 442 mg / kg	P: 11,148 mg / kg
	Fe: 10,926 mg / kg	Mn: 2,399 mg / kg
	Cu: 527 mg / kg	Al: 16,068 mg / kg

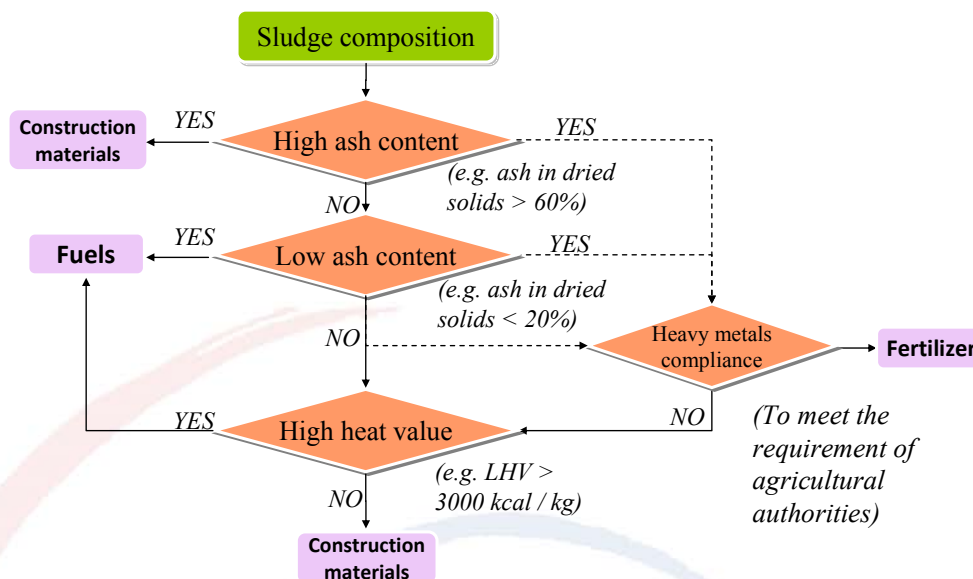


Figure 4 The decision making protocol of sludge resource utilization

2. Scenario Description: Co-treatment of sludge and forestry waste

To solve the aforementioned restriction of sludge treatment, a feasible alternative is to treat the sludge with the abundant forestry wastes like wood chips in Taiwan. The heat value of mixture can be elevated accordingly. The existence of woody materials mitigates the typical operation problems like sand sintering and clogging in commercial fluidized reactors due to the sludge ashes. The scenario for the subsequent evaluation is that the sludge and wood chips (forestry waste) are conveyed from one wastewater treatment plant in Taichung and an experimental forest in Nantou, respectively (Figure 5). Taichung is the largest city in central Taiwan, while Nantou is a famous forestry county. The sludge and forestry waste are then conveyed to the cogeneration power plant in Taichung harbor (powering capacity 5,824 MW). Based on this concept, not only the forestry waste, but also other agricultural waste, including the biomass from the constructed wetlands, may be co-treated with the sewage sludge (Figure 6).

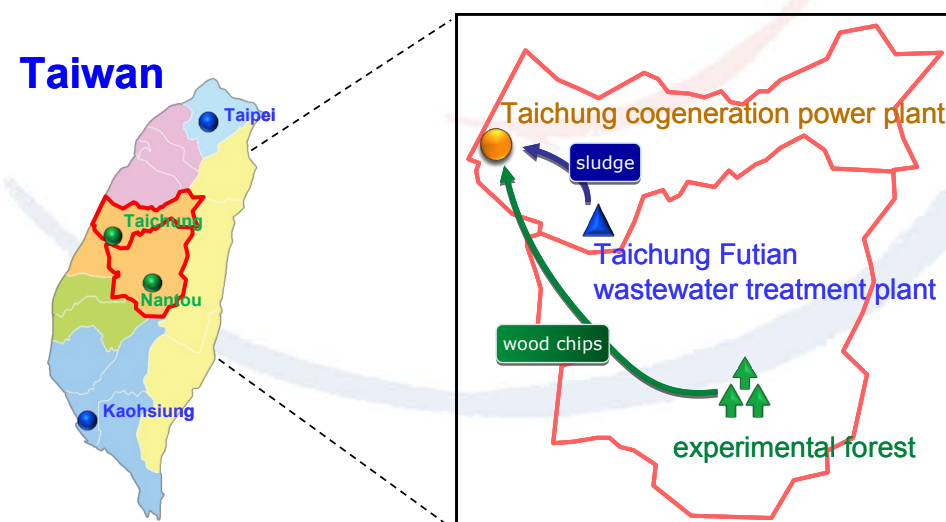


Figure 5 The scenario for subsequent description

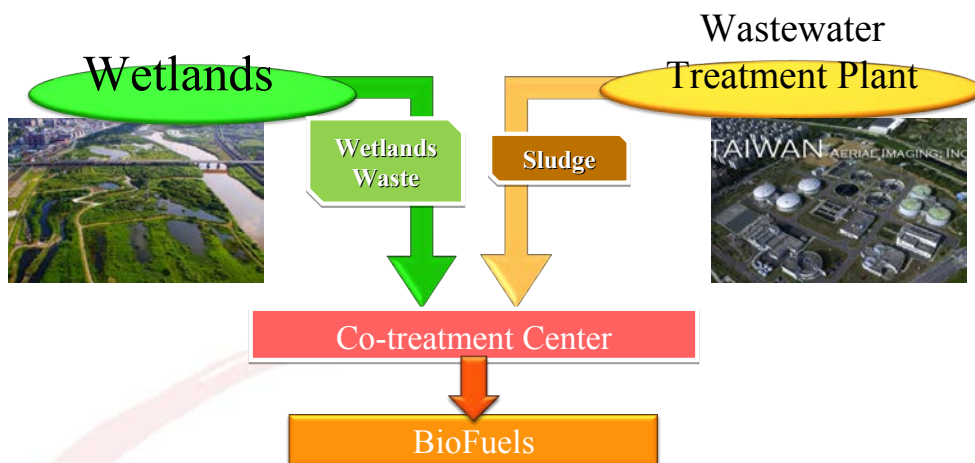


Figure 6 A future prospect: Co-treatment of wetland biomass and sewage sludge

To evaluate the feasibility, we have conducted a survey on the pelleting, pyrolysis and gasification of woody materials as well as its mixture with the sludge cake from municipal wastewater treatment plant. This study conducts the financial analysis and life cycle assessment of the co-firing process, pyrolysis and gasification, based on the running data in a commercial cogeneration power plant in Taichung (central Taiwan), along with the pilot-scale tests of pyrolysis (at 500°C) and gasification (at 800°C). All the tests are performed in pilot scale. The performance was evaluated, and the corresponding environmental impacts were also assessed using SimaPro 7.1 to compare with using coals, especially on the aspects of ecosystem damage and human health risk.

For the financial assessment, the cost and environmental impacts from the major stages of this process are considered, including dewatering, pelleting, logistics, furnace operation, derived pollution control (wastewater and flue gas) and product application. To evaluate the possible impacts of using bioenergy in relative to using fossil fuels, life cycle analysis (LCA) is a method to summarize the environmental aspects and potential effects throughout a product's life cycle starting from raw material acquisition, manufacture, use, recycling and disposal. It is helpful in measuring the ecological aspects of products composed of different raw materials though used for the same purposes. When selecting environmentally friendly fuels, raw materials, products, and production processes, the results of a comparative LCA study provide reference value for decision makers [4,5]. SimaPro 7.1 was widely used in this field for evaluating environmental impacts and damage of inventory elements. It provides seventeen methods for evaluation on various aspects, especially the greenhouse effects, eutrophication, acid rains, and so on.

3. Experimental

3.1 Biomass materials

Sugi (*Cryptomeria Japonica*) and sewage sludge cake taken from Futian Wastewater Treatment Plant in Taichung, Taiwan are tested in this study. Sugi was taken from the experimental forest of National Taiwan University at Nantou, Taiwan. The materials was first crushed and milled into size less than 1 mm for subsequent tests. The sludge cake was originated from the primary and secondary sludge in Futian Wastewater Treatment Plant. The sludge was thickened, anaerobically digested, dewatered and air dried to reduce the moisture content less than 40% (w/w).

3.2 Biomass pelleting

In this study, the ring-die extrusion molding machine (also known as “ring-die molding”) was applied to pelletize the sugi and sludge to form pellets. The appearance of this machine (Yong-Ming YMHP-15) is illustrated in Figures 7. The maximum pelleting capacity is 20 kg per hour with the rotating speed 350 rpm. It provides two different mold sizes (6 mm and 8mm), where we selected 6-mm mold in this test. To soft the lignin, the system may heat up the raw materials, and the maximum temperature is controlled using the water cooling. The dried sewage sludge was blended with smashed sugi for pelleting the “mixed pellets” (Figure 8). After repeated tests, the optimal temperature for pelletizing is around 80 ~ 90°C. The key factor to perform good pellets is to keep a homogeneous “roller press layer” in the mold, so that it prevent cracks appearing on the pellet surface. The pellets of sugi, sludge and the mixture are shown in Figures 9.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is enclosed within a circular graphic composed of two overlapping, thick, curved lines. The upper-left portion of the circle is a light red color, while the lower-right portion is a light blue color, creating a sense of rotation or a stylized 'i' and 'a'.



Figure 7 The appearance of ring-die molding machine (Yong-Ming YMHP-15)



Figure 8 The blending of sludge and woody chips (sugi)

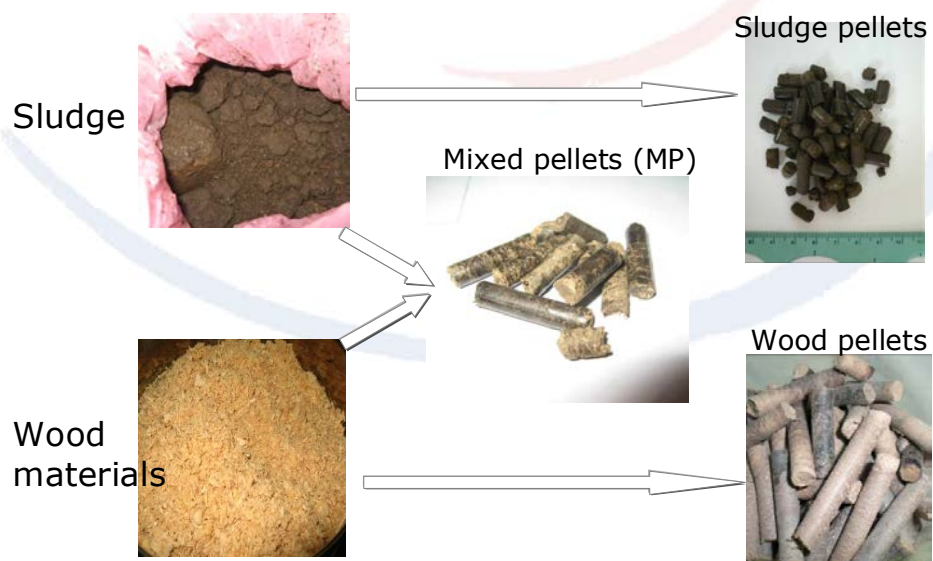


Figure 9 The appearances of sugi, sludge and their pellets

3.3 Pilot-scale pyrolyzer

The pilot-scale pyrolyzer and gasifier were used to conduct the pyrolysis and gasification in this study. The bubbling fluidized bed pyrolyzer included the purge gas system, heating facility, carbon removal, cyclone, and water-cooling system (Figure 10). For the convenience of disassembling, all related pipelines were connected by flange, and the pilot plant was fixed on a steel frame. Pyrolysis testing of the sugi, sludge, and their mixed pellets (the ratio of sugi to sludge is 50:50) was conducted in a pilot-scale pyrolyzer with the maximum feedstock rate of 5 kg/hr. Based on the calculation, the minimum fluidized velocity (U_{mf}) of sand bed is 19 cm/s. During the test, the velocity of the purge gas varied from $2U_{mf}$ to $4U_{mf}$ to observe the effects on the conversion rate (produced oil/feedstock $\times 100\%$). It is noticed that setting purge gas velocity at $2U_{mf}$ could reach a maximum conversion.

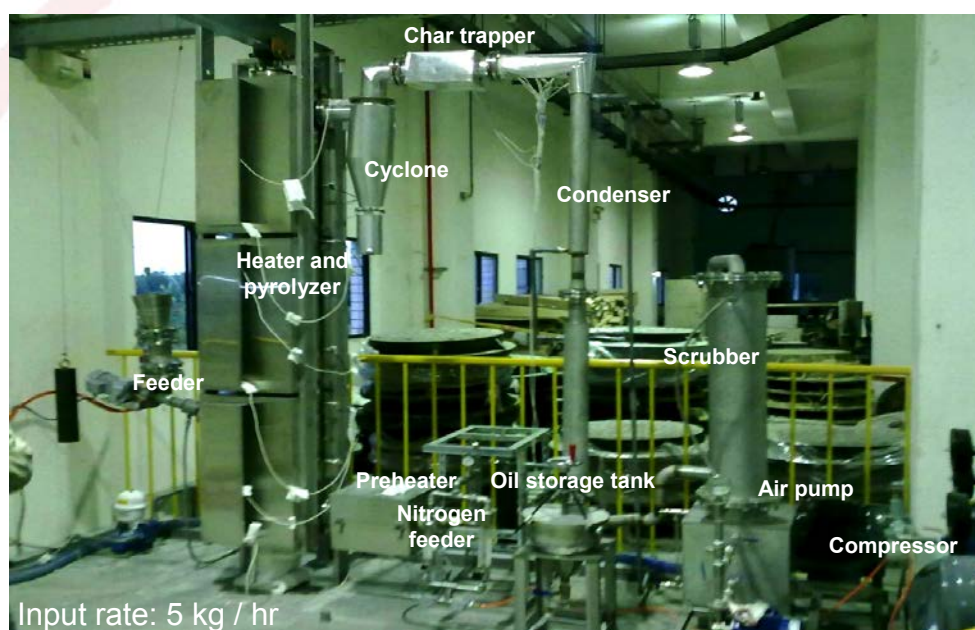


Figure 10 Pilot-scale pyrolyzer

3.4 Pilot-scale gasifier

Gasification testing of the sugi, sludge and their mixed pellets was conducted in a pilot-scale gasifier with the maximum feedstock rate of 5 kg/hr (30 kWth), diameter of 7.6 cm, and height of 1.9 m. The main components include feeder, gasifier, tar sampling, cyclone and scrubber (Figure 11). The testing variables included the gasification temperature (700 and 800°C), the air equivalence ratio (ER, 0.2, 0.3 and 0.4), and the steam injection. The feedstock rate depended on the ER values.



Figure 11 Pilot-scale gasifier

3.5 Environmental impact assessment

The LCA software SimaPro 7.1 applying Eco-indicator 95 as evaluating method was used to evaluate the environmental impacts and damage of inventory elements. The Registration Code of SimaPro 7.1 used in this study is K8PB PX8M 2L5N WY73. The Eco-indicator 95 method has been published in 1994 by a team of experts mainly from the Dutch PRé consultant and implemented over decade and based on European activities in 1990. It is a weighting method for the assessment of environmental impact that damages ecosystems or human health on a European scale and can fulfill the requirements of product design for environment. The structure of the Eco-indicator weighting method is schematically represented in Figure 12 [6].

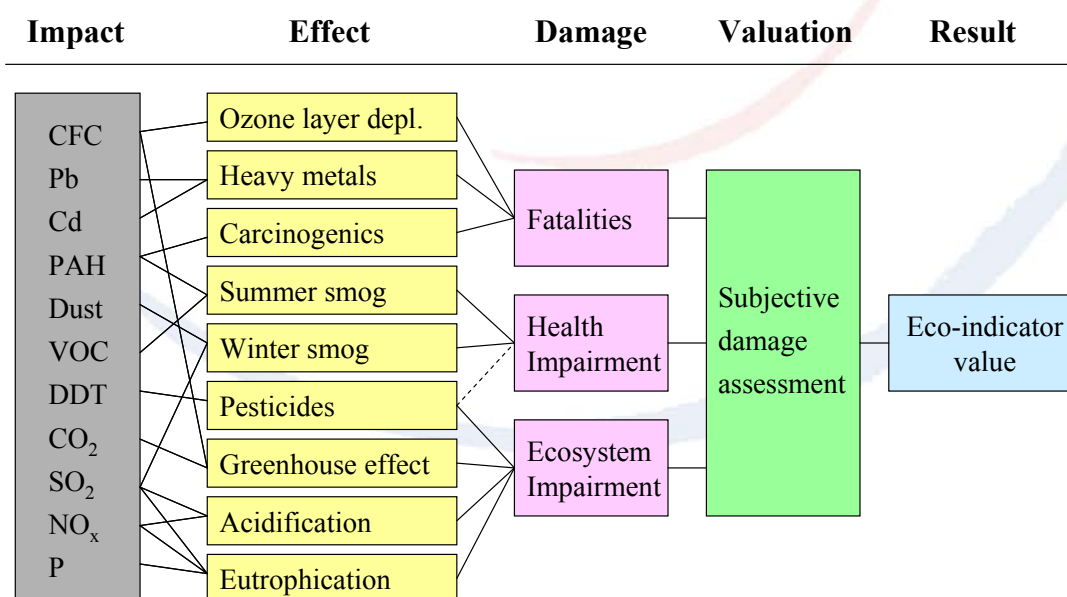


Figure 12 Schematic representation of the Eco-indicator weighting method

4. Results and discussion

4.1 Pelleting characteristics of sugi and sewage sludge cake

The properties of the raw materials and pellets were listed in Table 2 to reveal the difference before and after pelletizing. After pelletizing, the bulk density of woody plant increases about four times, from 144 kg/m³ to 562 kg/m³. For sludge, there was no obvious change on bulk density. The pellet durability index (PDI) was determined followed the method ASAE S269.3 [7], to evaluate the durability of pellets during the logistics. PDI of sludge is 91.2% and is higher than that of sugi (83.1%), implying the sludge pellets can resist the stress during transportation. The woody pellets, On the other hand, are more easily crushed. As pelletizing is a kind of physical process, three-components (water, combustibles and ash), lower heating value (LHV) has no noticeable change after pelletizing. The water content dropped slightly after pelletizing and increased the combustibles accordingly. The element component also has no obvious change except hydrogen. Hydrogen lowers after pelletizing because the water content decreases.

For the mixed pellets (sugi : sludge = 1:1), noticeably some properties are not located between those of sugi and sewage sludge. PDI of the mixed pellets is lower than sugi and sewage sludge. It implies that the surface hydrophilicity of sugi and sludge differs significantly, and the two materials could not be bound tightly in the pellets. Similarly LHV of the mixed pellets is 3,858 kcal/kg, higher than the average of LHV's of sugi and sludge (3,470 kcal/kg). A possible explanation is the inhomogeneity of the mixture and lead to the inaccuracy of LHV measurement.

Table 2 The comparison of biochemical characteristics of various biomass before pelletizing and after being pelletized

Parameters	Biomass			
		Sugi (<i>Cryptomeria japonica</i>)	Sewage sludge	Mixed pellets
Bulk density (kg/m ³)	Raw materials	144	581	-
	Pellets	562	577	577
Pellet Durability Index (PDI) (%)	Raw materials	-	-	-
	Pellets	83.1	91.2	76.0
Water (%)	Raw materials	12.0	21.3	-
	Pellets	10.1	10.8	10.8
Combustibles (%)	Raw materials	87.4	43.8	-
	Pellets	89.1	46.8	67.3
Ash (%)	Raw materials	0.59	34.9	-
	Pellets	0.85	42.4	21.9
Lower Heating Value (LHV) (kcal/kg)	Raw materials	4,470	2,629	-
	Pellets	4,285	2,654	3,858
Carbon (%)	Raw materials	45.5	27.5	-
	Pellets	49.7	25.1	36.9
Hydrogen (%)	Raw materials	6.11	4.37	-
	Pellets	6.92	2.91	4.43
Nitrogen (%)	Raw materials	0.07	3.45	-
	Pellets	0.14	4.14	3.52
Sulfide (%)	Raw materials	0.05	1.28	-
	Pellets	0.05	1.45	0.75
Oxygen (%)	Raw materials	48.3	63.2	-
	Pellets	43.2	66.4	54.4

Note: Mixed pellet: The dried sewage sludge was blended with smashed sugi

4.2 Pyrolysis and gasification testing

To determine the optimal parameters, we have examined the effect of pyrolysis temperature (400, 500 and 600°C) on the conversion rate at feedstock rate at 2.2 kg/hr. The results revealed

that the conversion rate of three materials (sugi, sludge and their mixed pellets) have the similar tendency which ascended at first and descended at last. The optimal temperature with the highest conversion rate of pyrolysis is 500°C, where the conversion is 34% for sugi, 12% for sludge, and 20% for mixed pellets (Table 3). Apparently the biomass cannot be efficiently decomposed at 400°C, while it can be easily decomposed into smaller molecules at 600°C and not condensed as oil.

Among the three materials, sludge had the lowest carbon content and the highest ash content. The high ash content in the sludge resulted in the sintering between fluidized sands and the ash and may cause defluidization. The sands became lump-like material, and this increased the difficulty in maintenance. On the other hand, woods had higher carbon and less ash, and the conversion could reach between 25-35%. The mixed pellets, however, performed between the sludge and the wood. The sintering problems of sands caused by ash in the sludge were also mitigated and thus elevated the conversion.

Noticeably, compared with the conversion (around 50%) reported in the literature, the conversion in this pilot plant was low, possibly because of the insufficient length of the cooling system, which could not condense all the oil in the flow gas. In the test, the operator kept a lower purge gas flow rate (2Umf) to ensure more oil being condensed. Such a system is different from so-called “flash pyrolysis”. Extending the cooling length and increasing the cooling water flow circulation may be the first priority to improve the system.

For gasification tests, more detailed results were reported in Wu et al. [8]. As the value of ER increased, concentration of three fuel gas (CO, H₂ and CH₄) increased accordingly. On the other hands, higher gasifying temperature led to more fuel gas (syngas CO and H₂). Thus the optimal condition was determined as gasifying temperature at 800°C and ER at 0.3. Feedstock rate in this case is 3 kg/hr. Table 3 also listed the composition of gasifying products. Though some data scattering exists, the hydrogen concentration reaches maximum (25%) in the case of mixed pellets, where the concentration of CO exhibits the similar trend. Possibly alkali metals contained in the ash of sludge might function as some kind of catalyst to facilitate the conversion the hydrocarbon to hydrogen and carbon monoxide, instead of converting to tar. It may function similar like commonly used catalyst dolomite CaMg(CO₃)₂. This is different from what we observed in pyrolysis, where ash in the sludge did not facilitate the conversion of mixed pellets.

Similar to the case in pyrolysis, ash in the sludge caused sintering with the sands in gasifier and would lead to the non-fluidizable bed. Using sludge as the only raw materials would be difficult to operate and control as defluidization may occur unexpectedly. Sugi and the mixed pellets may be easier for conducting the gasification.

Table 3 Performance of pilot-scale testing of pyrolysis and gasification

Biomass	Performance	Pyrolysis		Gasification		
		Oil conversion	CH ₄	H ₂	CO ₂	CO
	Sugi	34%	9	21	31	28
	Mixed pellets (50% sugi + 50% sludge)	12%	9	25	30	32
	Sludge	20%	15	17	32	26

4.3 Cost analysis of sludge disposal as fuels

Co-firing (combustion) of mixed pellets is now commercially available in Taiwan for power generation. The typical cost is NT\$2/kWh (7 US cents/kWh) for the power generation using biomass. On the other hand, gasification and pyrolysis of biomass are not so common in Taiwan. The following cost information is based on the operation in United States, and is then adjusted according to the pilot testing of this study. In summary, typical cost using gasification is NT\$9/kWh (30 US cents/kWh). Typical cost using pyrolysis is around NT\$12/kWh (40 US

cents/kWh), which is rarely reported in literature because the pyrolysis oil is not suitable for power generation.

4.4 Environmental impacts

To evaluate the possible effects on environment when using the biogas, four scenarios of production steam were compared as listed in Table 4. “Base” is the coal combustion in a entrained bed reactor. “Case A” is the gasification on the bubbling-fluidized bed using the pellets of woody waste to produce Syngas. Afterward, the syngas is combusted with coals to produce steam. “Case B” is the same as Case A while $\text{Ca}(\text{OH})_2$ is added in the reactor as catalyst. “Case C” is the pyrolysis on the bubbling-fluidized bed using the pellets of woody waste to produce liquid biofuel, and then combusts with fuel oil to produce steam. The input data refer to the literatures [8,9] and the results from the aforementioned pilot-scale testing. The comparison of environmental impacts for four scenarios using Eco-indicator 95 in SimaPro 7.1 is illustrated in Figure 13.

Table 4 Four steam producing scenarios

Scenario	Process	Materials	Product
Base	Combustion	Coal	Steam
Case A	1. Gasification	Woody waste	Syngas
	2. Combustion	Syngas + coal	Steam
Case B	1. Gasification with $\text{Ca}(\text{OH})_2$ injection	Woody waste	Syngas
	2. Combustion	Syngas + coal	Steam
Case C	1. Pyrolysis	Woody waste	Pyrolysis oil
	2. Combustion	Liquid biofuel + fuel oil	Steam

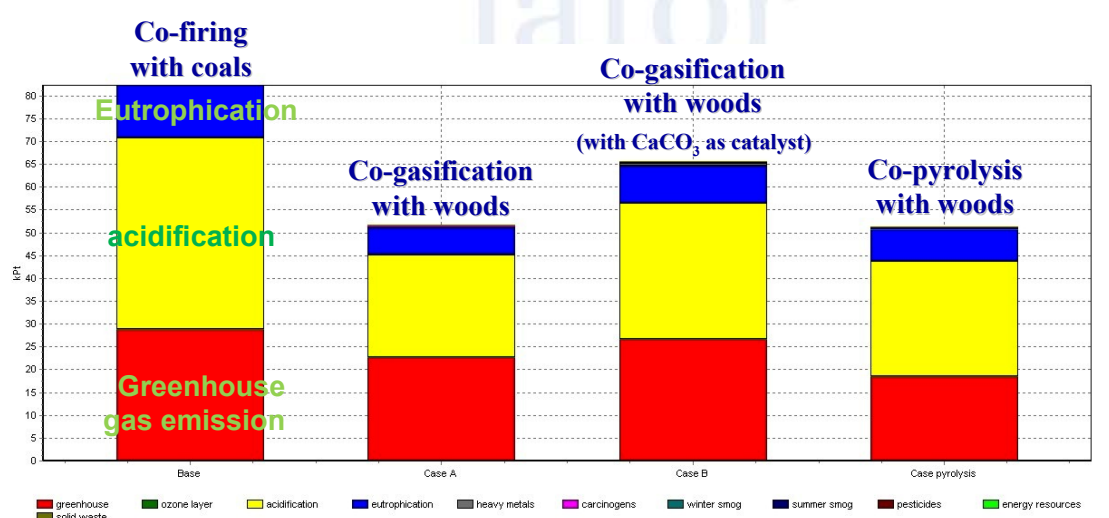


Figure 13 The comparison of four steam producing projects using Eco-indicator 95

The results are revealed that the coal combustion (Base) led to the most significant environmental impacts, followed by Case B, Case A, and Case C. The main impacts included greenhouse effects, acidification and eutrophication. The evaluation result may be ascribed to the noticeable emission of CO_2 and NO_x in the scenario “Base”. The other three cases using woody waste may be considered as more “carbon neutral”, while the emission of NO_x was low in the biomass that could be ignored. Thus it gives fewer impacts than using fossil fuels. As operated in lower temperature, pyrolysis may release less carbon dioxide, and it led to the lowest environmental impacts. More studies are required to give more objective evaluation.

4. Conclusions

The results show that municipal sludge in Taiwan is not suitable for being utilized as fuels alone. Co-treatment with forestry wastes (like wood materials) is feasible and mitigates the problems like ash melting and low heat value. We have evaluated the performance of pelleting, pyrolysis and gasification of sugi and its mixture with sewage sludge. Noticeably, the addition of sludge may play different roles in the individual process. When adding sludge to form the mixed pellets, the pellet durability index of mixed sludge became worse than the two raw materials. The possible explanation is their different surface hydrophilicity leads to the binding less efficient. More sludge in either pyrolysis or gasification would lead to more defluidization and sand sintering. For pyrolysis, the conversion became worse when the portion of sludge increased. At the optimal temperature 500°C, the conversion kept dropping from 34% to 12% when more sludge is added. On the other hand, for gasification, the syngas (hydrogen and carbon monoxide) concentration at the optimized criteria (ER = 0.3 and gasifying temperature 800°C) reaches maximum in the case of mixed pellets. Ash in sludge may play an important role to catalyze the hydrocarbon decomposition in this case. The environmental impacts analysis showed that both gasification and pyrolysis gave fewer impacts, where pyrolysis may have the lowest impacts among the four scenarios. Biomass pyrolysis and gasification, which produce oil and syngas respectively, may further increase the energy efficiency and mitigate the environmental impacts compared to the combustion or co-firing. In summary, among the three processes, the conventional co-firing in the cogeneration power plant is the most economically feasible, though the environmental impacts are highest, mainly from the aspects of greenhouse effects and acidification. More studies are still required to evaluate the feasibility of these thermal chemical processes for sludge resource utilization.

References

1. Gungor A, Eskin N. Effects of operational parameters on emission performance and combustion efficiency in small-scale CFBCs. *J Chin Inst Chem Eng* 2008;39:541-556.
2. Klein A, Whiting K, Archer E, Schwager J. Gasification and pyrolysis: what is the current situation for waste management? *Waste Management World* 2004;5:71-75.
3. Sutcu H. Pyrolysis by thermogravimetric analysis of blends of peat with coals of different characteristics and biomass. *J Chin Inst Chem Eng* 2007;38:245-249.
4. Kaewcharoensombat U, Prommetta K, Srinophakun T. Life cycle assessment of biodiesel production from *jatropha*. *J Taiwan Inst Chem Eng* 2011;42:454-462.
5. Pennington DW, Potting J, Finnveden G, Lindeijer E, Jolliet O, Rydberg T, Rebitzer G. Life cycle assessment part 2: current impact assessment practice. *Environ. Int* 2004;30:721-739.
6. Goedkoop MJ. Eco-indicator 95. Final report. Amersfoort Netherland: Mark Goedkoop of PRé consultants; 1995.
7. ASAE Standards. 1987. S269.3: Wafers, pellets, and crumbles – Definitions and methods for determining density, durability and moisture content. St. Joseph, MI: ASABE.
8. Wu KT, Chen CY, Yang KC and Chu CP, Co-gasification of Woody Biomass and Sludge in a Fluidized Bed. *Apply Energy* 2013 (submitted).
9. Lee HT, Wu KT, Juch CI, Tsai MY, Huang CC, Kylä-Sipilä M, Hiltunen M. Gasification of paper reject in a CFB pilot plant, pyrolysis and gasification of biomass and waste, CPL Press. UK; 2003.
10. Wu KT, Lee HT, Wana HP, Shim HS, Adams BR, Chen SL. Study of syngas co-firing and reburning in a coal fired boiler. *Fuel* 2004;83:1991-2000.

*Power from the People:
The Empowerment of Distributed Generation of Solar Electricity for Rural
Communities in Malaysia*

Nur Azfahani Ahmad*¹, Hugh Byrd*²

*¹The University of Auckland, New Zealand, *²The University of Lincoln, UK

0395

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This paper describes the decreasing energy security in Malaysia and the likely impact on maintaining power supplies to low income groups. The most vulnerable group is the low-income people in the rural areas, who have limited access to generate their own power supplies. The paper reviews the potential of distributed generation (DG) using photovoltaics as a means of mitigating this problem. Examples from other countries are reviewed and alternative methods of funding PV installations are discussed. Strategies such as community-based approach and innovative financing scheme will be introduced and discussed. The main objective is to utilize solar energy as the main energy resources for generating electricity and places rural people as the main stakeholder to deploy the strategic model. This model is also ideal to be integrated with the distributed generation (DG) system as one of the key components in developing a suitable energy policy that can help to sustain the energy development of rural community in the future. The paper concludes that distributed generation (DG) is feasible and that innovative funding schemes are required based on local knowledge.

Keywords: Solar Photovoltaic, Distributed Generation, Financing Model, Sustainable Rural Community

1. Introduction

In many developing countries in South East Asia, for instance Malaysia, Indonesia and Thailand, electrification of the grid system is centralized and controlled by the government or authorized corporate stakeholders. This type of electricity distribution model is prone to many issues of vulnerability as it is exposed to national and international energy security issues (Byrd, 2010), and carbon emission problems (Nel & Cooper, 2009) which will lead to unsustainable electricity distribution through the possibility of blackouts or load shedding due to grid systems failure. As these problems arise, people who depended on the supply of electricity via the grid become vulnerable and this can affect the livelihood of the people in the future. In the event of grid failures or load shedding it is likely that the more remote rural settlements, with lower income groups, are more vulnerable. As energy security decreases within the country, electricity from the grid may be cut-off to inadequate supply (Ahmad & Byrd, 2013).

Power outages, while often caused by technical errors at present, are a glimpse of the future when the electricity grid network is threatened by a lack of primary energy sources. Many ASEAN countries have passed peak oil production (IEA, 2007) and are threatened by an ownership dispute concerning territorial rights of the oil producing areas of the South China Sea (Energy Information Administration, 2008; Park, 1978; Severino, 2010). Malaysia, for instance, is heavily dependent on oil and gas from its fields in the South China Sea (International Gas Union (IGU), 2011) and to generate electricity, gas and oil constitute 93% of the fuel used to generate electricity (Ab Kadir, Rafeeu, & Adam, 2010). With the increasing rate of development and growth of population, electricity demand may become greater than supply and Malaysia is currently reviewing fuel sources to generate electricity including nuclear power (Oh, Pang, & Chua, 2010). Under these circumstances, energy security is improved by a more diverse source of fuels. One method is to introduce distributed generation (DG) system via renewable energy supplies in order to maintain adequate electricity supply. In this paper, deploying DG electricity using solar PVs will be discussed with the focus on sustainable rural livelihoods and financial mechanisms to make it available to lower income groups.

2. Sustainable Rural Livelihood

In 1986, the concept of “sustainable livelihood” was introduced during the World Commission on Environment and Development (WCED, 1987). The concept was then extended to include the rural population and introduced as “sustainable rural livelihood” by Chambers and Conway (1992). They defined a sustainable living as one which has four characteristics; capabilities, availability of assets and resources, and significant activities that can cope and maintain any shocks or disaster during livelihood. Through this concept, emphasis was made towards “securing the livelihoods of the rural poor” (WCED, 1987), and in 1998, this concept emerged effectively through the establishment of a sustainable livelihood framework (see Figure 1), which emphasised the human, natural, financial, social and physical capital (Scoones, 1998). This implies the need to face any vulnerability contexts that might compromise the livelihood of the people in many ways.

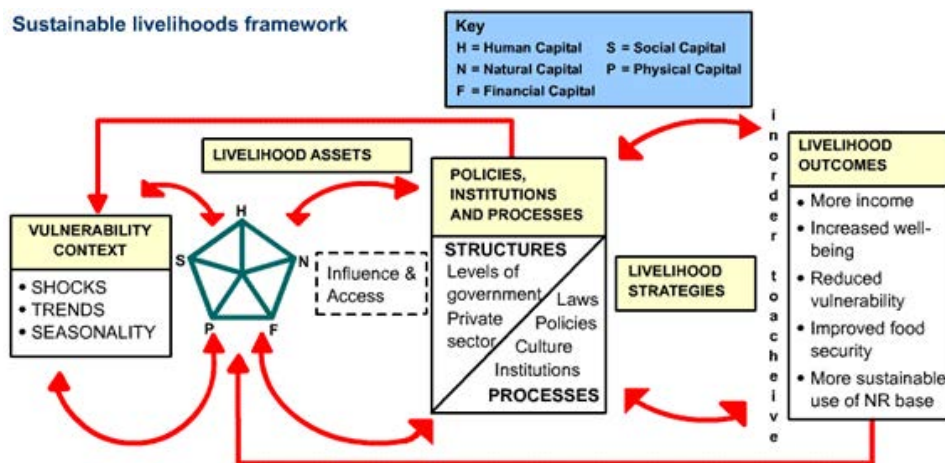


Figure 1: The Sustainable Livelihood Frameworks by Ian Scoones (1998).

To gain a sustainable livelihood requires a sustainable source of energy. At present Malaysia is dependent on fossil fuels to generate electricity, which is not sustainable. The electricity mix in Peninsular Malaysia is powered by resources of natural gas (45%), followed by imported coal (44%), hydro (5.7%), oil and petroleum (2.5%), distillate resources (2.5%) and small portion of imported resources (0.3%) (Noh, 2012) (see Figure 2) .

Currently the electricity grid network supplies all electricity in the country with only remote islands using DG electricity. This makes the population vulnerable to electricity load shedding (rationing) or blackouts should the imported coal or natural gas resources diminish. With the threat of electricity load shedding increasing and the likelihood of rapidly increasing prices, an alternative system based on localised generation of electricity becomes more financially feasible (Winter, 2007)

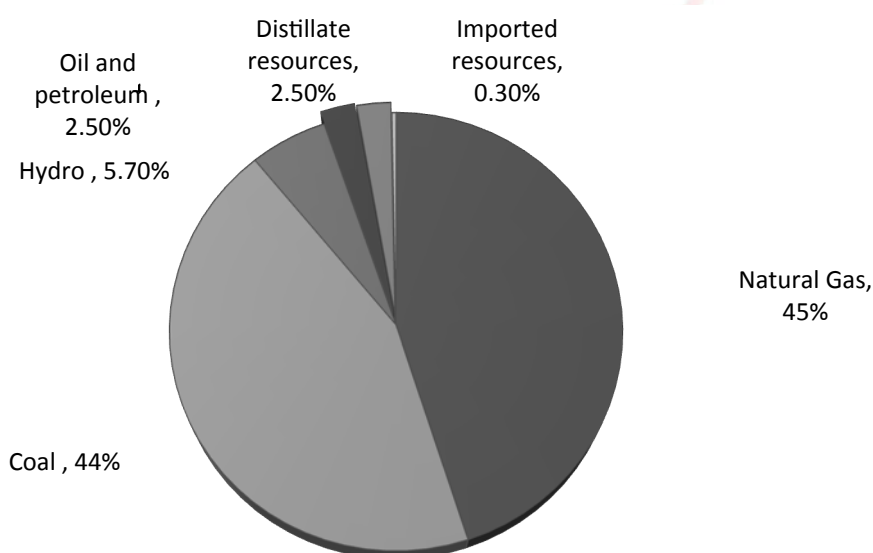


Figure 2: Generation Mix for Peninsular Malaysia (2011)
 Source: Adapted from (Noh, 2012).

Livelihood strategies vary from individual needs, household needs, to a bigger context of village, states and nation (Chambers & Conway, 1992; Scoones, 1998). The cost-effectiveness of distributed generation depends upon the electricity demand profile of a community, not only for normal residential use but also for commercial activities that form the livelihoods of many of the rural community.

3. The Case of Malaysia: Solar Electricity and Rural Electrification.

The potential of exploiting solar energy for generating electricity through photovoltaics on Malaysian residential roofs is substantial, with an average irradiance per year of 1643 kWh/m² (Chua, Oh, & Goh, 2011) which is higher than Germany (1150 kWh/m²), Spain (1613 kWh/m²) and Japan (1400 kWh/m²) (Lloyd & Forest, 2010). Through the establishment of the energy policy in the 9th Malaysia Plan (2006-2010) (Malaysia, 2006), PVs have been installed in many commercial and residential buildings in urban areas, but has not yet penetrated rural areas. At the moment, the price of PV panels for mass power generation is still high, between RM15,000 to RM 19,000 kWp (Jamaludin, 2009; MBIPV, 2011; Muhammad-Sukki, Ramirez-Iniguez, Abu-Bakar, McMeekin, & Stewart, 2011), which is far beyond the reach of the average homeowner if financing is not provided. This has become a constraint to the Government to introduce this technology to low income groups especially the rural communities.

Unlike many Asian countries, electricity coverage in rural Malaysia operates 24 hours a day throughout the country, with the coverage expanding from 79% in the 1970 to 95% in 2009 (TNB, 2009). Under the Rural Electrification Programme (BELB) which has been established by the Ministry of Rural and Regional Development (Jabatan Perdana Menteri Malaysia, 2011; Muhammad-Sukki et al., 2011), over 25, 000 MW of electricity (Naidu, 2010) was generated to fulfil household demand, which comprises 1/3 proportion from overall household's electricity needs in Malaysia. Electricity for rural areas has always been maintained at a lower price due to the aid of highly subsidized rate for electricity at 21.8 RM cents/kWh (TNB, 2012). Despite of the recent 19% increase in price for domestic electricity tariff (from 28.9 RM cents/kWh to 33.4 RM cents/kWh for 201kWh – 1000 kWh readings) (TNB, 2012), the electricity demand in housing sector continues to escalate every year averaging 4.9 percent growth per year for over the past 10 years (TNB, 2009).

People in Malaysia, especially the rural population are not fully aware of the consequences of energy insecurity and the potential impacts of a major power interruption. Only 1/3 of the population knows about renewable energy and from this population only 11% of the public know that this technology can be associated with electricity generation and this percentages came from well-educated people (university graduates) (Haw, Sopian, & Sulaiman, 2009).

Byrd (2010) has indicated that PVs mounted on the roofs of rural houses in Malaysia could generate about 25% of current electricity demand which shows a significant proportion of the electricity generation mix for Malaysia. This is due to the larger roof area provided by rural housing (averaging 92.5 m²) in meeting the electricity requirements of low-energy households if to be compared with urban housing. In addition, the use of electricity in rural areas in Malaysia is lower than in urban areas. At the moment, houses in rural Malaysia correspond to only 27% of the electricity demand in Malaysia (TNB, 2009) which indicates that the surplus of solar energy can be shared widely to other communities in the country.

Based from the Ministry of Energy, Green Technology and Water (2012), Malaysia forecasts to achieve 985MW share of renewable energy in the energy mix by 2015. At present, renewable energy supplies less than 1% to Malaysian energy mix (KeTTHA, 2012). The share for solar PV is relatively small in comparison with the quota capacity from other types of RE, which is only 65 MW from 985 MW (Malek, 2010). However, the establishment of a Feed-in-Tariff in Malaysia has started to give more emphasis to solar PV. The fund was achieved by increasing the current electricity tariff by 1 %, and that amount was pooled into the FIT fund (Haris, 2010). The solar PV power will become competitive once there is an adequate reduction rate for this energy. It is expected that solar power in Malaysia will reach grid parity in 2017 (BERNAMA, 2010). By then, the government might have revised the capacity quota of solar PV energy to a feasible extent, making it viable for many, especially low-income people in rural areas. This will help rural dwellers gain access to the grid-connected solar PV system in order to generate income by selling energy back to the grid. This can only happen if there is a suitable enforcement programme for PV roof-mounted technology for rural housing. This is important in order to establish a way in which energy can be used efficiently in order to support social infrastructure despite the rising issues of fossil fuels depletion. It is necessary to advocate for solar energy as a means for creating sustainable lifestyles, especially for rural peoples.

4. Distributed Generation (DG) Using Solar Energy: Examples From Other Countries

DG is a system that involves small-scale power generation which is located at a strategic point near the consumption point, known as load centre points (Lai & Chan, 2007; Masters, 2007). The small scale loads at each DG point is usually range below than 50 MW systems (Brass, Carley, MacLean, & Baldwin, 2012) which can be connected from an owner (customer) and sold to a utility, where then power generated from this DG point can be sold (Lai & Chan, 2007). The owner can also use all of the power if needed (Masters, 2007) in an isolated way, or sell a portion of the power into the grid at an appropriate time (Lai & Chan, 2007). This type of generation is feasible, cost-effective, clean and can be integrated effectively with renewable energy resources (Farret & Simões, 2006). Brass, et al (2012) highlighted that DG system allow the owners to adapt energy supply to local demand and employ systems that suit their power consumption, which can be better than centralised grid networks. Figure 2 illustrates the basic concept of DG system.

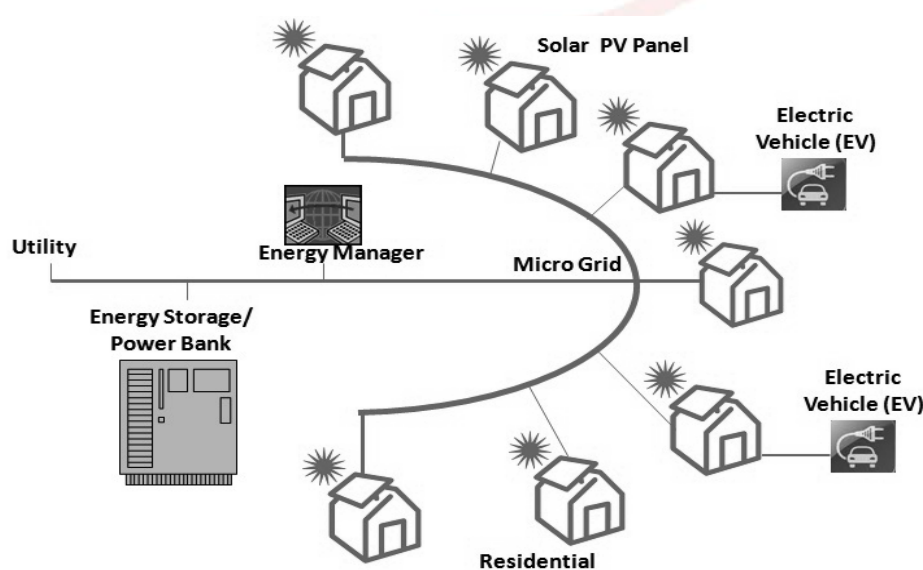


Figure 2 DG System Based On Solar Energy (illustrated by author)

Through the introduction of DG system, individual households will have alternative ways of generating their own electricity. The benefits of DG can be widely shared by many communities if the owners are able to supply the surplus of energy to the micro grids and share their electricity. However, there is a challenge that needs to be addressed in order to penetrate the DG system into Malaysian energy landscape. Focus need to be emphasised towards the suitable financing scheme that can be integrated to the system, which give benefit to owners and utility. Among the countries that are considering DG system for solar photovoltaic (PV) are European Union (EU) countries and Bangladesh. They viewed the potential for developing and establishing DG system in order to sustain long-term development outcomes and equitable energy resources (Biswas, Bryce, & Diesendorf, 2001; Brass et al., 2012; Dipal C, 2001; R  ther & Zilles, 2011).

For many developed countries, DG systems are gradually growing especially in the countries with bigger investment in renewable energy sector, for instance Germany, Spain and Denmark (Cossent, G  mez, & Fr  as, 2009). DG has been identified to help rural and poor communities in other parts of the world. In Bangladesh, an organisation known as Grameen Shakti has helped to install solar home system (SHS) for over 500,000 people in rural Bangladesh (Dipal C, 2001; Kabir, Dey, & Faraby, 2010). The application of solar PV technology through DG system has helped people to meet basic energy needs, increasing the quality of rural electrification in Bangladesh and is indirectly helping the people to generate additional income (Ahammed & Taufiq, 2008). The application of SHS has been identified to help reducing poverty and hunger through the increased income generation, increase education and safety through the application of solar lighting (Ahammed & Taufiq, 2008).

In Brazil, a larger scale of DG programs has been introduced to the people through many types of renewable energy projects. It is recognisable by many scholars that DG systems can help in providing a sustainable access to electricity for poor people (Borberly & Kreider, 2001; Weber & Vogel, 2008). Through DG programs, solar PV systems have been spreading across residential sector in Brazil due to its attractive tariffs, which is between US\$ 0.17 (R\$ 0.37) to US\$ 0.39 per kWh (R\$ 0.85) (R  ther & Zilles, 2011) and huge reduction of solar PV module prices from 23 US\$/W in 1980 to 1 US\$/W in 2012 (Jannuzzi & de Melo, 2013). According to Brazil's national energy agency, EPE, electricity from home solar panels is now lower than grid electricity which has created a competitive market (Nielsen, 2012). This has given an attractive option to home-owners in comparison with the price of grid-electricity in Brazil which is now rated at between US\$ 0.19 (R\$ 0.42) to US\$ 0.47 (R\$ 1.03) (R  ther & Zilles, 2011). With high electricity tariff, residential electricity users do not have any options than to consider solar electricity.

In India, through its NGOs, the Sadguru Foundation (Writers, 2009) and the Small-Scale Sustainable Infrastructure Fund (S³IFD)(Sovacool, 2013) have embarked a Solar Lantern Project to aid rural people in gaining solar lighting without depending on international donor or financial institutions (Sovacool, 2013). This project established a simple renting scheme of light points for people which are charged from solar-powered batteries. Through a 'fee-for-service' model, many pro-poor rural people have formed small scale groups which amalgamate their savings to provide loans based on daily needs (Chaurey & Kandpal, 2009). Solar lantern projects have helped hawkers and home-owners throughout India by reducing 55% of the cost burden from kerosene lighting (from Rs 90 to Rs 50 for 5 days) (Sovacool, 2013). Many positive impacts gained from Solar Lantern projects especially in providing a longer duration of lighting supplied by the solar lanterns. Children can study in a longer period, women can perform household works at night and safety level in remote areas increased (Writers, 2009).

5. Strategies To Expand Distributed Generation Of Solar PV

Several scholars have argued on the importance of DG technology as the importance mechanism to diffuse solar PV energy on a national scale (Wüstenhagen & Bilharz, 2006; Zhang, Song, & Hamori, 2011). It is essential to identify the stimulant factors to promote and encourage people to deploy solar PV, especially for households needs. Cases in Germany and Japan have proven that, with government intervention and extensive subsidy policies, solar PV energy can be effectively diffused in many households (Beise, 2004; Zhang et al., 2011). It has been argued that in order to make solar PV energy possible for low-income people in rural areas, the best incentive is adopting the FiT scheme within the solar PV programme (Chua et al., 2011; Muhammad-Sukki et al., 2011; Zhang et al., 2011).

5.1 Community-based Approach

The ‘community-based approach’ is a concept that integrates all level of groups in the same community, from individuals to the wider community and can be extended to the generation and demand of energy within a community (Frame, Tembo, Dolan, Strachan, & Ault, 2011). The United Nations has highlighted the ‘community-based approach’ as a group “who recognizes themselves or is recognized by outsiders as sharing common cultural, or other social features, backgrounds and interests, and that forms a collective identity with shared goals” (UNHCR, 2008). M. I. Khan, Chhetri, and Islam (2007) and is usually considered as the main stakeholder. This mechanism is very important because it helps to disseminate and deploy energy beneficial-projects to locals with similar backgrounds and concerns with the aid of local leaders and public organisations (Frame et al., 2011).

Countries like Bangladesh (Mondal, et al., 2010; Islam and Islam, 2005) and Indonesia (Retnanestri and Outhred, 2011) have shown that a direct interaction with local people is a very important mechanism in educating and promoting this technology to rural people. This has been supported by Walker and Devine-Wright (2008) which highlighted that more local people should be involved in any energy projects in order to gain their support and understanding. This can be achieved by installing people’ own micro-generation technology which encourage them to learn and to understand the technology (Dana Abi-Ghanem, 2011). Energy-community projects may be owned and managed by local organisations or community based cooperation (M. I. Khan et al., 2007). Using this approach, a head or leader of the community will consult with the government and disseminate information gained to the locals. Facilitators or trainers will participate in educating the people from individual unit (each household) to a neighbourhood and bigger community.

This is important, as part of the rationalization for public investment is to have stronger catalytic impacts in encouraging people to engage to renewable energy projects (Walker & Devine-Wright, 2008). For instance, renewable energy (RE) projects in India and Bangladesh proved that implementing a ‘community-based approach’ enables their government to persuade people to invest in local RE projects (Bhandari & Stadler, 2011; Dipal C, 2001; Writers, 2009). Through community project like Solar Home Systems and Solar Lantern programme, people are being educated through non-profit organisations on the importance of solar electricity for daily works. This does not necessarily mean that all people in the community have to be involved in a

community-energy project, but more into gaining wider exposure and information towards every leader of the community, so that people understand and favour micro-generation projects (Sauter & Watson, 2007). Since local people will usually own these energy-community projects, more money will be re-circulated in the community, helping the locals into maintenance problems and strengthened local participation, communication and social engagements (M. I. Khan et al., 2007).

5.2 Innovative Financing Scheme

Innovative financing schemes can be defined as a range of non-traditional methods to increase additional funds for development aid; in this context - for renewable energy projects; through "innovative" energy projects (Girishankar, 2009). Among the popular innovative financing scheme are micro-financing, taxes and public-private partnerships (Girishankar, 2009).

5.2.1 Public-Private Partnership (PPP) Programmes

Public-private partnership (PPP) programme is a participation programme that involved by private organisations and the public sector which usually related with infrastructure projects (Sovacool, 2013), and for the context of this paper, it is focusing on energy infrastructure. This programme is also known as privatization or liberalization programmes and signifies broad relationships between national governments and public sectors, for instance local councils and state governments (Klaus, 2010). This relationship will be joined by private organisations which involve numerous organisations, for instance non-profit organizations (NGOs), finance institutions, manufactures, banks and private organisations, energy providers and the residents (Klaus, 2010).

The PPP programme can be associated with helping the poor communities in accessing energy services and providing a way for the residents to join the energy business venture based on 'community-based approach'. Under the PPP programmes, as underlined by Sovacool (2013), there are several types of approaches that suitable for low-income consumers, namely; (a) project finance model that provide soft loans and financial support from banks or financial institutions, (b) technology development model which focusing on the improvement of an affordable technology for the people, (c) micro-credit or micro-finance programme that helps the public to pay the technology periodically, (d) a co-ownership energy project which emphasised on the cooperation of the consumer and investors, where they can own the energy technology after certain period of time, (e) the 'fee for service' model which requires consumer to pay certain amount of fees for the energy services provided and (f) combination of all types of approaches.

In Malaysia, an example of small scale PPP projects has recently been established as a pilot project which similar to a 'rent a roof' scheme, with a target of small residential areas in Alor Gajah, Malacca. This project involves Malacca state government (public party), Green Earth Design Solution (GEDS) (private party), the residents of Taman Rembia Perkasa and an investor from Holland (Choong, 2012). With each installation of the solar PV panel performed at 5 kWp, the pilot houses will collectively contribute nearly 2 MWp of solar PV generation capacity to the Malaysian national grid. But, since the cost for each solar home will cost at least RM50,000 (MBIPV, 2011); which is 1/3 of an average house' prices in Malaysia, a supporting mechanism need to be underlined in order to aid the consumers within financial matters of employing solar PV technology into the grid. The private sector, GEDS will be responsible to finance the

technology and the construction, together with the maintenance process for the duration of the contract period (11-years), which inclusive the entire system and all natural disturbances (Choong, 2012).

5.2.1.2 'Rent a roof' Scheme

Due to the limited financial resources of rural people, 'rent a roof' scheme can help rural dwellers earn an income from their own roof. Basically, there are two approaches to the co-ownership PV project. First, rural house owners have the mechanism to generate monthly income by 'renting' their roof areas to private investors or generating companies within agreeable rates and duration limits (Fricklas, 2010). The energy generated from the PV panels will be fully owned by the investors. This concept is very popular in Italy and Canada (Aanesen, Heck, & Pinner, 2012; Smith, 2007). Secondly, both parties (home owners and investors) reap equal benefits by installing PV panels at a cost supported by the investor. In return, the investor will profit from selling the electricity back to the grid within agreed upon revenue years. After the time is over, the house owner will claim ownership of the PV panels and continue to sell solar electricity to the grid (JFS, 2012; U Energy Solar, 2012). This is one way of beginning to solve the issue of the financial resources of low-income groups.

5.2.2 *Social Bankability and Crowd Funding model*

Many scholars agreed that there is a big hurdle of financing for clean and modern energy projects, especially renewable energy projects (particularly solar energy) in developing countries (Chandrasekar & Kandpal, 2005; Cossent et al., 2009; Girishankar, 2009; Kabir et al., 2010). In order to favour and to boost the market for distributed generation (DG) of solar PV technology, there is a need to gain crowd funding and to establish social bankability for energy projects. Crowd funding is one of the financial method that used to gather money from the public (Kaplan, 2013). At the moment, there are two examples of private organisations that have managed to establish an effective solar crowd funding platform, namely SunFunder (SunFunder, 2013) and Mosaic (Mosaic, 2013) that attract investors from the public to invest in solar energy projects using a simple periodical method as illustrates in Figure 3. The advantages of this model is (a) investors can invest only within a small cost of money (affordable to them) and able to choose their own community projects, (b) when the funding target achieved, the solar partners will start to facilitate and provide on-going energy services, thus, avoiding any hassle, (c) investors will be able to keep on track on their invested project through an online system, (d) increase the knowledge and attract the interest from local people and (e) secured with financial insurance. By this approach, funding for solar energy projects can be increased periodically in order to help poor-rural communities to gain this technology, without unduly dependent on government.

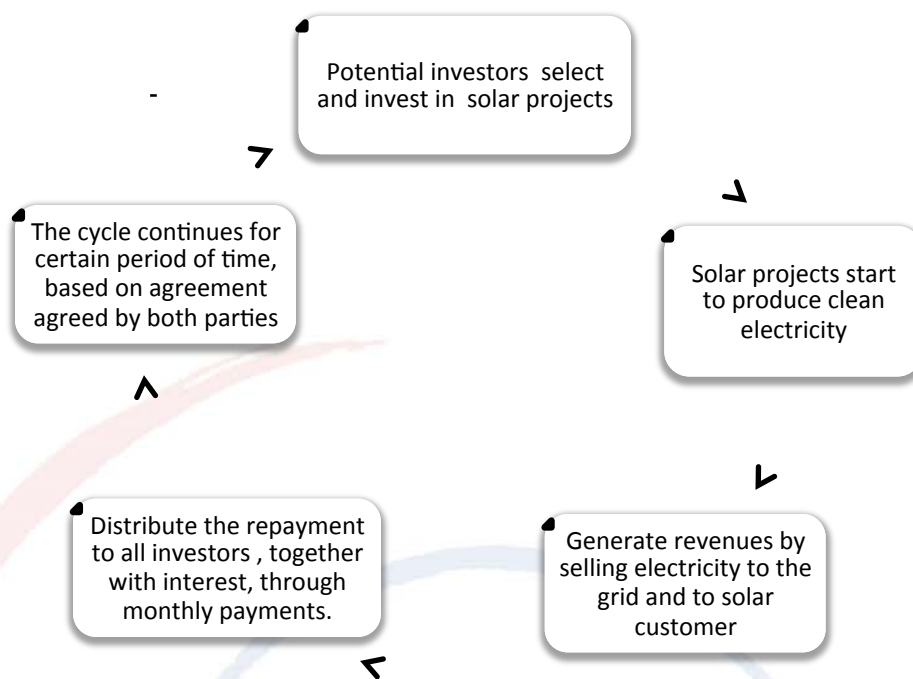


Figure 3 The cycle of crowd funding model

5.2.3 *Micro-credit and micro-enterprises programme*

A micro-credit programme is a fully structured financial aid scheme that helps people to access energy, parallel to a micro-enterprises programme, which provides technical training, maintenance service and product promotion at a mass level. This scheme has successfully been introduced in Bangladesh and had helped many rural women and small enterprises to generate income based on solar PV energy (Biswas et al., 2001; Dipal C, 2001; Kabir et al., 2010; H. J. Khan & Huque, 1998; M. I. Khan et al., 2007). This scheme allows peoples to pay different down-payments based on their monthly incomes and circumstances (Islam and Islam, 2005; Kabir, et al., 2010). People can choose the payment plan that suits their monthly expenditure. This programme has successfully set up technology centres in countries like Bangladesh and India, creating more prospects for employment for the locals, particularly in terms of starting up micro-enterprises programmes to help local businessman in PV sector (Alam Hossain Mondal, Kamp, & Pachova, 2010). This has developed into a long-term sustainable business model and promotes rural solar PV electrification (Campren, Guidi, & Best, 2000). Other examples, for instance countries like Kenya and Nepal which not only contribute towards the welfare and wellbeing of the people, but they have also increased the economic potential of rural dwellers, helping and educating local women in income-generating activities. 90% of the people pay for the system using cash sales from domestic businesses (Kabir, et al., 2010). This is all based on the implementation of the Micro-Credit scheme and the Micro-Enterprise Development programme (Islam & Islam, 2005) in the community.

6. Conclusion

In order to create conducive transition for solar PV development in rural communities, strategic measures, for examples community-based approach and innovative financing scheme are needed in order to evaluate the many push-factors for the diffusion of solar PV energy. This is essential

especially in determining suitable policies, energy action plans, innovative financing schemes and incentives. The involvement of the government, energy stakeholders, private sectors and the local people are important in order to create an effective Public Private Partnership (PPP) ventures for the sustainable development of rural community. Rural communities can be educated to understand and appreciate clean electricity if they are fully exposed to the beneficial side of solar PV energy through extensive programmes and supporting schemes. Instead of just copying and adopting solar PV energy projects from overseas, local knowledge, characteristics and skills need to be explored in order to develop solar energy projects for rural Malaysia.

References

- Aanesen, K., Heck, S., & Pinner, D. (2012). Solar power: Darkest before dawn
- Ab Kadir, M. Z. A., Rafeeu, Y., & Adam, N. M. (2010). Prospective scenarios for the full solar energy development in Malaysia. *Renewable and Sustainable Energy Reviews*, 14(9), 3023-3031. doi: DOI: 10.1016/j.rser.2010.07.062
- Ahammed, F., & Taufiq, D. A. (2008). Applications of Solar PV on Rural Development in Bangladesh *Journal of Rural and Community Development*, Vol 3(No 1).
- Ahmad, N. A., & Byrd, H. (2013). Empowering Distributed Solar PV Energy For Malaysian Rural Housing: Towards Energy Security And Equitability Of Rural Communities. *International Journal of Renewable Energy Development (IJRED)*, 2(1), 59-68.
- Alam Hossain Mondal, M., Kamp, L. M., & Pachova, N. I. (2010). Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—An innovation system analysis. *Energy Policy*, 38(8), 4626-4634. doi: 10.1016/j.enpol.2010.04.018
- Beise, M. (2004). *The international adoption of photovoltaic energy conversion- is Japan a lead market?* Tokyo.
- BERNAMA. (2010). Solar Power Usage in Malaysia expected to reach grid parity in 2017, *BERNAMA News*.
- Bhandari, R., & Stadler, I. (2011). Electrification using solar photovoltaic systems in Nepal. *Applied Energy*, 88(2), 458-465. doi: DOI: 10.1016/j.apenergy.2009.11.029
- Biswas, W. K., Bryce, P., & Diesendorf, M. (2001). Model for empowering rural poor through renewable energy technologies in Bangladesh. *Environmental Science & Policy*, 4(6), 333-344. doi: 10.1016/s1462-9011(01)00031-4
- Borberly, A., & Kreider, J. F. (2001). *Distributed Generation: The Power Paradigm for the New Millennium*. . Boca Raton, FL: CRC Press.
- Brass, J. N., Carley, S., MacLean, L. M., & Baldwin, E. (2012). Power for Development: A Review of Distributed Generation Projects in the Developing World. *Annual Review of Environment and Resources*, 37(1), 107-136. doi: doi:10.1146/annurev-environ-051112-111930
- Byrd, H. (2010). *The Potential of PVs In Developing Countries: Maintaining An Equitable Society In The Face Of Fossil Fuel Depletion*. Paper presented at the International Conference on Environment 2010, Penang.
- Campren, B. V., Guidi, D., & Best, G. (2000). Solar Photovoltaics For Sustainable Agriculture and Rural Development (E. a. N. R. S. S. D. Department, Trans.). In E. a. N. R. S. S. D. Department (Ed.), *Environment and Natural Resources* (pp. 76). Rome: Food and Agriculture Organization of the United Nations.
- Chambers, R., & Conway, G. R. (1992). *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century*. Brighton: Institute of Development Studies.
- Chandrasekar, B., & Kandpal, T. C. (2005). Effect of financial and fiscal incentives on the effective capital cost of solar energy technologies to the user. *Solar Energy*, 78(2), 147-156. doi: 10.1016/j.solener.2004.05.003

- Chaurey, A., & Kandpal, T. C. (2009). Solar lanterns for domestic lighting in India: Viability of central charging station model. *Energy Policy*, 37(11), 4910-4918. doi: <http://dx.doi.org/10.1016/j.enpol.2009.06.047>
- Choong, M. Y. (2012, October 16, 2012). Harnessing rooftops to generate solar power, *The Star*. Retrieved from <http://thestar.com.my/lifestyle/story.asp?sec=lifefocus&file=/2012/10/16/lifefocus/11510836>
- Chua, S. C., Oh, T. H., & Goh, W. W. (2011). Feed-in tariff outlook in Malaysia. *Renewable and Sustainable Energy Reviews*, 15(1), 705-712. doi: DOI: 10.1016/j.rser.2010.09.009
- Cossent, R., Gómez, T., & Frías, P. (2009). Towards a future with large penetration of distributed generation: Is the current regulation of electricity distribution ready? Regulatory recommendations under a European perspective. *Energy Policy*, 37(3), 1145-1155. doi: <http://dx.doi.org/10.1016/j.enpol.2008.11.011>
- Dana Abi-Ghanem, C. H. (2011). Shaping People's Engagement with Microgeneration Technology: The Case of Solar Photovoltaics in UK Homes. In P. Devine-Wright (Ed.), *Renewable Energy and the public: From NIMBY to participation*. London: Earthscan.
- Dipal C, B. (2001). Strategy for promotions and development of renewable technologies in Bangladesh: experience from Grameen Shakti. *Renewable Energy*, 22(1-3), 205-210. doi: 10.1016/s0960-1481(00)00012-4
- Energy Information Administration. (2008). The South China Sea: Country Analysis Brief. Retrieved Dec 2010, from EIA http://www.eia.doe.gov/cabs/South_China_Sea/pdf.pdf
- Farret, F. A., & Simões, M. G. (2006). Integration of Alternative Sources of Energy (pp. 333): John Wiley & Sons.
- Frame, D., Tembo, K., Dolan, M. J., Strachan, S. M., & Ault, G. W. (2011, 24-29 July 2011). *A community based approach for sustainable off-grid PV systems in developing countries*. Paper presented at the Power and Energy Society General Meeting, 2011 IEEE.
- Girishankar, N. (2009). Innovating Development Finance: From Financing Sources to Financial Solutions. (20 January 2010 ed.): World Bank.
- Haris, A. H. (2010). *Industry briefing on feed-in tariff procedures MBIPV*, SEDA & KeTTHA. Kementerian Tenaga, Teknologi Hijau dan Air; . Kuala Lumpur.
- Haw, L. C., Sopian, K., & Sulaiman, Y. (2009). *Public Response to Residential Building Integrated Photovoltaic System (BIPV) in Kuala Lumpur Urban Area*. Paper presented at the the 4th IASME / WSEAS International Conference on ENERGY & ENVIRONMENT (EE'09), Cambridge, UK.
- IEA. (2007). IEA Oil Market Report. In L. Eagles (Ed.), *IEA Oil Market Report*. France: International Energy Agency.
- International Gas Union (IGU). (2011). World LNG Report 2011 (PETRONAS, Trans.). In The Malaysian Gas Association & PETRONAS Malaysia (Eds.), (Vol. 1, pp. 65). Kuala Lumpur: Office of the Secretary General.
- Islam, A. K. M. S., & Islam, M. (2005). Status of Renewable Energy Technologies in Bangladesh. *ISESCO Science and Technology Vision*, Vol 1(May 2005), 51-60.
- Jabatan Perdana Menteri Malaysia. (2011). *Laporan Tahunan 2011: Program Transformasi Kerajaan*. Wilayah Persekutuan: Kerajaan Malaysia.
- Jamaludin, A. F. (2009). *Energy Mix and Alternatives Energy for Sustainable Development in Malaysia*. Paper presented at the Food, Agriculture and Environment in the New Century, Tokyo University of Agricultural.
- http://www.nodai.ac.jp/cip/iss/english/9th_iss/fullpaper/2-2-4upm-jamaludin.pdf
- Jannuzzi, G. d. M., & de Melo, C. A. (2013). Grid-connected photovoltaic in Brazil: Policies and potential impacts for 2030. *Energy for Sustainable Development*, 17(1), 40-46. doi: <http://dx.doi.org/10.1016/j.esd.2012.10.010>

- JFS. (2012). Japanese NPO Starts Residential Solar Co-Ownership Project. *Energy*, from <http://www.japanfs.org/en/pages/031892.html>
- Kabir, M. A., Dey, H. S., & Faraby, H. M. (2010). *Microfinance: The sustainable financing system for electrification and socio-economic development of remote localities by Solar Home Systems (SHSs) in Bangladesh*. Paper presented at the Systems Conference (2010) 4th Annual IEEE.
- Kaplan, K. (2013). Crowd-funding: Cash on demand. *Nature*, 497(7447), 147
- KeTTHA. (2012). *National Energy Balance 2011 Malaysia*. Kuala Lumpur: KeTTHA.
- Khan, H. J., & Huque, A. J. (1998). Solar Photovoltaic in Rural Electrification: Market Assessment Survey in Bangladesh. Washington: Energy Research Center.
- Khan, M. I., Chhetri, A. B., & Islam, M. R. (2007). Community-based Energy Model: A Novel Approach to Developing Sustainable Energy. *Energy Sources, Part B: Economics, Planning, and Policy*, 2(4), 353-370. doi: 10.1080/15567240600629534
- Klaus, F. (2010). *The Public-Private Partnership Handbook*. Manila: Asian Development Bank.
- Lai, L. L., & Chan, T. F. (2007). Distributed Generation - Induction and Permanent Magnet Generators: John Wiley & Sons.
- Lloyd, B., & Forest, A. S. (2010). The transition to renewables: Can PV provide an answer to the peak oil and climate change challenges? [doi: 10.1016/j.enpol.2010.08.014]. *Energy Policy*, 38(11), 7378-7394.
- Malaysia. (2006). *9th Malaysia Plan (2006-2010)*. Kuala Lumpur: The Government of Malaysia.
- Malek, B. A. (2010). *Renewable Energy Development in Malaysia*. Paper presented at the 34th APEC Expert Group On New And Renewable Energy Technologies (EGNRET), Malaysia.
- Masters, G. M. (2007). Renewable and Efficient Electric Power Systems (pp. 169): Wiley - IEEE Press.
- MBIPV. (2011). PV System Cost, from <http://www.mbipv.net.my/content.asp?zoneid=4&categoryid=12>
- Mosaic. (2013). Investing in Clean Energy Retrieved 10/05/2013, from <https://joinmosaic.com/>
- Muhammad-Sukki, F., Ramirez-Iniguez, R., Abu-Bakar, S. H., McMeekin, S. G., & Stewart, B. G. (2011). An evaluation of the installation of solar photovoltaic in residential houses in Malaysia: Past, present, and future. [doi: 10.1016/j.enpol.2011.09.052]. *Energy Policy*, 39(12), 7975-7987.
- Naidu, G. (2010). Chapter 7: Infrastructure Development in Malaysia. In N. Kumar (Ed.), *International Infrastructure Development in East Asia - Towards Balanced Regional Development and Integration* (pp. 204-227): Economic Research Institute for ASEAN and East Asia.
- Nel, W. P., & Cooper, C. J. (2009). Implications of fossil fuel constraints on economic growth and global warming. *Energy Policy*, 37(1), 166-180. doi: 10.1016/j.enpol.2008.08.013
- Nielsen, S. (2012). Brazil Solar Energy at \$299 a Megawatt-Hour Competes With Grid, *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2012-07-03/brazil-solar-energy-at-299-a-megawatt-hour-competes-with-grid.html>
- Noh, C. K. M. (Producer). (2012, 29/01/2013). Overview on the Energy Resources in Malaysia. [Forum]
- Oh, T. H., Pang, S. Y., & Chua, S. C. (2010). Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth. [doi: 10.1016/j.rser.2009.12.003]. *Renewable and Sustainable Energy Reviews*, 14(4), 1241-1252.
- Park, C. h. (1978). The south china sea disputes: Who owns the islands and the natural resources? *Ocean Development & International Law*, 5(1), 27-59. doi: 10.1080/00908327809545606
- Rüther, R., & Zilles, R. (2011). Making the case for grid-connected photovoltaics in Brazil. *Energy Policy*, 39(3), 1027-1030. doi: DOI: 10.1016/j.enpol.2010.12.021

- Sauter, R., & Watson, J. (2007). Strategies for the deployment of micro-generation: Implications for social acceptance. [doi: 10.1016/j.enpol.2006.12.006]. *Energy Policy*, 35(5), 2770-2779.
- Scoones, I. (1998). *Sustainable Rural Livelihoods: A Framework for Analysis* (pp. 22). Brighton: Institute of Development Studies.
- Severino, R. C. (2010). ASEAN and the South China Sea. *Security Challenges Volume 6*(Number 2 (Winter 2010), 37-47.
- Smith, K. (2007). Let the sun shine. *The Brief*, 17, 2.
- Sovacool, B. K. (2013). Expanding renewable energy access with pro-poor public private partnerships in the developing world. *Energy Strategy Reviews*(1), 181-192.
- SunFunder. (2013). Invest in Solar Empowerment Retrieved 10/05/2013, from <http://www.sunfunder.com/about/how-it-works>
- TNB. (2009). *Powering The Nation (1949 - 2009)* (T. N. B. (TNB), Trans.) (Vol. 1, pp. 313). Malaysia: Tenaga Nasional Berhad.
- TNB. (2012). Pricing and Tariff Retrieved 2 Sept 2011, from <http://www.tnb.com.my/residential/pricing-and-tariff.html>
- U Energy Solar. (2012). Rent My Roof, 2012, from <http://www.uenergysolar.co.uk/domestic-pv/rent-my-roof>
- UNHCR. (2008). *A Community-based Approach: in UNHCR Operations*. Geneva: United Nation.
- Walker, G., & Devine-Wright, P. (2008). Community renewable energy: What should it mean? *Energy Policy*, 36(2), 497-500. doi: <http://dx.doi.org/10.1016/j.enpol.2007.10.019>
- WCED. (1987). *the Brundtland Report*. World Commission on Environment and Development,.
- Weber, C., & Vogel, P. (2008). Assessing the benefits of a provision of system services by distributed generation. *Int. J. Global Energy Issues*, Vol. 29(Nos. 1/2), 162-180. doi: 10.1504/IJGEI.2008.016339
- Winter, M. (2007). *Sustainable Living: For Home, Neighborhood and Community*. the United States: Westsong Publishing.
- Writers, S. (2009). A Bright Future With Solar Lanterns For India's Poor 4 May 2009. Retrieved 27 June 2013, from <http://go.galegroup.com.ezproxy.auckland.ac.nz/ps/i.do?id=GALE%7CA198985778&v=2.1&u=learn&it=r&p=ITOF&sw=w>
- Wüstenhagen, R., & Bilharz, M. (2006). Green Energy Market Development in Germany: Effective Public Policy and Emerging Customer Demand. *Energy Policy*(34), 1681-1696.
- Zhang, Y., Song, J., & Hamori, S. (2011). Impact of subsidy policies on diffusion of photovoltaic power generation. *Energy Policy*, 39(4), 1958-1964. doi: DOI: 10.1016/j.enpol.2011.01.021

Collecting Energy from a Planetary Entropic Stirling Engine

S. Kazadi, A. Schwartz, J. Huang, R. Goy, C. Koo, S. Choi, J. Lim, A. Koh, J. Choi,
C. Koh, J. Wang

Jisan Research Institute, USA

0401

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

We extend previous work [1, 2] on *entrochemical systems*, energetically closed systems which spontaneously create an internal thermal gradients. Like an electrical battery, these *thermal batteries* use differing chemical potentials to generate work, though thermal work from their environment. This paper introduces a 'spontaneous' methodology for recharging the system. We utilize a solar chimney to generate airflow over a draw solution, evaporating water and reconcentrating the solution. The reconcentrated solution is used to restore the original internal concentration gradient which enables the entrochemical system. We examine a device comprising three major parts: a reaction chamber, a distiller, and a solar chimney. We measure the output of our thermal battery at $129.3 \pm 11.9 \text{ W/m}^2$ using KCl as an enabling salt and $235.3 \pm 15.3 \text{ W/m}^2$ using NaCl as an enabling salt. We measure internal recharge rates of $55.6 \pm 6.9 \text{ W/m}^2$ when using a KCl / NaCl salt pair and $116.4 \pm 18.0 \text{ W/m}^2$ when using a NaCl / CaCl_2 salt pair. We utilize a 6.096 m tall solar chimney with a 0.74 m^2 solar collector. This solar chimney enables airflow of $37.05 \text{ m}^3/\text{day}$. We measure a maximal evaporative performance of 1.213 L/day/m^2 . This corresponds to an effective energy utilization of 75.49 W/m^2 (50.5% of maximum, given the airflow). Extrapolation using the model of [3] to model a 35°C thermal lift and a 200 m tall chimney indicates an effective energy utilization of 405.49 W/m^2 . We discuss how this energy can enable water distillation. The process naturally stores entropic potential removing daily solar irradiance limitations and enabling on-demand energy. Waste products are humidified air, which may enable precipitation, and salt crystals.

1 Introduction

In 2010, Kazadi et. al. [1] coined the term entrochemical system to describe a class of systems in which the development of a thermal gradient through a spontaneous entropy transfer is possible. The devices presented in that work create a thermal gradient spontaneously as a result of the interaction between entropy and energy transfers between two water solution reservoirs of differing chemical potentials. Though the effect is predicted by thermodynamics [2], it has been largely unobserved due to the specific set of conditions required to enable it.

The systems also represent an example of what we call thermal batteries, devices that deliver a specific quantity of thermal energy, typically by using an exothermic chemical reaction. Recharging the system was not addressed in previous work. Entrochemical systems function via strictly physical changes as opposed to chemical changes. As a result, an input of heat can reverse the effect. Yet when the heat is directly applied to a closed system, this process is simple distillation of the concentrated solution, and requires more energy than one can extract from the thermal battery.

In this paper, we address a recharge method for entrochemical systems. This recharge method uses a solar chimney to enable evaporation of water from an intermediate solution used to “dry” the high concentration reservoir of the entrochemical device when it becomes diluted. This process, which is spontaneous, enables the continual use of the entrochemical system in “harvesting” atmospheric thermal energy.

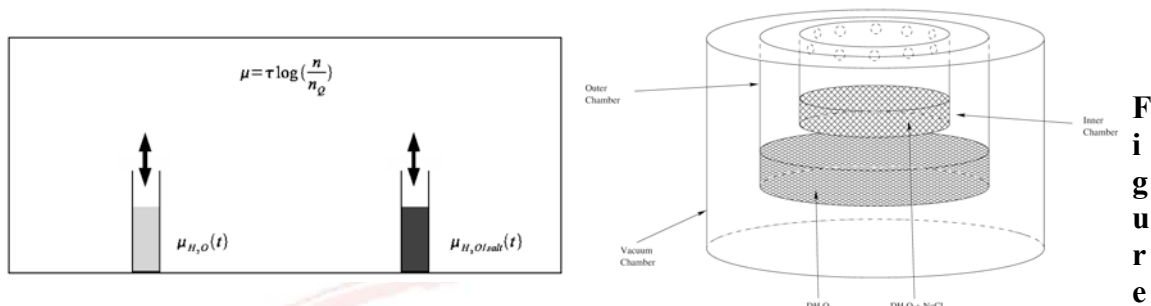
This device’s continual efficacy depends on the ability to continually transfer entropy to the atmosphere through evaporation, making this energizing step spontaneous. In order to explain why this effect does not ever stop, we introduce the concept of a planetary entropic Stirling engine, powered by solar heat. This analogy to a Stirling engine explains how, through the daily heating, the atmosphere is made able to accept entropy after daily rejecting entropy to space during cooling. In effect, our entrochemical system is “plugged in” to the planetary entropic Stirling engine by the solar chimney.

Section 2 describes the entrochemical systems and their energetic, entropic, and systemic properties. Section 3 discusses the planetary entropic Stirling engine. Section 4 describes the apparatus and procedures we developed to investigate this process. Section 5 provides experimental data. A discussion is given in Section 6. We conclude in Section 7.

2 Entrochemical Devices

2.1 Basic theory and experiments

The basic entrochemical system is diagrammed in Figure 2.1 below. In the basic system, two reservoirs are at least partially filled with water and enclosed in a larger chamber. One of the two reservoirs also contains salt.



F
i
g
u
r
e

2.1: (A) A diagrammatic description of a basic entrochemical system. The reservoirs of water, one containing salt (or more salt than the other) must, in equilibrium, be at the same chemical potential. This is only possible if they are at different temperatures. (B) A nested version of the entrochemical system with an external insulating vacuum jacket. [1] reported a thermal gradient of 2.5°C when used at 19°C with saturated NaCl solutions on top and distilled water on the bottom.

As a result, the chemical potentials of the two reservoirs, μ , cannot be the same at the same temperature. I.e.,

$$\mu_{H_2O}(t) \neq \mu_{H_2O/salt}(t). \quad (1)$$

In equilibrium the chemical potentials of the two solutions must be equal to that of the vapor

$$\mu_{H_2O}(t_{H_2O}) = \mu_{vapor}(t_{vap}) = \mu_{H_2O/salt}(t_{salt}). \quad (2)$$

contained in the chamber.

In order to avoid a contradiction, we must conclude that $t_{H_2O} = t_{salt}$, or that the two water reservoirs equilibrate at different temperatures. This equilibration is mediated by a vapor transfer from the water reservoir to the salt solution reservoir, increasing entropy and transferring heat (the heat of vaporization).¹

The resulting system approaches an equilibrium with a temperature gradient that brings the chemical potentials to approximate equality. The system never completely reaches equilibrium, however, as some of the thermal energy leaks out of the system from the warmer side or into the system through the colder side. At least a small flow of vapor from the water to the salt solution continues until either the concentrations of dissolved solutes in the two reservoirs become equal or all the water in the less concentrated side evaporates.

¹ A different proof is offered in [2].

2.2 Temperature gradients, entropy transfers, thermal work limits

We have shown elsewhere [2] that the temperature difference between two bodies of water of differing concentration is given by

$$T_1 = T_2 \frac{\mu_1 - 2 \frac{\partial U_1}{\partial N_1}}{\mu_2 - 2 \frac{\partial U_2}{\partial N_2}} \quad (3)$$

which can be used to yield

$$\Delta T = T_2 \left(\frac{(\mu_2 - \mu_1) + 2 \left(\frac{\partial U_1}{\partial N_1} - \frac{\partial U_2}{\partial N_2} \right)}{\mu_2 - 2 \frac{\partial U_2}{\partial N_2}} \right) \quad (4)$$

$$\Delta T \simeq T_2 \left(\frac{(\mu_2 - \mu_1)}{\mu_2 - 2 \frac{\partial U_2}{\partial N_2}} \right) \quad (5)$$

For solutions, where $\mu = -R \ln(x)$ with x the mole ratio of water in the solution² (4) becomes

$$\Delta T \simeq T_2 \frac{R(T_2 \ln(x_2) - T_1 \ln(x_1))}{RT_2 \ln(x_2) - 2 \frac{\partial U_2}{\partial N_2}} \quad (6)$$

$$\Delta T \simeq \bar{T} \left(\frac{4}{R \bar{T} \ln\left(\frac{x_2}{x_1}\right)} \frac{\partial U_2}{\partial N_2} - \sqrt{4 + \frac{16}{R^2 \bar{T}^2 \left(\ln\left(\frac{x_2}{x_1}\right)\right)^2} \left(\frac{\partial U_2}{\partial N_2}\right)^2} \right) \quad (7)$$

$$\bar{T} = \frac{T_2 + T_1}{2}$$

where $\frac{\partial U_2}{\partial N_2}$ is the molar heat of vaporization and \bar{T} is the average temperature. When applied to water, this temperature multiplier has the profile given in Figure 2.2 where the horizontal axes represent the mole fraction of the solutions and the vertical axis represents the multiplier.

² A derivation of this chemical potential may be found in [3].

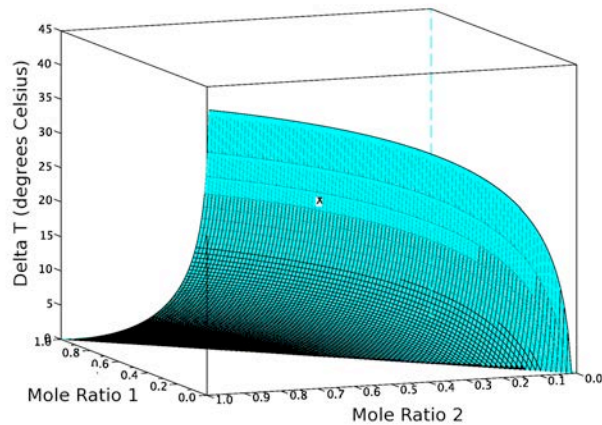


Figure 2.2: This figure illustrates the enthalpy multiplier given in equation (3). The horizontal axes represent the mole fractions of the two solutions and the vertical axis represents the multiplier value.

If x_1 is 1 (or pure water), the relation becomes

$$\Delta T \simeq RT_2 \left(\frac{\ln(x_2)}{\ln(x_2) - \frac{2}{RT_2} \frac{\partial U_2}{\partial N_2}} \right). \quad (8)$$

This becomes

In this case, the curve is given by

$$\Delta T \simeq \frac{4\bar{T}}{R\bar{T}\ln(x_1)} \frac{\partial U_2}{\partial N_2} - \bar{T} \sqrt{4 + \frac{16}{R^2\bar{T}^2 (\ln(x_1))^2} \left(\frac{\partial U_2}{\partial N_2} \right)^2}. \quad (9)$$

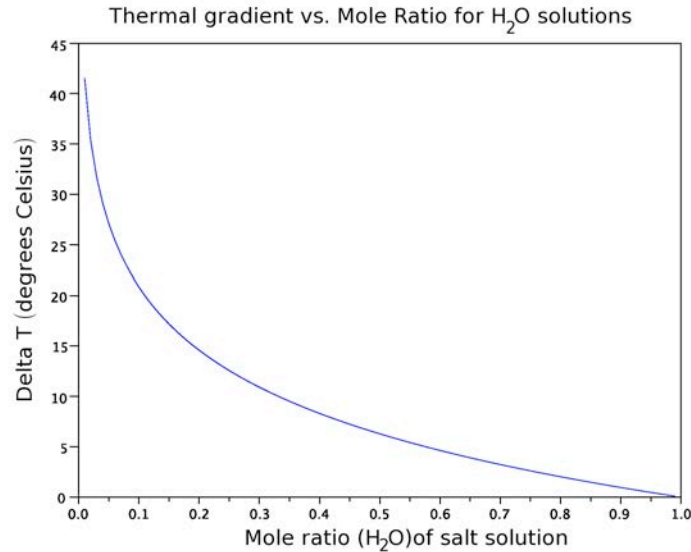


Figure 2.3: This figure illustrates the thermal gradient in a pair of water-based solutions in which one is pure and the other has the mole ratio given on the x axis (mole ratio of water in solution).

There is significant room for the development of thermal gradients when using water as a solvent.

Let there be two reservoirs containing saturated solutions of different species of salt, each with excess salt. If a quantity of water is transferred from reservoir 1 to reservoir 2, a quantity of energy equal to

$$\Delta U_1 = -(H_v - \Delta H_1) \Delta V \quad (10)$$

is extracted from reservoir 1. Likewise a quantity of energy equal to

$$\Delta U_2 = (H_v - \Delta H_2) \Delta V \quad (11)$$

is deposited in reservoir 2. ΔH_1 and ΔH_2 represent the enthalpy of dissociation of the salts within the reservoirs, and they need not be identical. In order to move ΔV from one reservoir to the next, a quantity of energy equal to ΔU_1 is absorbed by reservoir 1 and ΔU_2 is made available in reservoir 2. As a result, the efficiency is given by

$$e = \frac{\Delta U_2}{-\Delta U_1} = 1 - \frac{\Delta H_2 - \Delta H_1}{H_v - \Delta H_1}. \quad (12)$$

Note that this can be greater than 1 if $\Delta H_2 < \Delta H_1 < H_v$ or that $H_v < \Delta H_1 < \Delta H_2$.

The change in entropy is given by

$$\Delta S = \left(\frac{\Delta T}{2} \ln(x_1 x_2) - \bar{T} \ln \left(\frac{x_1}{x_2} \right) \right) \Delta V \quad (13)$$

$$\Delta S = \bar{T} \Delta V \left(\left(\frac{2}{R \bar{T} \ln \left(\frac{x_1}{x_2} \right)} \frac{\partial U_2}{\partial N_2} - \sqrt{1 + \frac{4}{R^2 \bar{T}^2 \left(\ln \left(\frac{x_1}{x_2} \right) \right)^2} \left(\frac{\partial U_2}{\partial N_2} \right)^2} \right) \ln(x_1 x_2) - \ln \left(\frac{x_1}{x_2} \right) \right) \quad (14)$$

The system always increases in entropy when moving a quantity of water from the lower concentration solution to the higher concentration solution (ΔS is always positive). As a result, this process is spontaneous.

The entropochemical device enables an entropy transfer from the lower to the higher concentration solution. The magnitude of the thermal gradient is limited by the concentration gradient between the two solutions, which is dependent on the specific solvent/solute pairs. In practice this magnitude can be quite small.

3 Plugging into the planetary entropic stirling engine

We define entropic potential as the maximum entropy a liquid can contribute to a volume of gas at a given temperature. If the water vapor in a volume V behaves like an ideal gas, then its total entropy is given by a form of the Sackur-Tetrode equation. This gives us that

$$\sigma = nV \left[\ln \left(\frac{n_Q}{n} \right) + \frac{5}{2} \right] \quad (15)$$

where P is given by ³

$$P = \frac{10^{\left(8.07131 - \frac{1730.3}{233.426 + (T - 273.15)} \right)}}{760RT} \quad (16)$$

in atmospheres and n_Q is given by

³ This is an approximation based on Antoine's equation [6].

$$n_Q = \left(\frac{mk_B T}{2\pi\hbar^2} \right)^{\frac{3}{2}}$$

As a result, an amount of water equaling

$$\Delta V_w = \frac{\Delta P V_g}{RT M_m \rho_w}$$

can be evaporated into the air, where V_g is the volume of air, M_m is the molecular mass, ρ_w is the solution density, and ΔP is the pressure difference between the vapor pressures at the two temperatures. This will have a concomitant increase in entropy. Thus heating the air has the potential to draw more vapor out of solution, transferring entropy. This potential change in entropy is the entropic potential of the system and it is this we wish to take advantage of.

The increase in entropy is graphed in Figure 3.1, which illustrates the temperature dependent maximum entropy of a volume of gas.

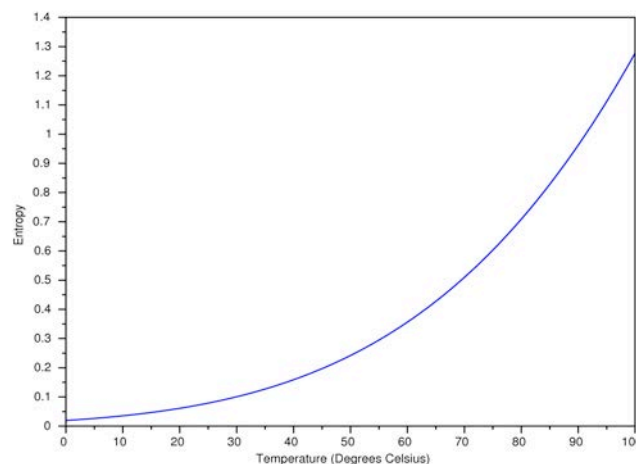


Figure 3.1: These figures give the temperature-dependent maximum entropy of a volume of gas.

The maximum entropy of the day and night environments are different, and this enables evaporative entropy transfer during the day and forces condensation-mediated nighttime entropy leakage at night.

Analogously to the Stirling engine, the daily process can be characterized as the creation of a high entropic potential atmosphere and the subsequent restoration of the previous low entropy state. What

is required to “plug in” to this Stirling engine is a method of taking advantage of the daytime expansion of entropic potential and its subsequent nightly reduction.

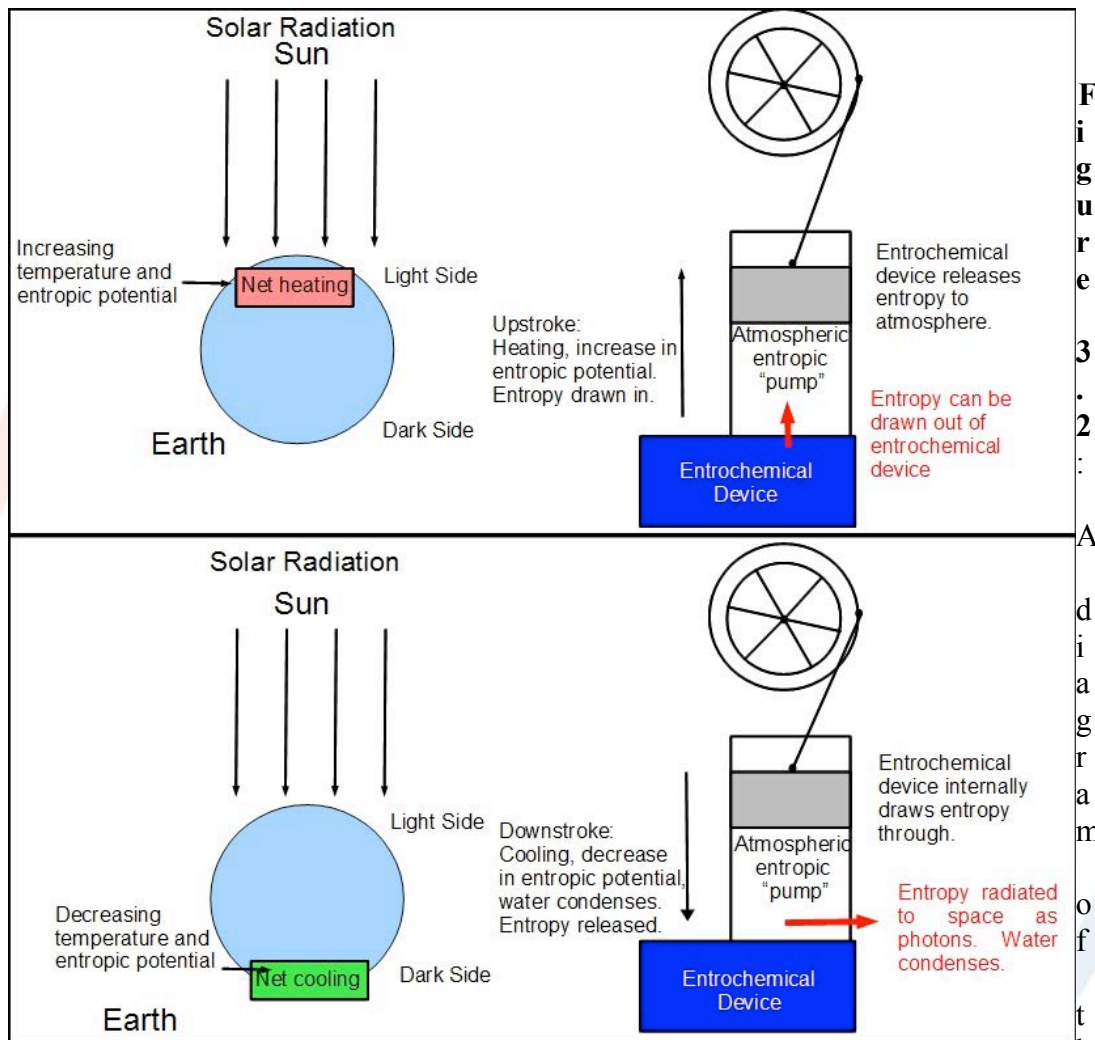
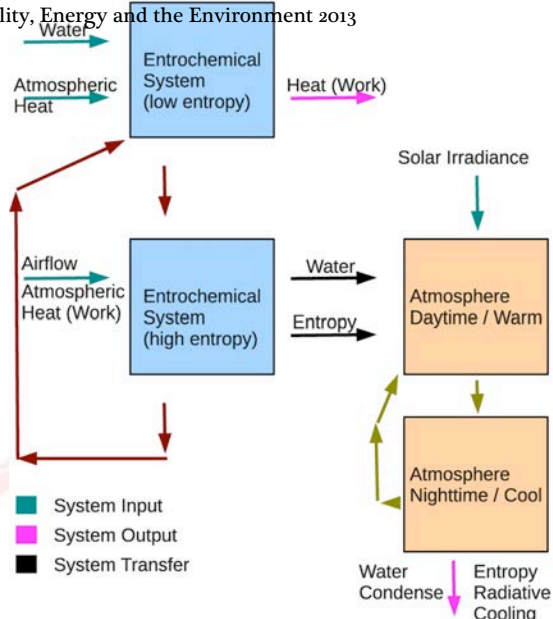


Figure 3.2: A diagram of the planetary Stirling engine daily cycle.

The capacity of an entrochemical system is reached when either the solute concentrations of the two solutions become equal or the solvent in the one of the two solutions (that with lower solute concentration) becomes exhausted. Once this capacity is reached the solvent has been transferred to the high concentration solution. In order to restore its functionality, new solvent must be provided to the bottom reservoir and the solvent must be separated from the solute in the top reservoir. It is the latter of these two steps that requires the input of energy. When coupled to a process that induces a positive entropy change, this step is spontaneous.

The overall process, which we call the “Kazadi-cycle” or “k-cycle,” is illustrated below in Figure 3.3 and involves three spontaneous steps. First, the entrochemical effect generates the movement of fluid from one reservoir to the other, producing work. Second, the entrochemical effect moves fluid from



the top reservoir into the draw solution. Third, evaporation of the solvent from the draw solution utilizes atmospheric thermal energy to transfer entropy into the atmosphere.

Figure 3.3: This process, known as the “Kazadi cycle” or “k-cycle” follows the entropic inputs to the system and its pathway out of the system.

The top reservoir has a T-S diagram illustrated in Figure 3.4.

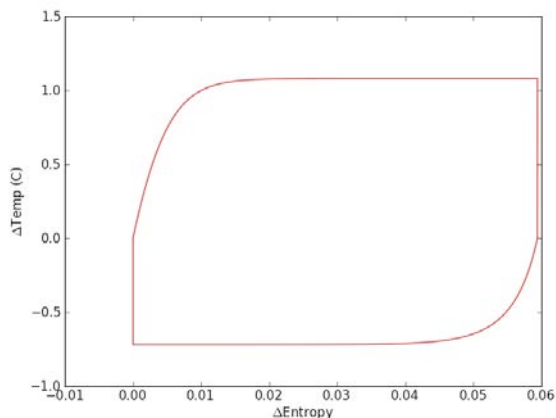


Figure 3.4: The T-S diagram associated with the top reservoir in the entrochemical device. Initially, the temperature increases, followed by a leveling off and concomitant increase in entropy. An adiabatic phase ends with the maximal entropy at which point the temperature difference decreases to zero. A reversal occurs as the entropy decreases coupled with an decrease in temperature until all the water has been extracted. At that point, entropy has returned to the minimum and the system equilibrates to a common temperature (no temperature difference).

This diagram illustrates the thermodynamic cycle the top reservoir goes through. Initially, vapor movement rapidly increases the temperature gradient between the high and low temperature reservoirs. Next, the reservoir goes through an isothermal stage during which heat is drawn into the system and radiated out of the system at a constant speed while the solvent is transferred between them. The rate at which the solvent is transferred is limited by either the maximal rate of the entrochemical effect or by the rate at which heat is radiated to the environment. Once the solvent transfer has ended the system rapidly comes to thermal equilibrium. Subsequently, during the evaporative stage, the temperature of the solution drops while the entropy of the solution drops. When the evaporative stage ends, the system reaches thermal equilibrium and returns to the initial point.

This cycle enables the continued extraction of environmental thermal energy for the purpose of doing work as long as the atmosphere is capable of absorbing water vapor. Since the world is turning, this ability is restored on a daily basis (or no water would ever evaporate from the ground when there is a spill, rain, etc.). As a result this process can continue virtually indefinitely⁴.

In order to tie the system's performance tightly to the environmental entropic potential, a method must be used to efficiently evaporate the water in the high concentration solution. Increasing airflow over a water body serves to increase the evaporative action. We utilize a solar chimney, which will be described in Section 4.1.2.

4 Materials and Methods

We have developed two devices capable of accomplishing together the thermal energy extraction and work production. In addition, we have developed several methods in order to achieve the experimental results of this study.

4.1 Apparati

4.1.1 Basic Entrochemical Reaction Chamber

We have developed an entrochemical reaction chamber which is diagrammatically illustrated in Figure 4.1.

4 In our experiments, water is used as the solvent. This means that the output of the system as a result of the evaporation is water vapor, which may be expected to have a negligible environmental impact. Other solvents one might use, such as ethanol, might have significantly deleterious environmental impacts if released in large quantities, and so are not solvents of choice for this purpose.

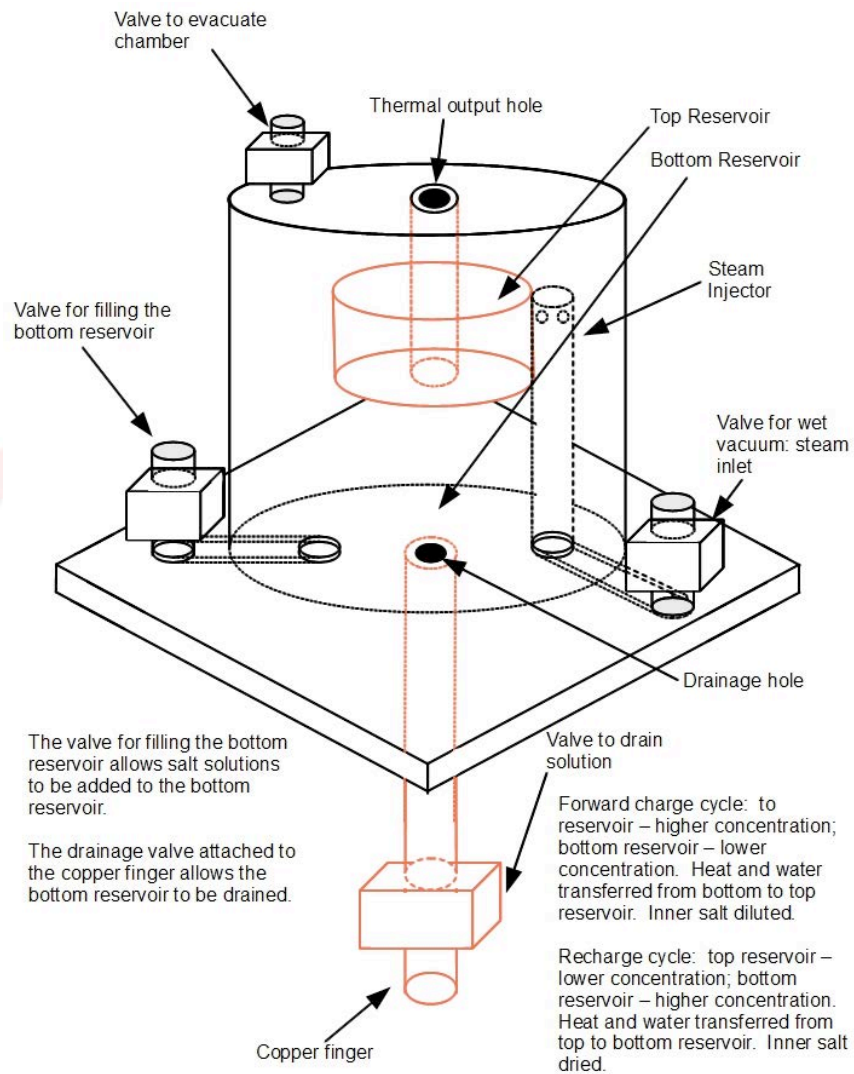


Figure 4.1: The entrochemical reaction chamber contains two reservoirs of salt at different concentrations. The resulting flow of fluid from one reservoir to another serves to alternately draw water into the top reservoir or draw it out of the top reservoir, depending on the relative osmolarities of the solutions.

The chamber is made from 4" OD cast acrylic tubing approximately 4" long and sealed on each end by 1/4" to 1/2" thick acrylic sheet. Channels in the acrylic approximately 1/8" deep and 3/8" wide connect the interior of the chamber to valves which seal off the chamber from its exterior. The chamber contains two reservoirs spatially separated from one another. The bottom reservoir can be alternately filled and drained by opening valves on the side or bottom of the chamber. The top reservoir contains a static salt supply which is alternately diluted as a result of the absorption of water vapor or concentrated as a result of evaporating water into the chamber. The chamber contains a steam injector through which steam can be injected. At the top of the reaction chamber is a valve through which a vacuum is applied. Underneath the reaction chamber is a copper tube and a valve. The valve enables the draining of the chamber while the copper tube enables the absorption of thermal energy. The top reservoir is made of copper. A copper tube is soldered into the center of the reservoir, sealing the tube's interior on the reservoir. The top of the tube is connected to the top of the chamber, and its interior is topologically connected to the exterior of the chamber through a hole in the top of the chamber.

4.1.2 Solar Chimney

Our solar chimney [4,5,6,10] comprises three principle parts: a solar collector, a dessicator, and a chimney. The parts are connected via ducting or direct contact as illustrated in Figure 4.2.

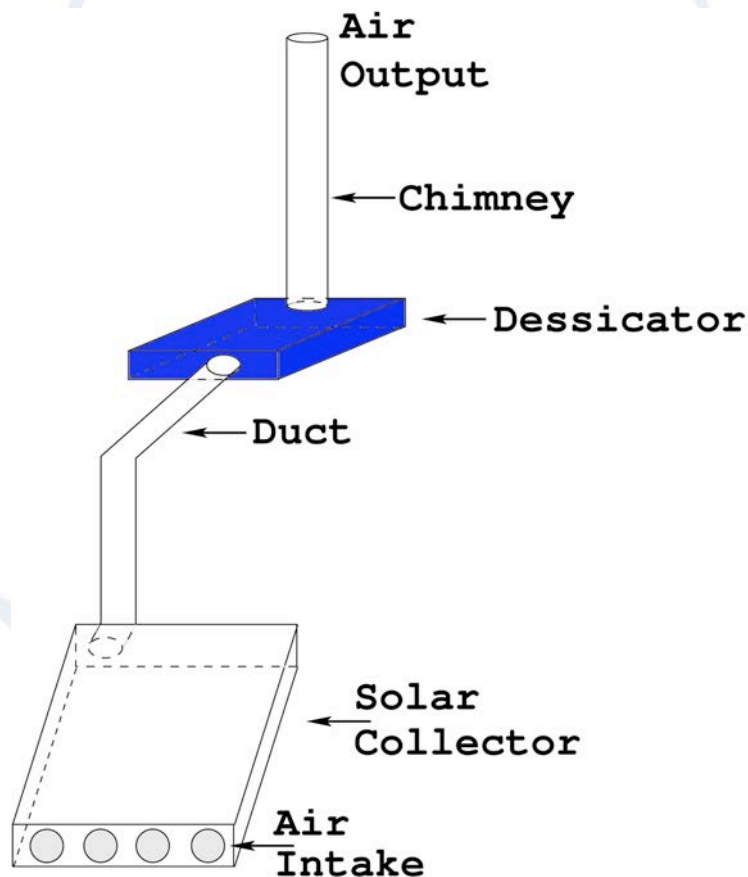


Figure 4.2: The solar distiller comprises three principle parts: a solar collector, a dessicator, and a chimney. These parts are connected with ducting and enable airflow through the system when exposed to sunlight.

Our solar collector has an approximate surface area of 8 ft² (or 0.74 m²). It has a simple “box” design with a transparent top panel, transparent side panels, and a black bottom panel.

Ducting connects the solar collector to the dessicator. The ducting is heavily outfitted with insulation. The dessicator is a plastic square approximately 2 ft (or 0.61 m) in side length made of 7.62 cm inner diameter ABS plastic tubing, two mating t-connectors, and four mating 90° connectors. It is connected to the ducting at the middle of one side of the square and the tower on the opposite side using the t-connectors. One t-connector is angled at 90° from the plane of the square and the other at 45° from the plane on the same side. The 90° connector is coupled to the tower while the 45° connector is coupled to the solar collector. This enables pooling of liquid to be dessicated, enabling approximately 2.5 cm deep liquid to be retained within.

Cotton strips approximately 2.5 cm in width are hung from the ceilings of the dessicator on the sides not containing the t-connectors so as to increase the evaporative surface area. The cotton strips are staggered with approximately 2.5 cm separating subsequent strips. The staggering allows airflow to be directed from one strip into the next strip, ostensibly increasing the overall evaporative capacity of the airflow.

The tower is constructed of 7.62 cm inner diameter ABS plastic tubing coupled by an ABS pipe fitting. It is 6.096 meters tall.

4.2 Wet vacuum

A wet vacuum is a vacuum in which all gasses have been removed excepting the solvent used in the experiment. We establish wet vacuums by injecting steam produced by applying vacuum to a warm water body into one part of the cavity while a vacuum is applied to another distal part of the cavity.

In our studies, we use 500 mL of water prepared by heating to approximately 76°C. Steam is injected into our chambers as outlined above. The vacuum is maintained for a period of at least one minute to ensure that most of the air that is not water vapor is removed from the chamber.

4.3 Salt production

It is necessary to utilize salt crystals that do not have air pockets contained within. Three methods of obtaining these crystals are described below.

4.3.1 Salt Drying Method 1

A quantity of water with an excess of salt is heated to boiling. This solution is decanted from the remaining salt into a pre-heated container. The container is then placed into a vacuum chamber and subjected to a mild vacuum. Boiling of the water in the container generates steam. Steam moving out from the container sweeps out unwanted air. The container is then sealed under vacuum and allowed to cool. Crystals precipitate out of the cooling solution in an air-free environment.

4.3.2 Salt Drying Method 2

Two chambers are connected to one another so that vapor can pass freely between them. A saturated salt solution is placed into one chamber. Both chambers are sealed and a wet vacuum is established

within. The saturated salt solution is heated, driving water from the solution into the other, colder chamber; salt crystals without enclosed air are thereby formed.

4.3.3 Salt Drying Method 3

One chamber is prepared with a quantity of a saturated solution prepared with a salt with a high osmolarity within. A thermally conducting container is placed within so that it is in contact with the surface of the water, but water cannot pass into the container. A second saturated salt solution prepared with a salt with a lower osmolarity is placed inside the container. The container is sealed with a wet vacuum. Salt crystals of the second salt form as the first salt solution absorbs the water from the second.

4.4 Forward Direction

The forward direction is that use of the system which enables thermal work. The forward direction is measured in terms of its maximal ability to move energy through the system. This is achieved by maintaining both the energy input and output surfaces at the same temperature via a water bath. The salts utilized in the forward direction are KCl and NaCl.

Referring to Figure 4.1, we place 20 g of prepared salt and 10 mL of H₂O in the top reservoir. We place 150 mL of water in the bottom reservoir, making sure that this water is not in physical contact with the top reservoir. A wet vacuum is established in the reaction chamber and the entire reaction chamber is placed into a water bath. The water is circulated around the thermal input of the reaction chamber and into the tube thermally connecting the top reservoir to the exterior. After a period of between 12 and 72 hours (varied so as to eliminate transient effects), the amount of water transferred between the two reservoirs is measured.

4.5 Recharge Procedure

Once the salt in the top reservoir has been fully dissolved, it is necessary to dry it, regenerating the salt crystals. This procedure consists of two different processes. In one, the salt in the top reservoir is directly dried. In the second process, the higher osmolarity solution used to dry the salt is itself dried. The salt pairs used in this study are KCl/NaCl and NaCl/CaCl₂.

4.5.1 Recharging the salt reservoir

Thirty grams of saturated KCl or fifty grams of saturated NaCl salt solution are put into the top reservoir. Approximately 450 mL of saturated high osmolarity salt solution is placed in the lower reservoir chamber – enough to bring the solution's surface into contact with the top reservoir. A wet vacuum is established in the reaction chamber. After a period of time, varying from 12 to 72 hours, the reaction chamber is emptied of the high osmolarity solution having regenerated the salt crystals. The amount of solution remaining in the top reservoir is measured; the amount of water moved is the difference between the initial amount and this measurement.

4.5.2 Recharging the high osmolarity solution

This procedure involves utilizing the solar chimney described in Section 4.1.2. A quantity of the high osmolarity solution, ranging from two to three liters, is placed in the dessicator device of the solar chimney. This solution is removed from the solar chimney between 5 and 24 hours later. The salt solutions used as high osmolarity draw solutions are NaCl and CaCl₂.

5 Data

We collected data on several different kinds of experiments. The first set of experiments validated those salt pairs that might be used in a system which enabled the full charge/recharge cycle of the thermal battery. These data are summarized in Table 5.1.

Charge Salt	Recharge Salt
<i>KCl</i>	<i>NaCl</i>
<i>KCl</i>	<i>CaCl₂</i>
<i>KCl</i>	<i>ZnCl₂</i>
<i>NaCl</i>	<i>CaCl₂</i>
<i>NaCl</i>	<i>ZnCl₂</i>
<i>CaCl₂</i>	<i>ZnCl₂</i>

Table 5.1: These charge/recharge salt pairs enable the full cycle entrochemical system.

These data are obtained by utilizing the reaction chamber to enable the forward direction of the reaction. In this case, the charge salt and a quantity of water are used for the forward direction. Subsequently, the water is replaced with a saturated solution of the recharge salt. The experiment initially evaluated whether the pair of solutions would yield a set of crystals in the charge salt solution as it was desiccated by the recharge solution. The pairs given in Table 5.1 are those tested that produced crystals at the conclusion of the cycle.

As $ZnCl_2$ cannot be dried via airflow of air through a solar chimney in most natural environments, we limit our examinations of the system to the salt pairs: $KCl/NaCl$ and $NaCl/CaCl_2$.

We collected data regarding the maximal rate of movement of liquid and energy in the forward direction using distilled water in the bottom reservoir of the reaction chamber and saturated saline solutions with excess salt crystals in the top reservoir of the reaction chamber using the process described in Section 4.4.1. These data provide the maximal energy transfer rates possible for our thermal batteries.

Saline Solution	Volumetric Rate (<i>L/day/m²</i>)	Energetic Rate (<i>W/m²</i>)
<i>KCl</i>	4.99 ± 0.46	129.3 ± 11.9
<i>NaCl</i>	9.08 ± 0.59	235.3 ± 15.3

Table 5.2: These are the measured rates of water throughput and their corresponding energetic rates.

We collected data regarding the rate of recharge – movement of liquid from the top reservoir to the bottom reservoir during which the salt crystals in the top reservoir are regenerated. This provides information about how quickly the devices can be restored to functionality. This process, as described in Section 4.5.1, negates the need for thermal energy input, as energy is repeatedly transferred to and from each of the solutions during the process. The data are given in Table 5.3.

Saline Solution	Recharge solution	Volumetric Rate(L/day/m ²)	Energetic Rate (W/m ²)
<i>KCl</i>	<i>NaCl</i>	2.14 ± 0.27	55.6 ± 6.9
<i>NaCl</i>	<i>CaCl₂</i>	4.49 ± 0.69	116.4 ± 18.0

Table 5.3: These are the measured rates of saline solution recharge and their corresponding energetic rates.

We measured the rate at which the recharge solutions used can be regenerated in the process described in Section 4.5.2. These data were obtained at 34°4'55''N 118°8'6''W at times during spring and summer months, with average irradiance as indicated in Table 5.4. The solar chimney's throughput was measured at

We measured the rate of wind flow in the solar chimney as 1.30 m/s. This corresponded to a total volume of 37.05 m³ /day⁵. We also measured the thermal lift at an average of 13.87°C. Given these data, we calculate the maximum daily evaporative capacity of this volume as 1.778 liters. Therefore the evaporative efficiencies of the solar chimney desiccating the NaCl and CaCl₂ solutions, respectively, were 50.5% and 5.62%.

6 Discussion

We are in search of an energy source that provides at least parity for solar irradiance at the surface of the earth but is capable of achieving this whilst

- generating little or no waste materials,
- being constructed of materials that can easily be built by virtually any society on earth,
- providing environmental remediation when used in the proper environments,
- and can be built in virtually any size and integrated into virtually any structure.

Saline Solution	Average Solar Irradiance	Volumetric Rate (L/day/m ²)	Energetic Rate (W/m ²)
<i>NaCl</i>	900	1.213 ± 0.145	75.49 ± 9.04
<i>CaCl₂</i>	913.44	0.338	26.27

Table 5.4: These are the measured rates of saline solution drying in our solar chimney at conditions water throughput and their corresponding energetic rates.

The technology described in this work is a promising candidate for an energy system that achieves these goals.

6.1 Energy potential

We have demonstrated that the use of our solar chimney can enable 1.213 L/m² /day of evaporation when used with NaCl and 0.338 L/m² /day of evaporation when used with CaCl₂. This means that the solar chimney is doing an amount of work on the solutions equivalent to the input of 2.717 MJ/m²

5 We assume a 10 hour day of significant solar irradiance.

/day or $0.757 \text{ MJ/m}^2 \text{ /day}$. As the movement of air is achieved by the solar chimney but the evaporation is largely enabled by the ambient thermal energy of the external air, most of this work can be viewed as having been done by the air on the liquid with a concomitant transfer of entropy to the air.

We have also demonstrated that when used in the recharge mode, these solutions enable $2.14 \text{ L/m}^2\text{/day}$ (KCl/NaCl) and $4.49 \text{ L/m}^2\text{/day}$ (NaCl/CaCl₂) of regeneration. This is equivalent to the effect of driving off water from the solutions using $4.8 \text{ MJ/m}^2\text{/day}$ (KCl/NaCl) and $10.1 \text{ MJ/m}^2\text{/day}$ (NaCl/CaCl₂). As a result, the ability of the NaCl and the CaCl₂ solutions to absorb liquid from the KCl and NaCl solutions, respectively, represents the equivalent of an energetic input. Yet, though it is mediated by a thermal transfer and a subsequent reverse thermal transfer through the reservoir material, it is accomplished without significant external energetic input, though some small environmental energy will be absorbed to compensate for the increase in entropy.

Finally, we have demonstrated the maximal energetic transfers possible in the forward direction using the basic entrochemical system. We have shown that a maximum of $4.99 \text{ L/m}^2\text{/day}$ (KCl) or $9.07 \text{ L/m}^2\text{/day}$ (NaCl) are transferred in the forward direction, and that this yields an energetic throughput of $11.17 \text{ MJ/m}^2\text{/day}$ (KCl) or $20.33 \text{ MJ/m}^2\text{/day}$ (NaCl).

Together, these indicate that the throughput of the device is limited by the performance of the solar chimney in our model. Extrapolating to much larger solar chimneys in hotter climates transfers the limiting factor to the recharge performance. However, as the units can be stacked to improve the overall performance given a specific footprint, it is likely that a facility employing this technology would still be primarily limited by the performance of the solar chimney. As a result, the power equivalent of the solar chimney is likely to be the limiting factor determining the energy potential of the technology.

We can evaluate the performance of larger solar chimneys in different climates using the model of Schlaige et. al. [3] If we extrapolate to a larger solar chimney with a height of 200 m and with a thermal lift of 35°C , the throughput and therefore energetic potential is 0.405 kW/m^2 or 6.52 L/day/m^2 .

6.2 Water and electrical energy production

We have already seen that the entrochemical effect generates a significant energy yield and that this energy is provided in the form of thermal energy drawn through the thermal battery. It makes sense, then, that this energy could be used for a variety of thermal processes, though these processes must be enabled. At energetic outputs described in Section 6.1, this process can enable the production of $1.214 \text{ L/m}^2\text{/day}$ of water when using the solar chimney used in this study. Projected production for a larger chimney is bounded above at 6.52 L/day/m^2 ⁶. In order to determine the actual output of this method, we propose the entrochemical distiller design given below. These experiments, though under way, will have their outcomes reported in an upcoming publication.

The entrochemical distiller comprises of a two parts: a basic entrochemical reaction chamber and a thermal distiller (Figure 6.1). Heat collected in the top reservoir passes naturally into the distillation water reservoir through the copper pipe connected to the top reservoir. The water in the distillation water reservoir is warmed by the heat, generating vapor which is warmer than the outside world. This

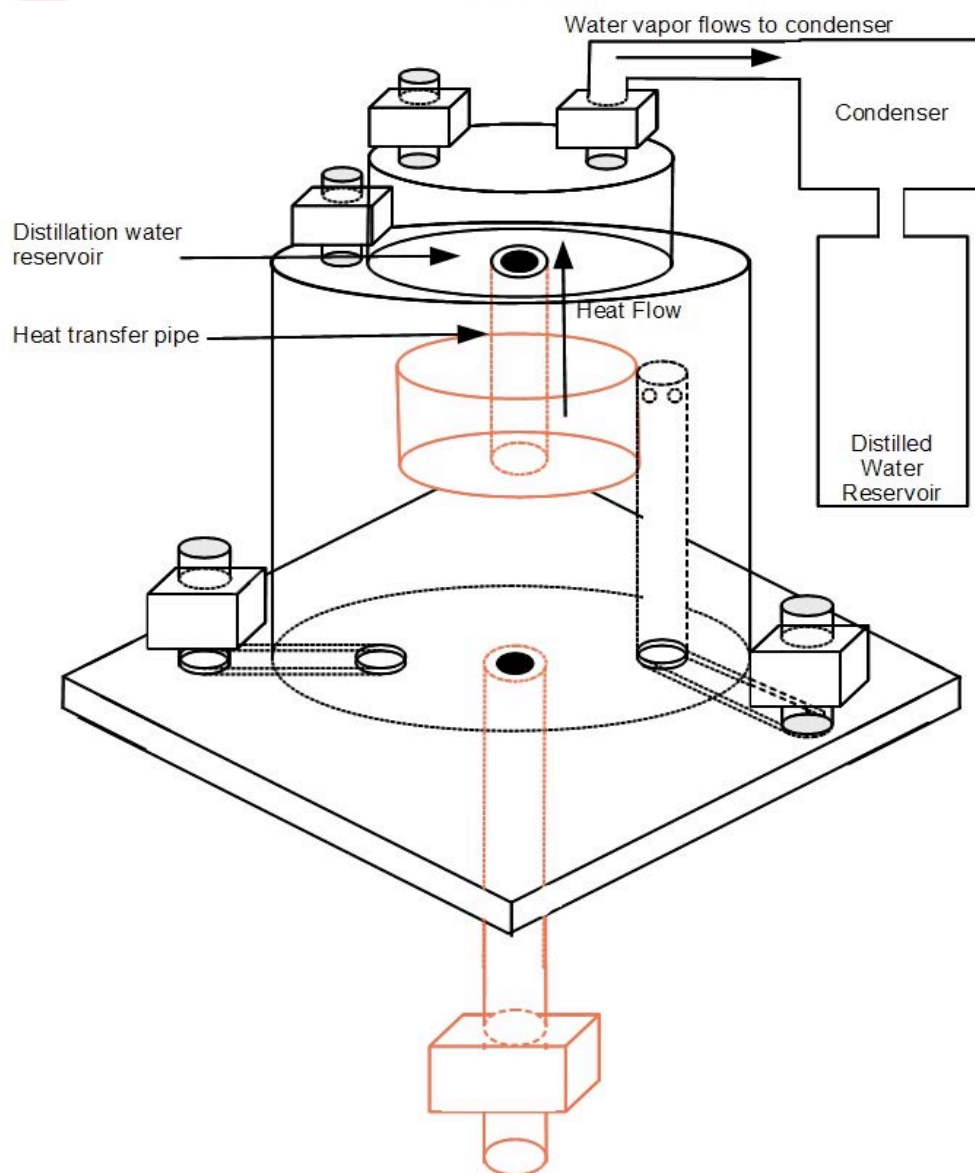
6 This amount is enough to supply the City of Los Angeles, California, assuming 100% efficiency and a 25,000 acre facility – the same size as that planned by the company Enviromission.

vapor travels to the condenser where it condenses and falls into the collector. This is a single effect distiller, so the heat passes naturally back into the environment.

Figure 6.1: The entrochemical distiller has the basic entrochemical reaction chamber embedded and adds to the simple system a thermal distiller which utilizes the heat of the entrochemical effect to heat and vaporize water which condenses and is collected.

This device is currently under investigation; results will be reported in an upcoming publication.

We also intend to investigate the use of the process in generating electrical power using a process of forward osmosis [9], enabled by our distilled water production. This work is underway and will be reported in an upcoming publication.



6.3 Energy storage

One of the important aspects of future renewable energy systems is their ability to, either independently or in concert with supporting technologies, store energy. We have shown that the method of drawing in energetic potential in the thermal battery technology is in restoring the properly generated crystals in the top reservoir of the reaction chamber through the recharge process. This process can easily be decoupled from the forward (work mode) process, and the crystals therefore represent stored energetic potential. The crystals, once created, can be physically removed from the systems and stored virtually indefinitely without degradation of their potential for future energetic activity. As a result, the system automatically stores the energetic potential it extracts from the air during the evaporative process.

6.4 Environmental Remediation

A current and urgent problem around the world is the availability of water and the lack of rainfall. It has been noted elsewhere[4] that the use of solar chimneys can enable cloud formation both outside of and within solar chimneys. The reason for this is that updrafts can yield humid air that cools as it rises. If the cooling proceeds beyond the point where the air's dew point is higher than the current temperature, water vapor can condense immediately. This process generates condensation which can grow into clouds and, eventually, into rain.

Even in the case that the solar chimney does not generate clouds, it will generate humidified air. If the air is in sufficient volume, it can generate localized condensation at night as it cools. Such condensation could generate rainfall affecting drought prone regions. This effect requires significant additional research, and remains as an interesting potential effect of this energy-generating modality. If this effect is observed, it would provide water that would, in turn, generate increased growth of local vegetation. The environmental remediation due to such growth could include carbon sequestration, if sufficiently large devices are deployed or if sufficiently many devices are used.

Though other technologies are known which change ambient heat into work [8] and others are, aside from producing heat, potentially environmentally neutral [7], no other renewable power source is known to the authors with the potential for generating environmental remediation.

7 Concluding Remarks

This paper centers the observation that the temperatures of two solutions with different osmolarities are necessarily different at equilibrium and that the entropic potential of the earth's atmosphere varies daily, enabling the absorption of additional entropy during the day and the rejection of entropy during the night. The combination of these two things enables the creation of the Kazadi cycle during which thermal energy can be extracted from the environment and made available to do work; additional thermal energy from the environment can enable the transfer of water and associated entropy to the atmosphere. As the process is enabled by the planetary entropic Stirling engine, it can be expected to continue indefinitely.

In thermodynamic terms, we have demonstrated that the process of transferring water from a low concentration solution to a high concentration solution is spontaneous, as is transferring water to the environment through evaporation. We have demonstrated that the atmosphere has a positive entropic potential change through the daily heating and a subsequent reduction in entropic potential through a rejection of heat during the night. As a result, the processes that enable these entropy transfers are spontaneous and indefinite, powered by thermal energy from the sun, its absorption in our atmosphere daily, and its subsequent rejection.

We developed a set of apparatus and processes to examine this effect and measure the forward (work-enabling) modality and the reverse (regenerating) modality. We find that when these two modalities are implemented using the salt pairs KCl/NaCl and NaCl/CaCl₂ the maximum forward liquid transfer is 4.98 and 9.02 L/m²/day, respectively, and the maximum recharge rate is 2.19 and 4.49 L/day/m². These are equivalent to a forward energy production of 129.3 W/m² or 235.3W/m², respectively. We have also examined the use of a small solar chimney as a means of restoring the high osmolarity solution and found that the NaCl and CaCl₂ solutions may be restored at a rate of 1.213 L/day/m² and 0.338 L/day/m² respectively. We estimate that solar chimneys similar to that deployed during the early 1980's in Manzanares Spain by the American company Enviromission can extend this capacity beyond the maximum single chamber recharge rate, with estimates as high as 6.52 L/day/m².

This process and these apparatus provide a significant step toward a fully renewable power source. The energy derived from this process may be delivered in the form of heat and subsequently transformed to any number of alternative forms. We have already outlined a process by which this can be applied to water distillation – a process that we are currently investigating and will report in an upcoming paper. The apparatus described and processes developed are such that they may be implemented by virtually any society on the planet using indigenous materials and processes. As a result, it represents a promising potential form of power generation that can be adopted virtually anywhere.

Future work will focus on the development of fully integrated (charge/recharge) systems for the purpose of generating sustained heating/cooling, water distillation, and electrical power generation.

References

- [1] S. Kazadi, R. You, M. Kim, M. Kim, M. Kim. *A passive regulated thermal gradient device and application to unpowered refrigeration and heating*, **Proceedings of the Renewable Energy Conference 2010**, Yokohama, Japan, June 27-July 2, 2010.
- [2] S. Kazadi, Y. Hong, C. Chau, A. Chaudhary, A. Chaudhary, J. Park, J. Liu, M.Kim, D. Kim, S. Kim. *Desalination powered by entropy*. **Proceedings of the Asian Conference on Sustainability, Energy, and the Environment 2011**, Osaka, Japan, June 2-5, 2011.
- [3] Kittel and Kroemer. **Thermal Physics**. New York: W. H. Freeman and Company, 1980
- [4] J. Schlaich, R. Bergermann, W. Schiel, and G. Weinrebe. *Design of Commercial Solar Updraft Tower Systems – Utilization of Solar Induced Convective Flows for Power Generation*, **ASME J. Solar Energy Enj.**, 127(1), pp. 117-124, 2005.
- [5] A. G. Ferreira et. al. *Technical Feasibility Assessment of a Solar Chimney for Food Drying*. **Solar Energy**, 82, 198-205, 2008.
- [6] T. VanReken and A. Nenes. *Cloud Formation in the Plumes of Solar Chimney Power Generation Facilities: A Modeling Study*, **Journal of Solar Energy Engineering**, 131, 011009, 2009.
- [7] Goldstein, B., G. Hiriart, R. Bertani, C. Bromley, L. Gutiérrez-Negrín, E. Huenges, H. Muraoka, A. Ragnarsson, J. Tester, and V. Zui: *Geothermal Energy*. In **IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation** [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2011.

- [8] P. Santhanam, D. Gray Jr., and R. Ram. *Thermoelectrically Pumped Light-Emitting Diodes Operating above Unity Efficiency*. **Phys. Rev. Lett.** 108, 097403, 2012.
- [9] T.Y. Cath, A.E. Childress, and M. Elimelech. *Forward osmosis: principles, applications, and recent developments*. **Journal of Membrane Science**, 281, 70-87, 2006.
- [10] Y. Jannot and Y. Coulibaly. *The “evaporative capacity” as a performance index for a solar-drier air-heater*. **Solar Energy**, 63 (6): pp. 387-391, 1998.



An Impact Evaluation of Rural Electrification Projects in China

Xueting Wang

National University of Singapore, Singapore

0408

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

China has made remarkable achievement in rural electrification in the past century. This study analyzes and evaluates the socioeconomic impacts of rural electrification projects in China using data from 2003 Rural Survey on World Bank Project Evaluation. Both the results of Difference-in-Differences (DiD) method and a combined Propensity Score Matching (PSM) and DiD approach show that rural electrification in China has raised rural income significantly. The increase of income can be attributed to productive use of electricity and increased output from Township and Village Enterprises (TVEs). Though positive impact is found on the percentage of people with high school diploma or above, it is not practically significant, which shows that the causal mechanism suggested in the literature that links electrification to academic success may not hold beyond basic education.

Introduction

Rural electrification has been of great interest because it has been seen as an important policy tool for rural development. Rural Electrification in China has been implemented in several stages. Before 1979, rural electrification rate only grew slowly. There is still thirty-seven percent of the rural population, or 245 million people had no access to electricity by 1979 (Peng and Pan 2006). From 1979 to 1998, electrification access grew rapidly, and electricity access rate for rural townships, villages, and households was 99.2%, 98.1% and 96.87% respectively by 1998 (Pan et al 2006). From 1998, the focus began to shift to upgrading, renovating and consolidating the rural electricity system to increase supply capacity and reliability as well as providing electricity access to the remaining non-electrified areas. The Brightness Program was put forwarded in 1996 aiming at providing electricity access to non-electrified households mainly using local renewable resources (Wang et. al. 2006).

Rural electrification influences economic, society and environment in multiple ways. The World Bank (2008) has identified several benefits of rural electrification: provision of domestic lighting and use of electric appliance, health and education benefit, productive use, more spare time and additional environmental benefit for off-grid renewable electrification projects. Moreover, rural development and poverty reduction are often listed as important policy goals of rural electrification projects (Javadi et. al. 2013). Hence, it is imperative to analyze and evaluate the socioeconomic impacts of rural electrification in China.

Literature Review

Rural electrification has long been regarded a “special” kind of investment based on the justification that it can serve as a catalyst to rural economic development, promoting “social goods” such as health and education and benefiting the poor (Pearce and Webb 1987). Economic development can occur through job creation in local enterprises brought by electrification and higher productivity due to mechanization in the industry. Education benefits come from extended hours of studying at night, freeing up child labor to study and learning from Information Communication Technologies (ICTs) (Kanagawa and Nakata 2008). Using a cross-sectional survey of 100 households in Madagascar, Daka and Ballet (2011) found that lighting in the evening allows children to study more hours and freed up parents especially mothers’ time to help their children with homework.

Besides descriptive studies, quasi-experiment methods are also used to analyze the impact of electrification projects. To study the household socioeconomic outcomes in India, Khandker et al (2012) used an instrumental variable approach, where the proportion of households in the village with electricity served as an instrument. They showed that electrification access increased weekly study hours by more than an hour, and the average completed schooling year increased 0.3 years for boys and 0.5 years for girls. Using land gradient as an instrument, Dinkelman (2011) found a 9-9.5% increase of female employment due to rural electrification project in South Africa.

Research on rural electrification in China has mainly focused on the economic viability of rural electrification in China, its technical and institutional challenges and potential solutions (Zhang and Kumar 2011; Byrne et. al. 1998). There are few papers on impact assessment of rural electrification projects in China. Furthermore, most of the studies have only accessed the direct impact of electrification on changing energy use pattern. To analyze the implementation and impact of China's National Township Electrification Program, Shyu (2012) conducted household survey and interviewed relevant stakeholders in two townships in Qinghai and Tibet provinces. The survey result showed the amount of traditional energy sources used for lighting and electrical appliances has significantly decreased after electrification. Pereira et al. (2011) surveyed households before and after they got electricity access, and found that there were a dramatic increase in the acquisition of electric home appliance soon after the power system was installed, and 15% of the families use electricity for productive purposes such as small retail store, restaurants and commercial processing of raw materials.

However, this is little attention to the socioeconomic consequences of these changes in energy use. Yang (2003) analyzed provincial level time-series data in six province of China with different level of economic development, and showed that at provincial level investing one million Yuan in rural power network will increase net income per capita by 0.2-1.8 Yuan per year in each province studied. The increase in income is most prominent in economically developed provinces.

From my knowledge, there is no natural experiment that evaluates the socioeconomic impact of rural electrification at village level in China. In this study, a rigorous impact evaluation will be conducted to assess whether the rural electrification projects in China have improved rural standard of living. Income and educational level are chosen as the outcome variables in the subsequent regression analysis because they are the two key dimensions of standard of living and worldwide surveys have shown that increase in income and education level are important outcomes of rural electrification (Saghir 2005).

Data and methodology

The dataset used for impact evaluation is from 2003 Rural Survey on World Bank Project Evaluation in China. The survey was conducted by Center for Chinese Agriculture Policy, Chinese Academy of Sciences, University of California at Davis and University of Toronto. Data was collected for six provinces across rural China including Jiang Su, Si Chuan, Shan xi, Gan Su, He Bei, Ji Lin, which used multi-stage stratified sampling. It surveyed 36 counties, 216 township and 2459 villages. Socioeconomic indicators of the village pertaining to income, land use, labor force information, infrastructure, geographic information and environment were collected for both 1997 and 2002. Among these villages, 236 villages implemented electrification project in 1998, and 517 did not implemented any electrification project during 1997-2002. Villages that implemented electricity projects in 1998 are included in the treatment group, while villages without any electricity project during 1997-2002 are considered as the control group.

Impact evaluation attempts to establish the causal relationship between the project implemented and outcome, and estimates the average treatment effect on the treated (ATT) of the project by the difference between outcome occurred and outcome that would have occurred if the project was not implemented for the same object, which is called the counterfactual (equation 1).

$$ATT = E(Y_{1i} - Y_{0i} | G_i = 1) = E(Y_{1i} | G_i = 1) - E(Y_{0i} | G_i = 1) \quad (1)$$

Y is the outcome variable; Y_{1i} is the outcome if treated, and Y_{0i} is the outcome if not treated.

G_i is the binary indicator of whether the object is in the treatment group.

However, in reality, it is impossible to observe the exact counterfactual because the same object cannot be treated and untreated at the same time. Hence, constructing a legitimate counterfactual is the key for accurate impact evaluation. The Difference-in-Differences (DiD) method is a natural experiment that establishes the causality between the project and outcome, which is superior to simple OLS regression analysis. The DiD approach constructs a counterfactual by computing the difference of outcome variables before and after the project implementation for both the treatment and control group (equation 2).

$$ATT_{DiD} = E(Y_{ai}^T - Y_{bi}^T | G_i = 1) - E(Y_{ai}^C - Y_{bi}^C | G_i = 0) \quad (2)$$

Superscript T indicates treatment group, and C indicates the control group.

Subscript a and b refer to after and before the project implementation.

The villages in the treatment and control group may have diverse socioeconomic characteristics and natural endowment, and these unobserved characteristics may affect both the assignment of electrification project and the outcome variables. Those potential confounding variables that are constant between 1997 and 2002 could be differenced out because the same village is observed both before and after the treatment, even though data for these characteristics may not be available. The ATT_{DiD} also takes the natural rate of change over time into account by subtracting change of outcome in control group from the change of outcome in treatment group. For example, it cancels out the effect of income changes due to fluctuations in macroeconomic condition over years because it happens to both treatment and control group.

$E(Y_{ai}^C - Y_{bi}^C | G_i = 0)$ is a good counterfactual if the treatment and control group would have followed the same trend without the project. To improve the validity of the equal trend assumption, DiD approach is combined with Propensity Score Matching (PSM). Propensity Score Matching (PSM) matches the baseline socioeconomic conditions of the treatment and control groups. In the PSM-DiD approach, only the matched villages are selected for subsequent DiD analysis. Since the matched villages have similar baseline conditions, the equal trend assumption is more likely to hold. The PSM-DiD approach has been adopted in recent literature, and was shown to reduce bias and inconsistency (Rishika 2013).

Model Specification

The DiD regression model is specified in equation 1.

$$Y_{it} = \beta_0 + \beta_1 G_i * D_t + \beta_2 G_i + \beta_3 D_t + \beta_4 W_{1it} + \dots + \beta_{3+r} W_{rit} + u_{it} \quad (1)$$

Where:

Y_{it} is the outcome variable; there are two outcome variables: net income per capita and percentage of people with high school diploma or above

G_i is the binary indicator of treatment: whether the village implemented any electrification project in 1998

D_t is the binary indicator of time period. $D_t = 0$ when year = 1997; $D_t = 1$ when year = 2002

W_{rit} are the additional covariates

u_{it} is the error term

The coefficient β_1 of the interaction term $G_i * D_t$ gives the estimated effect of rural electrification project. The covariates are divided into three categories: village characteristics, other development projects implemented during the survey period and county-fixed effects, which potentially affect the outcome variable and correlate with the treatment. For DiD with PSM, caliper matching with caliper of 0.01 is used to match the baseline.

Results

Table 1 (see Appendix) shows the summary statistics for the outcome and key independent variables. 31% of the villages in the sample had implemented rural electrification project in 1998. In 1997, the average net income per capita was 1417 Yuan, and percentage of people with high school diploma or above was 5%. Both sample average income and education have improved in 2002.

Table 2 presents the regression results on income for DiD models and DiD with matching of the baseline. In the DiD model without covariates, the electrification project has increased net income per capita by 174 Yuan. After accounting for village characteristics, the effect of the electrification project on income diminished to 146 Yuan. The result remains unchanged in the PSM-DiD model, and the impact is statistically significant at 10% level. This increase is also practically significant because it represents a 10% increase of income compared to the baseline.

The reason why the magnitude of the impact decreased significant after controlling for village characteristics can be explained by the financial concerns for selecting the location of the project. Since most of the electricity projects in the survey are funded by the World Bank, financial viability is often a great concern. Those villages with better infrastructure and other conditions that are conducive to economic development and

financial viability of the electrification project have higher propensity to be selected for the project (World Bank 2008).

Table 3 shows the impact of electrification on education for DiD models and DiD with matching of the baseline. In the DiD model, electrification increased the percentage of people with high school diploma or above by 0.4%, and the impact is statistically significant at 10% significance level. In the PSM-DiD model, the result remains unchanged. However, this improvement is not very significant practically. In a typical 300 people village in China, there is only one additional person who got high school degree or above by 2002 due to the electrification project implemented in 1998.

Discussion

The regression results show that income and education benefits are statistically significant, but the improvement in education is not very significant practically. This is contrary to findings in the literature from other countries. The possible reason is in China admission into high school or university is quite competitive. Though better lighting and access to audio and video learning resources can be beneficial to student's academic performance by studying longer hours and learning more effectively, other factors such as teaching quality affordability and parental education are also key determinants of student's academic success. Knight and Li (1996) showed that the effect of parental education on children's education attainment becomes larger beyond basic education. Freeing up parents' time to help with homework is listed as one of the reasons for improving education level due to electrification. Since few parents in rural China have college degree, their ability to help decreases beyond basic education. Meanwhile, though lighting provides opportunity to study in the evening, children can also choose to watch TV or have other types of entertainment, so it does not necessarily lead to increase of study hours. Therefore, providing electricity alone may not have a significant impact on whether the children can get high school or higher degrees.

The positive impact on per capita income due to electrification found in this study is consistent with the literature. This can come from the development and increased productivity of Township and Village Enterprises (TVE) as shown by Yang (2003). In addition, it may also be the result of productive use of electricity found by Pereira et al. (2011), which creates more jobs and increases the number of small businesses.

There are some limitations associated with the model and dataset. DiD estimator is biased if there are other time-variant omitted variables that are not included in the regression models. However, such biases are reduced by inclusion of county-fixed effect in the model, which accounts for unobserved characteristics and policy initiatives at county level during 1997-2002.

Several limitations are pertaining to the dataset. Firstly, data is only available at the village level, and policy impact may vary across households. For example, it is interesting to analyze how does the policy affect household below the poverty line, which is related to the policy goal of poverty reduction. Nevertheless, since the sample is

stratified, the result is still a good estimate of average effect as both wealthier and poorer villages are represented. Secondly, the data is limited to six provinces in China, so external validity issues may exist when the findings are generalized to the whole country. However, since the provinces selected are geographically representative and have varying degrees of economic development, the ATT in this study can be a reasonable estimate of the project effect across the whole country. Thirdly, the project implemented in each village may not be uniform. For example, the project of some villages may mainly involve renovating consolidating and upgrading existing grid and facility, while other villages are given new access to electricity. Though this is not distinguished in the dataset, the amount of investment in the project is included as a control variable that can be seen as a proxy for the scope and intensity of the project.

Hence, despite the above limitations, the evaluation results still provide a sound estimate of average effect of the electrification project in China, which will provide guidance for future electrification projects in both China and other developing countries. Additional household survey may be helpful to analyze other impacts of electrification such health and gender equality. Household surveys can also be used to further investigate the causal mechanisms of income increase and possible improvement in education as well as the distribution of the socioeconomic benefits. These evidences can be used for design and implementation of future electrification projects.

Conclusion

This paper evaluated the impact of China's rural electrification projects. The results showed that rural electrification project in China brought substantial increase in rural income. This change can be due to productive use of electricity and increased productivity of TVEs. However, the improvement in education attainment beyond basic education is not practically significant, which showed that the causal link from electrification to longer study hours and academic success may not hold. More in-depth surveys can be helpful to understand the causal mechanisms.

This study not only offers insights about the past lessons of rural electrification, but also is useful for future electrification projects. In China, though over 99% of villages have gotten electricity, in absolute number there are still 4 million people in China without electricity access in 2010 (IEA 2010). In the electrified villages, improving system capacity and reliability is also ongoing. Understanding the impact of the project can help to better target and design effective electrification projects in the future.

Reference

- Byrne, J. Shen, B. and Wallace, W. 1998. The economics of sustainable energy for rural development: A study of renewable energy in rural China, *Energy Policy*, 26, 1, 45-54.
- Daka, K. R. and Ballent, J. 2011. Children's education and home electrification: A case study in northwestern Madagascar, *Energy Policy*, 39, 2866-2874.
- Dinkelman, T. 2011. The effects of rural electrification on employment: new evidence from South Africa, *American Economic Review*, 101, 3078-3108.
- IEA 2010. *World Energy Outlook: Global status of modern energy access*, <http://www.worldenergyoutlook.org/resources/energydevelopment/globalstatusofmodernenergyaccess/> accessed on 28th June 2013
- Kanagawa, M. and Nakata, T. 2008. Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries, *Energy Policy*, 36, 2016-2029.
- Khandker, S. R. Samad, H. A. Ali, R. Barnes, D. F. 2012. *Who Benefits Most from Rural Electrification: Evidence from India*, Policy Research Working Paper 6095, The World Bank Development Research Group Agriculture and Rural Development Team, June 2012.
- Javadi, F.S. Rismanchi, B. Sarraf, M. Afshar, O. Saidur, R. Ping, H.W. Rahim, N.A. 2013. Global policy of rural electrification. *Renewable and Sustainable Energy Reviews*, 19, 402-16.
- Pan, J. Peng, W. Li, M. Wu, X. Wan, L. 2006. *Rural electrification in China 1950-2005*. Research Centre for Sustainable Development, Chinese Academy of Social Sciences and Program on Energy and Sustainable Development, Stanford University, Beijing, China and Stanford, CA.
- Pearce, D. and Webb, M. 1987. Rural electrification in developing countries: A reappraisal, *Energy Policy*, 15, 329-338.
- Peng, W. and Pan, J. 2006. Rural Electrification in China: History and Institution, *China & World Economy*, 14, 1, 71-84.
- Pereira, M. G. Sena, J. A. Freitas, M. A. V. da Silva, N. F. 2011. Evaluation of the impact of access to electricity: A comparative analysis of South Africa, China, India and Brazil. *Renewable and Sustainable Energy Reviews*, 15, 3, 1427-1441.
- Rishika, R. Kumar, A. Janakiraman, R. Bezawada, R. 2013. The effect of customers' social media participation on customer visit frequency and profitability: an empirical investigation, *Information Systems Research*, 24, 1, 108-127.
- Saghir J. 2005. *Energy and poverty: myths, links and policy issues*, World Bank, energy

working notes. Energy and Mining Sector Board; May 2005 (No. 4).

Shyu, C. W. 2012. Rural electrification program with renewable energy source: An analysis of China's Township Electrification Program, *Energy Policy*, 51, 842-853.

Yang, M. 2003. China's rural electrification and poverty reduction, *Energy Policy*, 31, 283-295.

Wang, Z. Gao, H. Zhou, D. 2006. China's achievements in expanding electricity access for the poor, *Energy for Sustainable Development*, 10, 3, 5-16.

World Bank 2008. *The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits*, World Bank Independent Evaluation Group.

Zhang, X. and Kumar, A. 2011. Evaluating renewable energy-based rural electrification program in western China: Emerging problems and possible scenarios, *Renewable and Sustainable Energy Reviews*, 15, 773-779.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is partially overlaid by a large, faint, circular graphic element that appears to be a stylized 'S' or a similar shape, composed of two curved lines in shades of red and blue.

Appendix

Table 1: Summary statistics of key variables in 1997 and 2002

	No. of Observations	Mean	Min.	Max.	Standard Deviation
Electrification Project in 1998 (1=Yes; 0=No)	753	0.31	0	1	-
Net income per capita (1997)	753	1417	97	7148	1039
Net income per capita (2002)	753	1805	100	5950	1273
% of high school graduate or above (1997)	753	0.05	0	0.44	0.05
% of high school graduate or above (2002)	753	0.06	0	0.37	0.06

The summary statistics was calculated using data for six Chinese provinces in 1997 and 2002 from 2003 Rural Survey on World Bank Project Evaluation.

Table 2: Summary of regression results for different specifications: net income per capita

	DiD without matching				PSM-DiD
	(1)	(2)	(3)	(4)	(5)
$G_i * D_t$ (Yuan)	174 (130)	174** (82)	147* (82)	146* (82)	146* (82)
County-Fixed Effect	No	Yes	Yes	Yes	Yes
Village characteristics	No	No	Yes	Yes	Yes
Other projects	No	No	No	Yes	Yes
No. of Obs.	1506	1506	1502	1490	1470

These regressions were estimated using data for six Chinese provinces in 1997 and 2002 from 2003 Rural Survey on World Bank Project Evaluation. Robust standard errors are given in parentheses under the coefficients. The individual coefficient is statistically significant at *10% level, **5% level and ***1% significance level. The following are included in the regression model but not reported: amount of project investment per capita, village characteristics (% of Han Chinese, land area, labor, road, tap water access, distance to road, soil erosion, villagers working at township and county governments, village debt) and other projects (Build road or bridge, school, clinic, irrigation, drainage, telephone line, Radio/TV cable, land improvement, watershed management, terracing, downtown planning, logging band and foresting, eco-forest, grain for green, building pasture, activity and recreation room, grain crop, cash crop, orchard, green house, economic forest, livestock, fishpond, family business, computer, microcredit)

Table 3: Summary of regression results for different specifications: % of high school graduate and above

	DiD without matching			PSM-DiD	
	(1)	(2)	(3)	(4)	(5)
$G_i * D_t$ (Yuan)	0.005 (0.006)	0.005** (0.002)	0.005* (0.002)	0.004* (0.002)	0.004* (0.002)
County-Fixed Effect	No	Yes	Yes	Yes	Yes
Village characteristics	No	No	Yes	Yes	Yes
Other projects	No	No	No	Yes	Yes
No. of Obs.	1506	1506	1502	1490	1470

These regressions were estimated using data for six Chinese provinces in 1997 and 2002 from 2003 Rural Survey on World Bank Project Evaluation. Robust standard errors are given in parentheses under the coefficients. The individual coefficient is statistically significant at *10% level, **5% level and 1% significance level. The following are included in the regression model but not reported: Amount of project investment per capita, village Characteristics (% of han Chinese, land area, labor, road, tap water access, distance to road, soil erosion, villagers working at township and county governments, village debt) and other projects (Build road or bridge, school, clinic, irrigation, drainage, telephone line, Radio/TV cable, land improvement, watershed management, terracing, downtown planning, logging band and foresting, eco-forest, grain for green, building pasture, activity and recreation room, grain crop, cash crop, orchard, green house, economic forest, livestock, fishpond, family business, computer, microcredit)

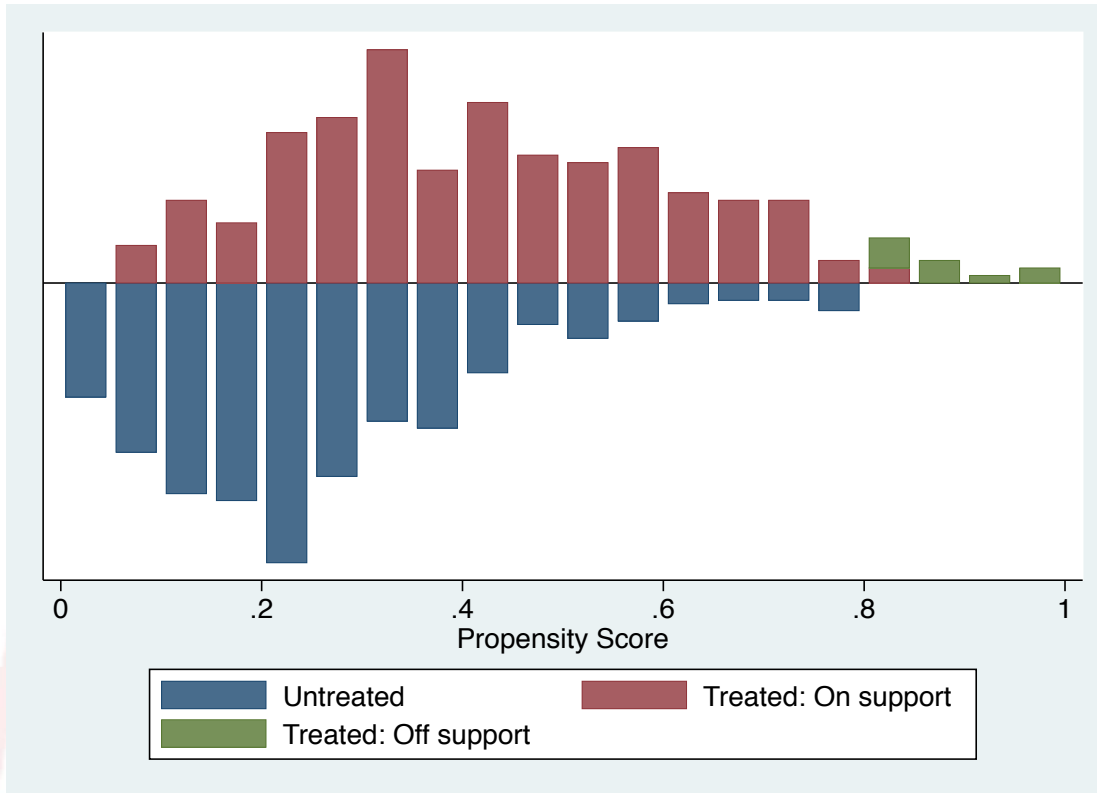


Figure 4: Propensity score matching result of baseline data in 1997

PSM matches data in 1997 from 2003 Rural Survey on World Bank Project Evaluation using caliper matching with a caliper of 0.01. The variables included in matching are % of Han Chinese, land area, labor, road, tap water access, distance to road, soil erosion, villagers working at township and county governments, village debt, % of household with electricity access, number of migrants, number of illiterates, number of schools, number of clinics, % of phone users, number of village and township enterprises, number of farmer's professional associations.

*The Sustainability of Cultural Heritage for Community-based Activity under Flood
Disaster: A Case Study of Ayutthaya, Thailand*

Wittaya Daungthima, Kazunori Hokao

Saga University, Japan

0437

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Ayutthaya Historical City was registered as a world heritage site by United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1991, was valued as one of the world heritage sites in Thailand. The main threat affecting on the existence of Ayutthaya heritage sites is at risk from natural disaster through a devaluation of the cultural heritage sites. The historical sites value and cultural relativity between local people, local government, private sector and academic has been decreasing. The civil society has importance for flood prevention. That need is because of the physical, social and environmental that the historical city was devalued its attractiveness for the conservation of historical monument sites.

The study focuses on actual participation by community-base. Furthermore, the study adapts technique for indicating participation factors influencing on individuals perception and awareness in cultural and historical heritage sites by conducting questionnaire.

The research found that perception of cultural property participation and the history of disaster procedures for disaster mitigation arising from the participation of the local people in the flood protection. The participation in the activities of the community and the relationships in activity and perception with the urban flood disaster, found two zones that are most important to analyses participation of flood protection and perception of cultural property, zone 3 the most likely relationship of local people in community and perception is cultural property, followed by zone 5.

Keywords: community-based, cultural heritage, flood disaster management, perception and awareness.

1. Introduction

The present study is based on a questionnaire survey and is aimed to assess the quantification of community-based perceptions on flood protection and cultural property conservation, the participation between various sectors, in a group of local people adults living in an area of “Ko Mueang” or Ayutthaya City Island and around areas which was severely affected in 2011 by the flood.

The Historic City of Ayutthaya, founded in ca.1350, was registered as a world heritage site on 1991[1]. World Heritage Properties are important for national and community proud and for social cohesion, under the World Heritage Convention, the States Parties sign up to the obligation of preserving World Heritage properties for future generations. Disasters do happen therefore it is best to be prepared to manage these unavoidable events [2].

Thailand is regarded as highly vulnerable to natural disasters caused by hydro-meteorological phenomena (floods, landslides, storms, droughts, etc.). Moreover it is also ranked as the seventh most flood prone country in the world. The flood occur almost annually, and they are by far the most devastating disaster in the country. Official statistics from 2002–2008 show that the country floods average was approximately 10 times per year [3-4].

Ayutthaya has a long history of flood cycles in seasonal variance. Ayutthaya’s river flooding problems long time ago. In the past, the local people solved this problem by digging canals [5]. As current situations change, canal digging is no longer an appropriate way for the city flood protection. The past flood in 2011, has its results to the physical, economic, social and environment damages [6]. The important cultural property of Ayutthaya were also affected and damaged.

2. Methodology

2.1 Research site

The study was conducted in Ayutthaya, Thailand. More precisely, we selected all the six zones include, Ayutthaya Historical City, In areas outside the Ayutthaya Historical City, The Eastern areas outside the Ayutthaya Island, The Western areas outside the Ayutthaya Island, The Northern areas outside the Ayutthaya Island, The Southern areas the Ayutthaya Island. Ayutthaya is a province in middle of Thailand, located 75 km. from Bangkok, the capital city. The elevation of these areas ranges from 1-2 m and the total area is approximately 3,000 rai (4.80 Sq.km.) [1,5]

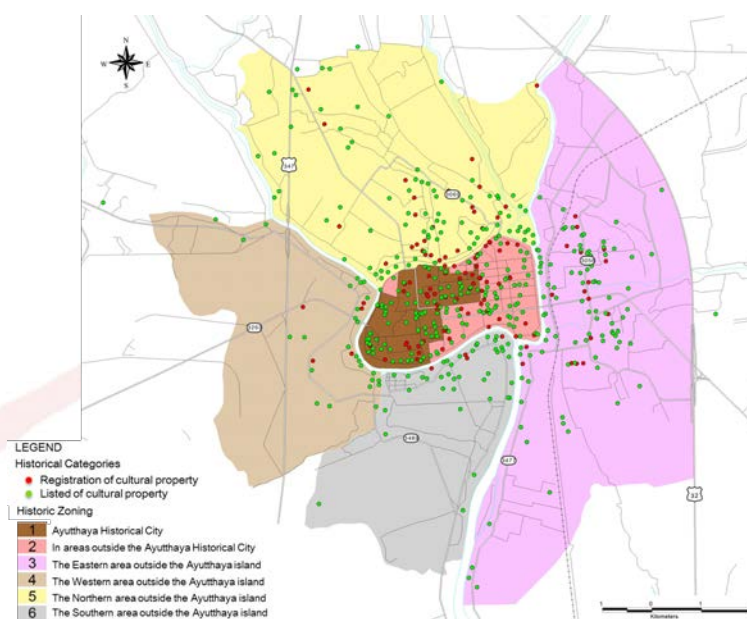


Fig. 1. The Distribution of Cultural Property around Ayutthaya Historical City Coordinated by the Global Positioning System.

2.2 Sample and procedures

The questionnaire was developed for study by field survey on civil society of flood protection and cultural property by community-based, historical of flood protection, flood protection of cultural property, the level of participation by community-based and social vulnerability. This study attempts to quantify perceptions of cultural property remaining in community and perceptions of flood protection and cultural property, the participation between various sectors and the level of participation by community-based. The final sample consisted of 374 respondents who were interviewed in May 2012 (shown in Table 1) [7-8]. Fifty-eight percentage of the respondents were women (n=218) and 42% were men (n=156). This age ranged from less than 20 (n=54), 21-30 (n=119), 31-40 (n=84), 41-50 (n=65), 50-60 (n=42), more than 60 (n=10). As regards level of education, 3% of respondents had attended less than primary school, 12% had attended primary school, 19% had a high school, 16% had a diploma, 45% had a university degree and 5% had a graduate degree. The period of living in this community, 27% had living less than 5 years, 18% had living 5-10 years, 19% had living 11-20 years, 17% had living 21-30 years, 10% had living 31-40 years, 4% had living 41-50 years and 5% had living 51-60 years. Ninety-one percentage of the samples were Buddhist, 3% were Christ, 5% were Islamic and 1% was other.

Table 1. The Distribution of Cultural Property Sites in Ayutthaya.

Cultural Property	Registered	Listed	Grand total	Percentage	Sample size
Zone 1	30	75	105	21.48%	80
Zone 2	30	64	94	19.22%	72
Zone 3	18	90	108	22.08%	82
Zone 4	5	26	31	6.34%	24
Zone 5	27	79	106	21.68%	81
Zone 6	5	40	45	9.20%	35
Total	115	374	489	100%	374

3. Result and Discussion

3.1 The relationship of local people in community

The table 2 shows relationship of local people in community. The relative is 30.68%, followed by respect the elders is 23.01%, know the whole community is 22.33%, respect the religious leaders is 12.05%, the faith community leaders is 9.05% and no correlation 2.88%.

Figure 2 shows relationship of local people in community by zone. The relative the most likely relationship is zone 5(54), followed by zone 1(47), zone 2(43), zone 3(39), zone 6(29) and zone 4(12). Know the whole community the most likely relationship is zone 3(40), followed by zone 5(38), zone 2 (37), zone 1(24), zone 4 and zone 6(12). Respect the elders the most likely relationship is zone 3(44), followed by zone 5(43), zone 2(28), zone 1(27), zone 6(16) and zone 4(10). The faith community leaders the most likely relationship is zone 3(21), followed by zone 5, zone 1(14), zone 4(8), zone 2(6) and zone 6(3). Respect the religious leaders the most likely relationship is zone 3(19), followed by zone 5(18), zone 1(13), zone 2(12), zone 4(5) and zone 6(1). No correlation the most likely relationship is zone 3(5), followed by zone 5, zone 1, zone 2(3) and zone 6(2).

Table 2. The relationship of local people in community

The relationship	Total	Percentage
1.The relative	224	30.68%
2.Know the whole community	163	22.33%
3.Respect the elders	168	23.01%
4.The faith community leaders	66	9.05%
5.Respect the religious leaders	88	12.05%
6.No correlation	21	2.88%

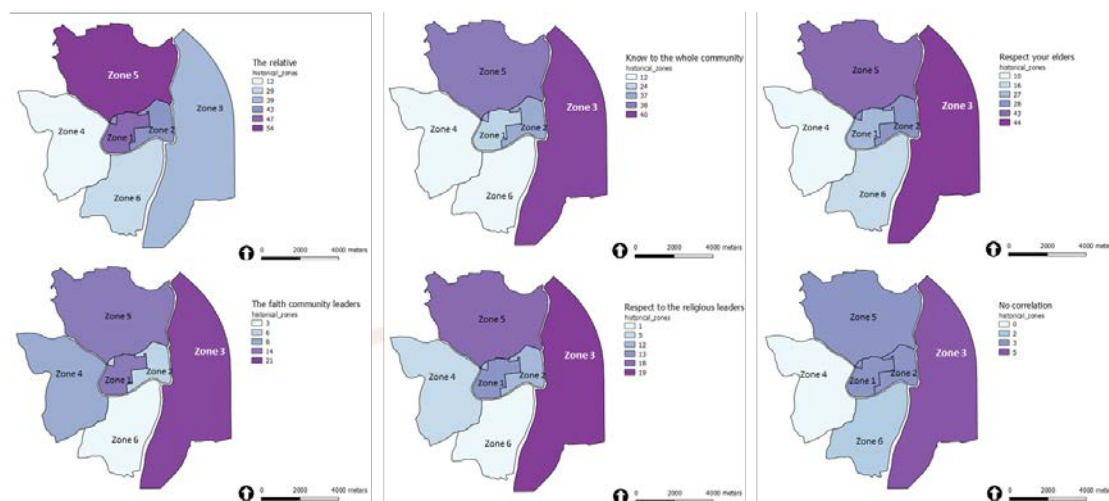


Fig. 2. The relationship of local people in community by zone.

3.2 Perceptions of cultural property.

Table 3 shows perceptions of Cultural Property. The perception of Canal, Wall, Gate is 24.71%, Abandoned temple/ Deserted pagoda is 23.97%, Religious buildings is 23.68%, Historical park 20.29% and Cultural Landscape is 7.05%, respectively. Zone 1 the most likely perception is Historical park (33), followed by Canal, Wall, Gates (27), Abandoned temple/Deserted pagoda (24), Religious buildings (22) and Cultural landscape (13). Zone 2 the most likely perception is abandoned temple/deserted pagoda (37), followed by Religious buildings (29), Canal, Wall, Gate (28), Historical park (26) and Cultural Landscape (10). Zone 3 the most likely perception is Religious buildings (57), followed by Canal, wall gates (44), Abandoned temple/Deserted pagoda (40), Historical park (14) and cultural landscape (5). Zone 4 the most likely perception is Religious building (13), followed by Abandoned temple/Deserted pagoda (12), Canal, Wall, Gate (10), Historical park (6) and Cultural Landscape (4). Zone 5 the most likely perception is Canal, Wall, Gate (43), by Historical park (40), Abandoned temple/Deserted pagoda (38), Religious buildings (25) and Cultural Landscape (15). Zone 6 the most likely perception is Historical park (17), followed by Canal, Wall, Gate (16), Religious buildings (15), Abandoned temple/Deserted pagoda (12) and Cultural Landscape (1).

Figure 3 shows perception of Cultural Property in community by zone. Religious building the most likely perception is zone 3 (25), followed by zone 2 (29), zone 5 (25), zone 1 (22), zone 6 (15) and zone 4 (13). Abandoned temple/Deserted pagoda the most likely perception is zone 3 (40), followed by zone 5 (38), zone 2 (37), zone 1 (24), zone 4 and zone 6 (12). Canal, Wall, Gate the most likely perception is zone 3 (44), followed by zone 5 (43), zone 2 (28), zone 1 (27), zone 6 (16) and zone 4 (6). Historical park the most likely perception is zone 5 (40), followed by zone 1 (33), zone 2 (26), zone 6 (17), zone 3 (14) and zone 4 (6). Cultural landscape the most likely perception is zone 5 (15), followed by zone 1 (13), zone 2 (10), zone 3 (5), zone 4 (4) and zone 6 (1).

Table 3. Perception of Cultural Property in community.

Cultural Property	Zone	Zone	Zone	Zone	Zone	Zone	Total	Percentage
	1	2	3	4	5	6		
1. Religious buildings	22	29	57	13	25	15	161	23.68%
2. Abandoned temple/ Deserted pagoda	24	37	40	12	38	12	163	23.97%
3. Canal, wall, gates	27	28	44	10	43	16	168	24.71%
4. Historical park	33	26	14	6	40	17	136	20.29%
5. Cultural landscape	13	10	5	4	15	1	48	7.05%
6. Other	1	3	0	0	0	0	4	0.59%

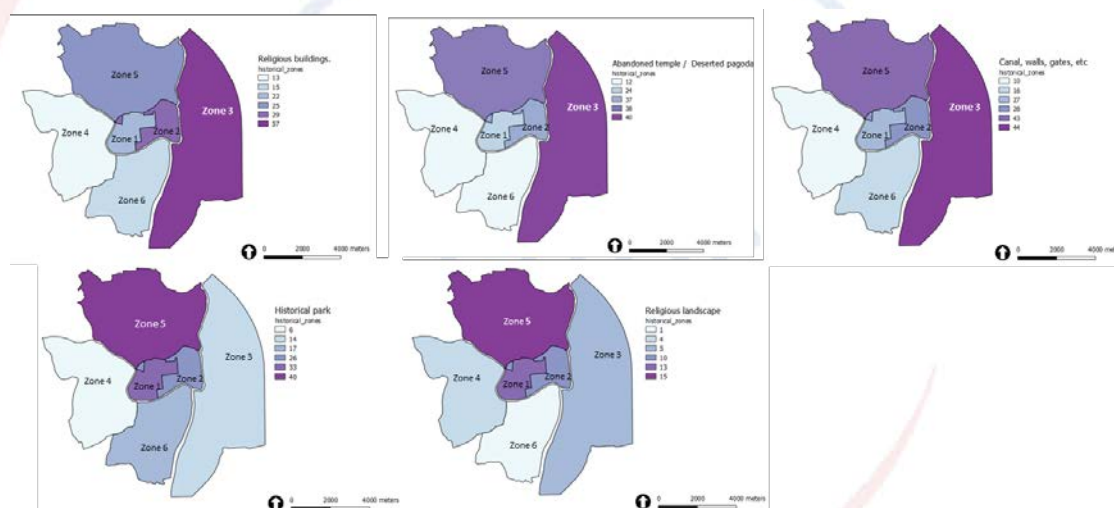


Fig. 3. The perception of Cultural Property in community by zone.

3.3 Perceptions of flood risk.

Flood characteristics are divided into six areas between Ayutthaya Island (two zones) and areas outside the Ayutthaya Island (four zones) [7-8]. Table 2 shows participation of flood protection in community events proposed can be obtained by looking at the mean values of each item. In zone 1, the most likely event is facilitates the problem search ($M=2.66$, $S.D.=1.27$), followed by persuade others to join the operation ($M=2.65$, $S.D.=1.45$), provide information ($M=2.64$, $S.D.=1.32$), comment on the plan ($M=2.54$, $S.D.=1.40$) and analyse the issues and problems ($M=2.51$, $S.D.=1.24$). In zone 2, the most likely event is provide information ($M=3.04$, $S.D.=0.97$), followed by facilitates the problem search ($M=2.97$, $S.D.=1.02$), solve the problem ($M=2.92$, $S.D.=1.26$), persuade others to join the operation ($M=2.89$, $S.D.=1.18$) and comment on the plan ($M=2.89$, $S.D.=0.99$). In zone 3, the most likely event is provide information ($M=2.61$, $S.D.=1.30$), followed by facilitates the problem search ($M=2.52$, $S.D.=1.29$), analyse the issues and problems ($M=2.49$, $S.D.=1.27$),

comment on the plan(M=2.39, S.D.=1.35) and persuade others to join the operation(M=2.34, S.D.=1.37). In zone 4, the most likely event is analyse the issues and problem (M=2.29, S.D.=1.16), followed by Facilitates the problem search(M=2.17, S.D.=1.17) persuade others to join the operation(M=2.13, S.D.=1.33), solve the problem(M=2.08, S.D.=1.32),and facilitate planning(M=2.08, S.D.=1.21) . In zone 5, the most likely event is provide information(M=3.23, S.D.=1.43), followed by facilitates the problem search(M=3.22, S.D.=1.44), analyse the issues and problem(M=3.21, S.D.=1.44), comment on the plan(M=3.20, S.D.=1.44) and persuade others to join the operation(M=3.20, S.D.=1.42). And zone 6, the most likely event is provide information, analyse the issues and problems, Facilitates the problem search(M=2.37, S.D.=1.09), followed by comment on the plan(M=2.34, S.D.=1.06) and facilitate planning(M=2.29, S.D.=1.13).

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is surrounded by several large, overlapping, semi-transparent circular arcs in shades of light blue and light red, creating a stylized, abstract background.

Table 4. Participation of flood protection in community

	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 6	
	Me an	S. D.	Me an	S. D.	Me an	S. D.	Me an	S. D.	Me an	S. D.	Me an	S. D.
To provide information about historic and cultural heritage	2.64	1.32	3.04	0.97	2.61	1.30	2.00	1.25	3.23	1.43	2.37	1.09
To analyse the issues and problems	2.51	1.24	2.52	0.98	2.49	1.27	2.29	1.16	3.21	1.44	2.37	1.09
Facilitates the problem search	2.66	1.27	2.97	1.02	2.52	1.29	2.17	1.17	3.22	1.44	2.37	1.09
To comment on the plan.	2.54	1.40	2.89	0.99	2.39	1.35	1.79	1.18	3.20	1.44	2.34	1.06
Prepare a plan	2.29	1.36	2.63	1.03	2.29	1.37	1.71	1.12	3.12	1.46	2.20	1.11
Coordination with other agencies involved.	2.44	1.35	2.74	0.96	2.28	1.31	1.88	1.23	3.15	1.48	2.20	1.11
To facilitate planning	2.44	1.33	2.83	0.98	2.28	1.29	2.08	1.21	3.20	1.42	2.29	1.13
To solve the problem.	2.48	1.43	2.92	1.26	2.27	1.37	2.08	1.32	3.10	1.47	2.29	1.07
The persuade others to join the operation	2.65	1.45	2.89	1.18	2.34	1.37	2.13	1.33	3.20	1.42	2.20	1.08
The track and find ways to improve operations.	2.43	1.51	2.86	1.20	2.20	1.28	1.75	1.26	3.12	1.49	1.97	1.07

4. Conclusions

The results of this research indicated that there are importance for both of participation of flood protection and perception of cultural property and flood risk by community-based activity under flood disaster. The description of the relationships in activity and perception with the urban flood disaster, found two zones that are most important to analyses participation of flood protection and perception of cultural property, zone 3 the most likely relationship of local people in community and

perception is cultural property, followed by zone 5, This research expands social understanding of the conservation of cultural property should still focus on the cooperative tasks in order to enhance people's awareness of historical preservation of common heritage. The participation should be effective but flexible enough to offer alternatives for the management of cultural heritage and to encourage the local people to participate in the process. This also could promote public awareness for the conservation of the cultural property and the participation of community in the activity of the various sectors. The protection of the cultural property will not be complete without the participation of the people." The participation of community-based" is also a part of conservation of tangible and the sustainable future.

Acknowledgments

We wish to special thanks to the people of Ayutthaya, who have provided information of community-based perceptions on flood protection and cultural property conservation in 2011 in this study through questionnaire. We sincerely thank Ms.Wanpawee Senboon, Faculty of Architecture and Environmental Design, Maejo University, for help and supports in conducting the collection questionnaire.

References

- [1] Office of Fine Art Department. *Renovation of Master Plan of Phanakhon Sri Ayutthaya Province Project*. Bangkok: AS 3D co., 1994.
- [2] Unesco. *Managing Disaster Risks for World Heritage, June 2010*.
- [3] The World Bank. *THAI FLOOD 2011 Rapid Assessment for Resilient Recovery and Reconstruction Planning*, 2012.
- [4] <http://www.preventionweb.net/english/countries/statistics/index.php?cid=170>
Accessed 11 March 2013.
- [5] World Bank. *Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region*, March 2009.
- [6] UNDP, *Reducing Disaster Risk a challenge for development*. A Global Report, United Nations Development Programme Bureau for Crisis Prevention and Recovery, 2004
- [7] Wittaya Daungthima, Kazunori Hokao. *Analysing the possible physical impact of flood disasters on cultural heritage in Ayutthaya, Thailand*. International Journal of Sustainable Future for Human Security J-Sustain, Vol. 1, No.1 (2013) 35-39.
- [8] Wittaya Daungthima, Hokao Kazunori. *Assessing the flood impacts and the cultural properties vulnerabilities in Ayutthaya, Thailand*. Procedia Environmental Sciences, volume 17 (2013) 739-748.

Investigating Farm Land Ownership: Farm Land Owner's Response to Regional Growth and Sustainable Agriculture in Indonesia

Arrohman Taufiq Hidayat, Satoshi Hoshino, Shizuka Hashimoto

Kyoto University, Japan

0445

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

In the modern era, regional growth and sustainable agriculture have aroused as prominent issues. Indonesia, those issues has affected land use change. In order to facilitate regional growth, farmland has been converted. Now days, sustainable agriculture are being implemented by government to reduce the impact of land use change, and, indeed, to reach self-sufficient of rice demands. Moreover, import restriction has made condition more challenging. Farmland as production capital is demanded to be preserved with any cost. Driving forces of farmland ownership change has been found but none observes mapping personal cognition of the respondents as good as Repertory Grid Technique, developed by Kelly (1955), This study was applied RGT to indigenious farm owners of Indonesia by eliciting own driving forces (construct) of six given decisions (elements). The constructs were limited to land owner profile, sustainable agriculture (community and social condition), spatial aspects (farmland conversion and accessibility), and economic aspects. By using principal component analysis, first component relates to buying and converting. Leasing is closely located to joint farming. Further, component plot shows that group of long-lasting farmland (i.e. buying, and keep farming) is in the first quadrant while vulnerable farmland (i.e. joint farming, converting, selling, and leasing) is in the fourth quadrant. It implies that passive farmers would work as trigger of land use change.

Keyword: decisions, PCA, farmland owner, RGT

Introduction

In 2010, population of Indonesia has reach 231 million with 1.3% average population growth each year since 2000 to 2005. It made the increasing of food demand especially rice as staple food. Meanwhile, rice production has not shown good performance. In the last 10 years, rice production reach 57,000 thousand ton (BPS, 2013) or about 23% of total agricultural production (WPF, 2008). This condition has become challenging when the Ministry of trade of Republic Indonesia was coming up with import act amendment in to achieve self-sufficient and food security (Ministry of Trade, 2009).

Meanwhile, farmland conversion emerges to be prominent issue. As recorded National Statistical agency, farmland conversion during 1983 to 2003 had surpassed 1.2 million hectare (Central Bureau of Statistics, 2003) and regional growth contributed to farmland conversion as well as transportation (Leinbach, 1989), and economic growth (Irawan, 2004). Moreover, land use changes possibly trigger the land use pattern change in the surrounding area as specially increasing built up area (Hidayat, 2010).

In order to secure food production especially rice, national government not only preserve farmland, but also expands new farmland (Bappenas, 2010). They projected 1.5 million new farmland in the end of 2015 to support rice production. As important as farmland protection, sustainable agriculture was invented in 1980's. Numerous studies have been conducted to define sustainability in agriculture (Conway and Barbier, 1990; RFA, 2005). Main concept of sustainable agriculture is to maintain productivity by managing production factors (e.g. soil, input, and machinery). In order to increase productivity rate, sustainable agriculture has been adopted by many countries including Indonesia. By adopting sustainable agriculture, farmers do not only preserve environment but also sustaining socio-economic aspects.

For the last 10 years, scholars have found driving forces of farmland ownership change (Poeta et al, 2012; Tan et al, 2009; Azadi, 2010). Honestly, those ignore the personal driving forces. Bearing this content in mind, this study examines land owner decision regarding regional growth and sustainable agriculture by using Repertory Grid Technique (RGT) where this technique is able to deeply explain personal point of view of the subjects. In the end of this research, personal driving forces can be explained and refined for multipurpose related to land use policy and planning.

Methodology

Repertory Grid technique is derived from personal constructs psychology theory by George A. Kelly. This technique originally was used as an aid for psychotherapy. Its main applications being in clinical, counseling and educational settings (Beail, 1985). In fact, repertory grid analysis has also been used in studying human response to urban (Harrison and Sarre, 1971), architectural (Honikman, 1976), tourism (Fenton and Pearce, 1988) and natural environments (Fenton, 1988). Repertory Grid (RepGrid) is a cognitive mapping technique that attempts to describe how do people think about phenomena in their world (Tan and Hunter, 2002). RepGrid is widely used by scholars for studying personal and interpersonal information of the respondents in many subjects (e.g. economy, psychology, education, and engineering) because of its flexibility and adaptability. Personal information (e.g. respond, opinions) from the respondents are drawn into grid so it will easy to understand. RepGrid theory is established by element and constructs, those are linked by links.

Shaw and McKnight (1981) stated that RGT reliable for in decision making process. The elements represent the alternative decisions. Constructs are represent the criterion or consideration of alternative decisions. And links represent the importance of those criterion. In some cases, decision making process consider the outcomes that possibly come after taking certain decision. In the RGT, the technique do not consider the after effect. It is trying to deliver which consideration or construct that affect to certain alternative decision base on their importance value or “link” score.

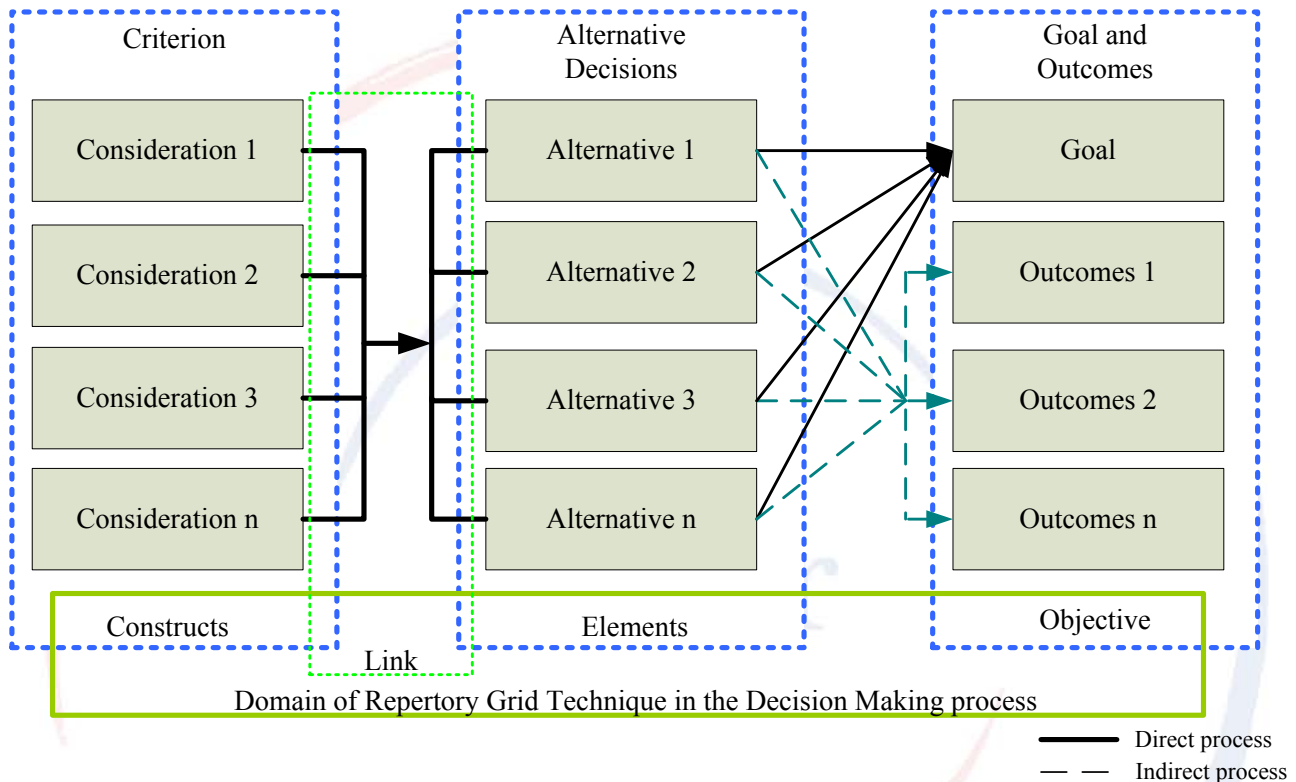


Figure 1. Decision making process by using Repertory Grid Technique

Elements are the things or event which are abstracted by construct and are seen as one of the formal aspects of a construct (Kelly, 1955/1991, p.137/volume 1, p.35). Elements are the objects of attention within the domain of investigation (Tan and Hunter, 2002). The type of element used in the grid will have determine the type of elicited constructs (Wright, 2007). Wright (2007;p.755) mentioned four keys of element. Those are homogeneous (i.e. made up of all object, events, and situations but not a combination of different groups), representative (i.e. represent of area being investigated, Fransella, Bell, and Bannister, 2004, p.18), discrete (i.e. not be a subset of other elements), and supplied or elicited (i.e. the way to get elements depending the research purpose, elements can be provided by researcher or elicited from the respondent).

In this research, the elements were supplied and derived from community itself and options may be chosen by landowner regarding regional growth and sustainable agriculture issues (Dorfman et.al.2003; Pouta et, al. 2011; Alamsyah, 2010; Subali, 2005). Those are buying, selling, leasing (to other farmer), joint farming (with other farmer), keep farming, and converting (to other land use). The definition of decision is explained as follows:

- a. Buying: Farmland owner tends to buy farmland and still to be farmer.
- b. Selling: Farmland owner tends to sell their farmland and give up being farmer.
- c. Leasing: Partially or all of farmland is leased to other farmer and no longer as farmer.
- d. Keep farming: status quo, nothing change.
- e. Joint farming: other farmer looks after the farmland. As exchange, land owner gets some share from the harvest.
- f. Converting : Converting farmland to other land use, no longer a farmer. Their farmland will convert to other land use

Construct is a way in which two or more things are alike and thereby different from third or more things (Kelly, 1957). Construct represent interpretations of the element and has own attributes. a way of seeing two or more things or persons as similar, and at the same time different from the third. Those are described as dichotomy corollary and bipolar, where each pole represents the extreme of particular observation (Niu and Easterbrook, 2006). Bipolar represent importance of the constructs. In term of decision making process, constructs were defined as consideration that drive to alternative decisions or elements.

Elicited constructs should be accommodated the respondent's thinking. And, it also encourages respondents to be able to see themselves among the elicited constructs. Group of variables were selected prior to limit the elicited constructs. It also gives advantages to respondents in order to gain understanding the designed issues.

Table 1. Main constructs

Constructs				
	Household condition	Agricultural sustainability	Regional growth	Policy
Social	<ul style="list-style-type: none"> • House hold size • Education level • Farming experience • Successor availability • Successor education 	<ul style="list-style-type: none"> • Social management for farming • Contribute to local community 	<ul style="list-style-type: none"> • Participation on community activities 	
Economic	<ul style="list-style-type: none"> • Income • side job 	<ul style="list-style-type: none"> • Regional minimum wage • Labor 	<ul style="list-style-type: none"> • Job opportunity • Input price • Output price • Productivity 	<ul style="list-style-type: none"> • Farmer loan program • agricultural subsidies
Spatial	<ul style="list-style-type: none"> • Land size • Soil quality 		<ul style="list-style-type: none"> • Distance to road • Distance to market 	
Agricultural practice	<ul style="list-style-type: none"> • Family participation 	<ul style="list-style-type: none"> • Tools and technology 	<ul style="list-style-type: none"> • Farmland conversion 	<ul style="list-style-type: none"> • farming guidance

The field survey was taken place in the Kediri Municipal, East Java Province, Indonesia. Three villages were selected. Those are Ngampel Village, Gayam Village, and Pojok Village. Recently, the district where those villages located are designed as center of growth. At the same time, sustainable agriculture policy has being implemented.

Research procedure.

The respondents were limited to inhabitant within administrative boundaries and farm land owner. We counted 210 farmers or prospective respondents. Forty respondents were selected randomly from 3 different villages.

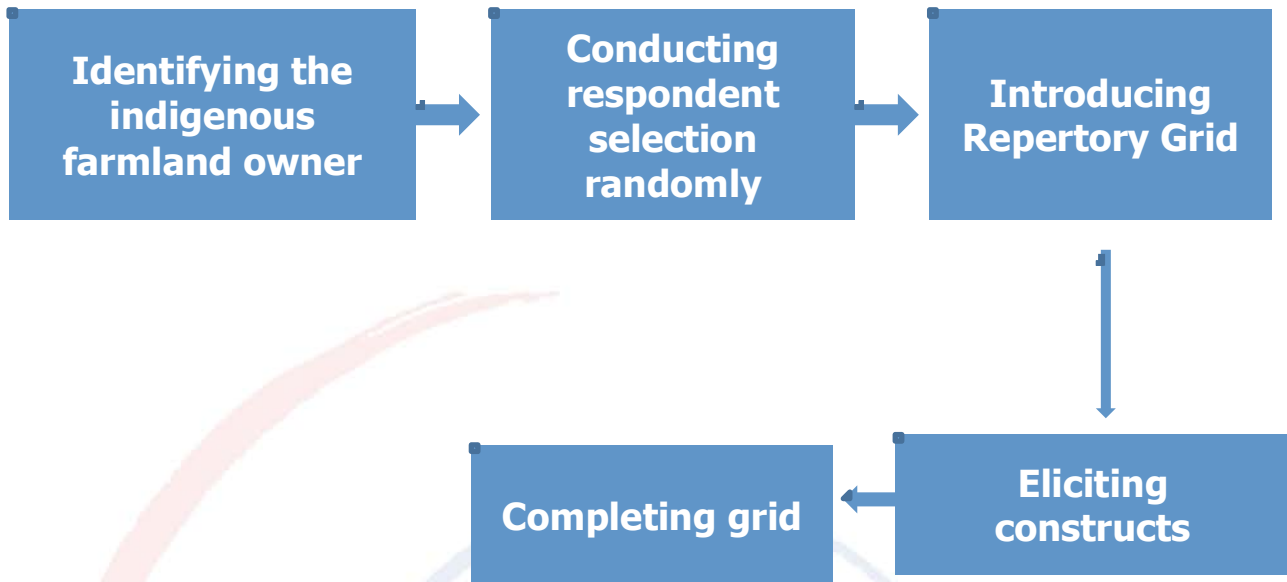


Figure 2. Field survey procedure

First, 40 respondents were divided into 3 big groups based on their location. Each group selected representative and created small group that consist 2-4 respondents. The field survey was started from small group. The small group built understanding of the research purpose and repertory grid technique. It help the researcher to explain the research purpose to their member. In order to get fruitful results, the steps has been determined as follows (Jankowicz, 2004, see also Fransella et al., 2004):

- a. Explain to the respondent about the research purpose, research procedure, set of variable and set of element.
- b. Take three elements and ask the respondents: what do two of these elements have in common, as opposed to the third?
- c. Ask the respondents the reason behind the answer
- d. Make sure the respondent understand the kontras of the constructs
- e. Write the constructs in the left or right base on respondents
- f. Replace the element to other element and perform step “c” trough “e”
- g. Repeat the steps “c” trough “f” until the respondents cannot state other constructs
- h. Ask the respondent to scoring each cell base on Likert scale. Respondent could choose 1 to 5 where 5 means respondents prefer to left pole, and 1 means respondents prefer to right pole. Ask the respondents to rate each of the remaining elements on this construct

Second, the small group simulated construct elicitation process and bring the result to big group. In order to get more understanding, respondents had a right to erase or add constructs. Then, they asked to fill out the constructs. Respondents were virtually positioned their self into other elements and completed the entire grid. This role play is important due to repertory grid represent respondents personal opinion.

Analysis procedure

After having field survey, multiple grids were generated. There are 2 ways to analyze the grids. Those are single grid analysis and multiple grids analysis. Single grid analysis, every grid is analyzed

one by one. Multiple grids analysis is reproducing new grid by calculating the mean of each cell. It may lost personal identity of single grids (Ilbery, 1985). However, It gains better vision of group.

After reproducing the mean grid, the grid was analyzed by using Principal Component Analysis (PCA). IDIOGRID was used instead of SPSS. IDIOGRID is a special software for RGT analysis. PCA in IDIOGRID is designed to reveal correlation between elements and constructs.

Results and discussion

• Profile of respondent

40 respondents were actively participating the RGT process. This research selected 3 different villages from Kediri Municipal, those are Pojok Village, Ngampel Village, and Gayam Village. Those villages are located in the Mojoroto district, the biggest district of Kediri Municipal. Pojok Village and Gayam Village are located in the edge of Kediri Municipal, East Java province, Indonesia.

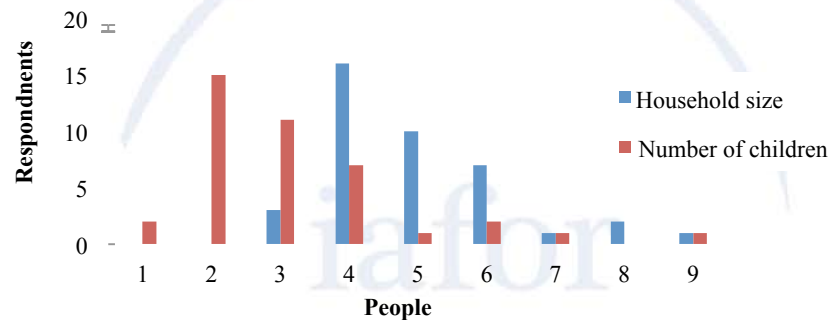


Figure 3. Comparison between Household size and Number of children

The household size is ranged from 3 people to 9 people. According field survey, 16 of 40 respondents, their household size is 4 people. Some of farm owners live with their parents or relatives. Or, their child moved out from the house because they got married.

Banyak anak, banyak rejeki (more children, more fortune) is a slogan of Javanese people. Their religious experience involves in their family planning. They believe, if they have many children, fortune will comes rapidly. Somehow, it is not fully wrong. In the agricultural point of view, many children mean the number of unpaid labor increase. However, those concepts will torn apart when modern lifestyle involves in their daily life. Basic needs should be provided such as education and food.

Based on result of field survey, 15 out 40 respondents have 2 children and respondent who has 3 children comes second. The highest is 9 children. According family welfare program, number of children is not more than 2 children. Those table shows respondents have been follow the government recommendation. Oppositely, more than half of total respondents have more than 2 children.

37 respondents (92%) are farmer and farmland owner, They also consider it as main occupation. Only a single respondent has declared himself as an entrepreneur. However, he is considering farming as side job. About a half of total respondents posses side job in their daily schedule, such as craftsman, peasant, or raising cattle. Raising cattle seem to be saving for unexpected expenses. Yet, it

turns becoming big business when the special day (i.e. in calendar of Islam) is coming. In this case, raising cattle refers to business itself. They consider raising cattle as business rather than for saving.

According to figure below, 17 respondents earn 1 to 2 million each month. That earning is slightly higher than regional minimum wage (i.e. about 1.1 million per month). However, 19 respondents have lower income than the regional minimum wage. Only 4 respondents have income double than margin minimum wage. It is hardly to say that a conclusion whether farming is good occupation or not. It depends on farm size in their possession. Roughly, farm size and type of crop affect to income.

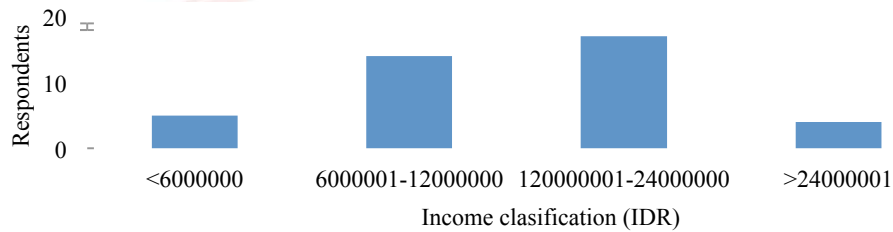


Figure 4. Income of the respondents annually

• **Principal Component Analysis**

After having eliciting construct procedure, 85 new constructs have elicited from 40 respondents. Those respondents have emerged their opinion regarding those issues. They mentioned various constructs, yet interesting. New constructs do not cover respondents consideration related existing condition but also the threat and the opportunity. For example, government involvement in the farming activity. Respondents mentioned that amount of subsidy is important. Nevertheless, distribution is also important.

The constructs are orthogonal or independent each other. Therefore, varimax rotation was chosen. Main purpose conducting Principal Component Analysis (PCA) is to gather better understanding how do the driving forces affect to decision. Idiogrid (developed by Grice in 2008) is a suitable software for RGT that produce fruitful result. PCA in Idiogrid is able to identify correlation between elements and construct. The constructs located in the same quadrant as element are identified give high score to the element. In this research, those are considered as driving force for the decision.

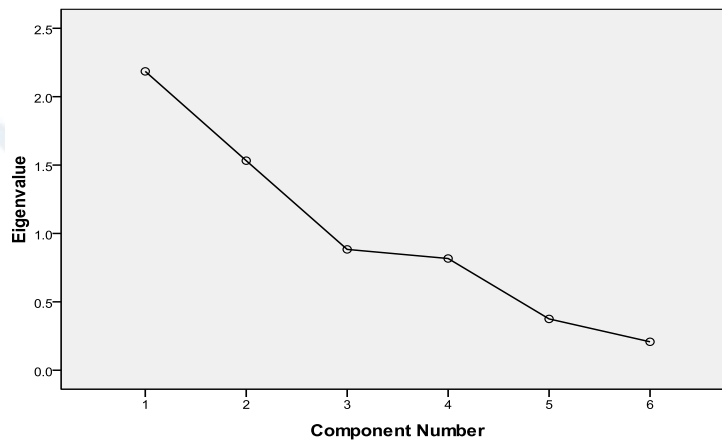


Figure 2. Initial result of element's eigenvalue.

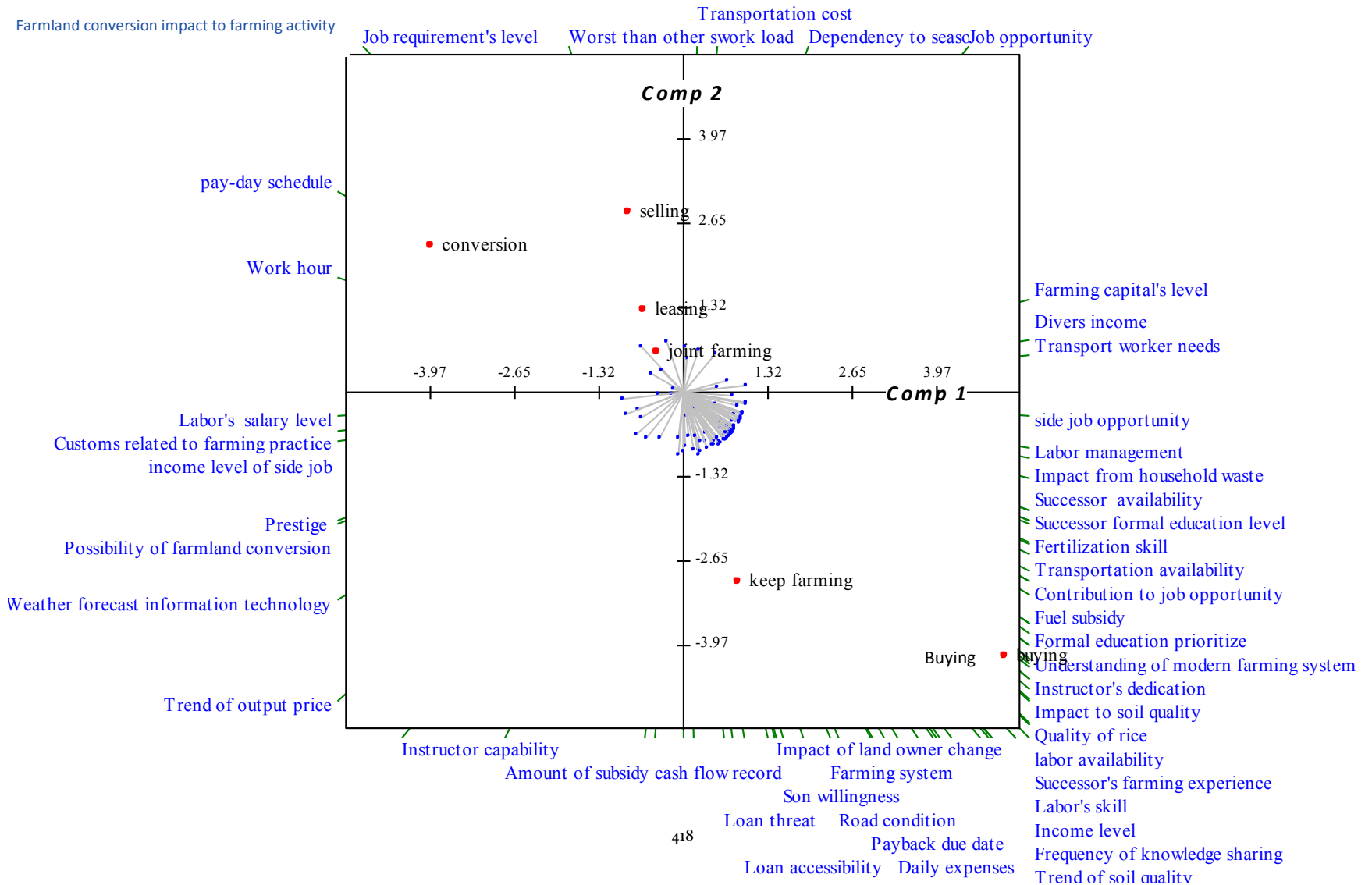
The number of component was decided by eigenvalue of elements. Only 2 components have score more than 1. That result was used to determine the number of component of construct in PCA for

construct. It should be noted that all constructs are orthogonal and indirectly connected each other. Therefore, varimax rotation was chosen.

Comparison between PC 1 and PC 2 shows emerge pole of constructs where the best condition according expectation of respondents. There are two result can be obtained from that figure. First, decision can be classified according its driving forces. Keep farming is sharing driving forces with buying and conversion shares its driving forces with leasing, selling, and joint farming. Second, constructs are divided into 4 groups and closely related with element. When it is associated with elements, it gives high score to elements. For example, respondent will keep farming or buy new farmland if road condition is better. Oppositely, they will sell or other decision if road condition is bad.

The second component accounts for 36% of total variance where selling (+2.82), leasing (+1.3) and conversion (+2.31) are close each other especially selling and converting. In addition, joint farming merges in this group with small loading score (0.65). As well as first group in the second component, keep farming and buying show same result. Those two decisions are related each other with great gap.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is surrounded by a large, faint, circular graphic composed of several overlapping, curved lines in shades of red and blue, creating a sense of motion or a globe.



Capital of production has done a lot. Farming has been affected by house hold size that provide unpaid labor (-0.84) as well as successor expectation (-0.81) and expecting own as successor (-0.79) for farming sustainability at house hold level as well as family participation in farming activity (-0.71) and son willingness to inherit the farmland for farming (-0.92). Also, government involvement is being expected. Second group of second component tends to correspond with response to governments' programme (-0.74), and the effectiveness of governments' programme (-0.75). This group also addressed loan threat (-0.69) and due date of the debt (-0.64) at medium level. But, it highly considers the availability of loan program for farmer and benefit of loan programme that shown by high loading scores, (-0.93) and (-0.89) respectively. Subsidy also took part to build this group, including the amount (-0.71) and the distribution (-0.7) as well.

Farming guidance was invented by Ministry of Agriculture to assist famer tackle down their obstacles. Capability (-0.73) and Innovation (-0.81) of instructor are highly considered if they tend to choose keep farming and/or buying new farmland decision. Those are reflected by high loading score. It is quite reason able since transfer technology and guidance will bring new experience to overcome all the obstacles may affect to their income level.

It can be easily seen that elements are divided into two big groups; those are sustainable farmland and endangered farmland. Sustainable farmland is located in the second quadrant. And, endangered farmland is located in the forth quadrant. Those big groups share the driving forces. Oppositely, constructs scatter in all quadrants and created 3 big groups; those are driving forces of sustainable farmland, driving forces of endangered farmland, and grey zone. Grey zone refers to the constructs where those constructs give average score to both groups of elements. Last but not least, prestige (-0.73), weather forecast information technology (-0.67), and trend output price (-0.73) are recorded close related to this group. Finally, this group is related to impact of farmland conversion to farming activity but in the low degree (-0.35).

We can easily find that 70% of total constructs are positioned in the second quadrant. It implies that certain constructs established the decision of sustainable farming. Respondents are really concern about those constructs when they choose those decisions (i.e. keep farming and buying). Otherwise, respondents easily choose endangered decision with a few considerations. It is ironic, yet a serious situation. Respondents can change their decision from sustainable farmland to endangered farmland any time, especially when the driving forces (i.e. constructs) satisfied the respondents demands.

Grey zones consist of uncertainty considerations. Based on respondent point of view, constructs at the grey zone moderately drive to certain condition. Nevertheless, those constructs possibly drive respondent to certain decision if user of this research result (e.g. policy maker, and land use planning agency) do not pay attention. Some constructs are suspected corresponding to other construct due to elicited from same variable. For example, farmland conversion possibility is close related to impact of regional growth in farming activity. If the user does not pay attention on farmland conversion possibility, it may drive respondent or farmland owner to endangered farmland decision.

Implications

Result of RGT is amazing and the process either. It is able to enrich knowledge related policy studies especially land use policy. During the RGT process, participation is fully accommodated. Indirectly, PCA result, which is produced by IDIOGRID can be used to drive farmland owner to certain decision. Of course, conditions are applied. Since the RGT in this research are using multiple grid, regional and group of farmland owner profile should alike.

Currently, bottom up paradigm is being applied broadly for spatial planning process. There is high possibility that RGT process can be adopted during spatial planning process. Not only its process, the result of RGT has implication to spatial planning process. Consideration of certain driving forces should be kept in high performance. Those considerations need to be adopted by policy maker in every policy or programmes.

Meanwhile, farmland conservation emerges to stop the wildness of regional growth. Farmland is not only important for food production but also keeps environment balance. It means, farmers are subjected to keep farming. And keep farming itself is a decision that should be taken by the farmland owner. It is not easy to choose that decision because it has a set of consideration. Leasing, and joint farming may include in this decision. But, it is too risky to take those decision because it shares consideration with selling and converting.

The government cannot be easily excused designing conserved farmland and avoid the farmland owner concern. Those owners are also actor economic activity also part of living society, and has a right as human well being. If the government design their farmland as conserved farmland, they have to keep farming. If they intend to retire, they have to inherit it to other farmer. It is not simple action.

According to PCA process, if farmland owner intends to continue farming, a bunch of consideration has lined up. Those considerations are not only about farming capital (i.e. including availability, and condition) but also external factors such as government involvement, community involvement, as well as pressure of regional growth (i.e. house hold waste and regional economic). It means that those consideration should be kept high to ensure farmland owner keep farming.

However, big question mark still appears. How to keep those considerations in high performance? External factors may can be manipulated. To be honest, internal factor is the hardest one. The best way is adopting the considerations for governments' programme. Currently, expectation and responses of farmer to governments' programmes are statistically good enough (0.7 in average, based on PCA).

The groups of PCA result show the farmland owners' willingness on farming activity. Sustainable farmland decision represents active farming where farmland owner has strong willingness to engage farming business. This first group seems to safe decision. Otherwise, the second group, endangered farmland decision shows aversion of maintaining farmland.

The first second of decisions, joint farming and leasing, they prefer to collaborate with other farmers and leave it to their farming partner for maintaining their farmland rather than doing by them self. Farmland owners do not fully involve the farming business, it can be identified from the characteristic of the decision.

May collaboration is a good choice. However, it possibly provoke the farmland owner to hand farming works off to their partner. The farmland owners just wait the yield at home. According to PCA result, at this rate, the aversion would trigger the farmland conversion and losing farmland ownership because joint farming, and leasing, are highly related to converting and selling.

PCA result is also useful for altering decision of respondent from one decision to other decision by improving driving factor of designed decision or using driving factor of designed decision. For example altering decision from selling to keep farming. In this case, reducing performance of farmland conversion impact to farming activity is the best option. The next step is choosing

appropriate driving forces that possibly reduce the performance of farmland conversion impact to farming activity. Conceptually, any driving forces can be used. In this case, road condition is selected to reduce farmland conversion impact. Of course, the selection is based on existing condition such as internal attribute and external factor. When farmland is converted, automatically, accessibility is needed to support new land function. In this situation, new road should support farming activity. For example, truck can utilize the road to transport the yield from the field.

Conclusion

After more than a half century, Kelly's work, Repertory Grid technique can be used in the land use studies. Ilbery had spearheaded and made it possible applied in the land use study. His work about decision making in agriculture that is closely related to land use study is tombstone of this study. Agricultural activities are closely related to decision in the various dimensions; such as economic, social, environment and of course spatial aspect as part of environment. Ilbery (1987) put in geographical aspect in his decision making process and RGT as tool to investigate behavior of farmland owner. His finding has made RGT can be possible used in the land use studies since land use studies also has decision aspect.

Again, thank goes to Kelly for his magnificent work. RGT is indeed a power full and fruitful technique. This technique produces the outstanding finding and better insight of people opinion. Afterward, IDIOGRID was created base on RGT and also provides best result and fantastically could analyze bored score on the grid in to simple form but meaning full result. And it gave better result than ordinary statistical tools.

In generally, 2 groups of decisions have emerged. Those are sustainable farmland and endangered farmland. Sustainable farmland decision is built by keep farming and buying decisions where mainly driven by availability of successor, soil quality, farming system, education, yield and its quality and dependent to subsidy and supporting farming program from government.

There is a gray zone where driving forces do not significantly associate to certain decision. Some driving forces of gray zone inconsistently associate with two decision group in the same time. However, it gives clear signal that those driving forces work for any decision in the different condition depends on it loading score. Further research is needed to give better understanding of gray zone.

It seems keep farming is the best way to conserve the farmland. When the farmer leasing and joint farming, in directly, they just started to threat the farmland because those decisions are closely related to selling and conversion. It shows that passive farming would be trigger of losing land owning and farmland conversion. To alter farmland choosing endangered farmland decision, the constructs that drive to sustainable farmland decision should be kept in the high performance. In order to support farmer keeping the performances The policy markers may adopt the driving forces in their programme on issues related to land use policy and agricultural policy.

Acknowledge

The first author is a scholarship grantee of Directorate General of Higher Education, Ministry of Culture and Education, Republic of Indonesia. The field survey was funded by Rural Planning Laboratory, Graduate School of Agriculture, Kyoto University.

References

1. Azadi, H., Ho, P., Hasfiati, L. (2010). *Agricultural land conversion drivers: a comparison between less developed, developed, developing and developed countries*. Land degradation and development. doi: 10.1002/ldr.1037
2. Badan Pusat Statistik (2003). *Sensus pertanian 2003-angka nasional-Hasil pendaftaran rumah tangga-Katalog BPS 5010 ST03 Buku A3*, Jakarta:Badan Pusat Statistik Indonesia.
3. Dunn, W (2001). *Using the method of context validation to mitigate type III errors I environmental policy analysis*. In: Hisschemoller, M., R. Hoppe, W. Dun and J. Ravetz (eds.). *Knowledge, power and participation in environmental policy analysis*. Transaction Publisher. New Jersey. USA.417-436
4. Fransella, F, R. Bell & Bennister (2004). *A manual for repertory grid technique*. Second edition. JohnWiley & Son, Ltd. UK. Saturday 2 2pm
5. Kelly, G.A. (1991). *The psychology of personal constructs one: A theory of personality*. Routledge. London. UK (originally published New York, 1955)
6. Ministry of Agriculture of Republic Indonesia: *Laporan kinerja kementerian pertanian 2011*. (2012), Retrieved from <http://www.deptan.go.id/pengumuman/berita/2012/laporan-kinerja-kementan2011.pdf>
7. Ministry of Trade of Republic Indonesia: *Ketentuan Impor dan Ekspor Beras*. (2008). 12/M-DAG/PER/4/2008. Retrieved from <http://inatrade.kemendag.go.id/index.php@module=login&action=downloads>
8. Pouta, E., Myyra, S., Pietola, K. (2012). *Landowner response to policies regulating land improvement in Finland: lease or search for other option?*, Land Use Policy, 26,961-974.
9. Tan, R., Beckmann, V., Van den Berg, L. Qu, F., (2009). *Governing farmland conversion: comparing china with the netherlands and germany*. Land Use Policy, 29(2012),367-376
10. Van de Kerkhof, M. (2004). *Debating climate change. A study of stakeholder participation in an integrated assessment of long-term climate policy in the Netherland*, Lemma Pubisher. Utrecht. The Netherlands.
11. Van der Sluijs, J., M. Hisschemoller, J. de Boer and P. Kloprogee (2001) *climate risk assessment: evaluation of approaches*. Synthesis report. Utrech University. The Netherlands.
12. Sastraatmadja, Entang (2010). *Suara Petani*. Bandung : Masyarakat Geografi Indoonesia.

*A Simplified Mathematical Model to Predict the Thermal Physiological Responses of
a Sleeping Person in Steady-state and Uniform Conditions*

Pan Dong-mei, Chan Ming-yin

The Hong Kong Polytechnic University, Hong Kong

0487

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This paper reports on the simplified mathematical model to predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions. By modifying Gagge's two-node model and coupled with a mathematical model of predicting the total insulation value of a bedding system, a mathematical model for predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions was firstly developed. This is followed by comparing the predicted values using the mathematical model with the previous experimental data.

Keyword: Thermoregulation model; sleeping person; total insulation value of a bedding system

1 Introduction

A human being spends approximately one-third of his / her life in sleep. Sleep is not simply a state of rest, but has its own specific, positive functions [1]. Sleep can help people overcome tiredness and is very important to one's memory. For decades, numerous medical researchers have investigated various factors that affected the quality of sleep [2–6]. It was commonly acknowledged that the quality of sleep was mainly determined by mental-physical factors of a sleeping person and environmental factors in a bedroom. Although the latter one covered lighting, noise and thermal environment, the influence of thermal parameters in a sleeping environment on the quality of sleep was gradually understood [7–10]. Previous experimental results have demonstrated that when the thermal environment in a bedroom deviated greatly from the so-called 'thermal comfort zone', there were a remarkable increase in numbers and duration of wakefulness and a decrease in Rapid Eye Moment (REM) stage [8–10]. Although thermoregulatory responses were present across different sleep stages, they would be partly depressed in REM stage [11–15]. Hence, an increase in wakefulness and a decrease in REM stage reflected thermoregulatory need, and suggested that there was a competition between sleep maintenance and thermoregulation [15, 16]. Therefore, sleep quality became disturbed or even deteriorated as soon as the thermoregulatory responses were present. Consequently, it was necessary to investigate the thermoregulatory responses of a sleeping person in order to improve sleep quality.

A human being's thermoregulation is very complicated due to numerous variables involved in many control loops [17]. Using a thermoregulation model to predict human thermal physiological responses is a very useful tool in investigating the thermoregulation capability of a human body. Therefore, a large number of models for thermoregulation have been developed [18–26]. From early 40's to late 60's, human thermoregulation was studied primarily using analogue simulation [18–20]. In 1970s, there was a transition from the use of analogue simulation to digital simulation which was powerful in computational capability. Since then, a number of thermoregulation models have been developed, including the Gagge, the Stolwijk and the Wissler models [21–23] which were the most commonly used. With the further advancement of computer technology, Smith-Fu finite element thermoregulation model [24, 25] and a 65-node thermoregulation model [26] were developed to predict three-dimensional body temperature distributions, local sweat rates, and latent and sensible heat losses from a human body surface.

However, all above mentioned thermoregulation models developed were for a person who was awake. For a sleeping person, his/her thermoregulatory process can be different from that of an awaking person because of two reasons. Firstly, the total insulation value of a bedding system was different from that of clothing and would play an important role in people's thermal sensation [27, 28]. Secondly, the set points for skin temperature and core temperature were different [29–31]. Therefore, thermoregulation models previously developed should be modified in order to predict thermal physiological responses of a sleeping person.

This paper reports on the simplified mathematical model to predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions. By modifying Gagge's two-node model and coupled with a mathematical model of predicting the total insulation value of a bedding system, a simplified mathematical model for predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions was firstly developed. This is followed by comparing the predicted values using the mathematical model with the previous experimental data.

2 The development of the mathematical model

Based on Gagge's two-node model [21], the mathematical model was developed by considering the following features for a sleeping person:

- The total insulation value of a bedding system would significantly affect the thermal comfort of a sleeping person, instead of the clothing insulation.
- The skin set-point temperature of a sleeping person would be larger than that of an awake person, and core set point temperature would be less. The set point skin and core temperature were set at 34.6°C and 36.8°C, respectively [14, 18].

2.1 Controlled system of the mathematical model

The whole body was subdivided into two concentric compartments. The outer compartment represents the skin, and the inner compartment the core. The heat is transferred between skin and core by conduction. The body and the environment exchange heat by conduction, radiation, convection, evaporation and respiration.

These equations represented were as follows:

(1) Heat storage for skin and core compartments

$$S_{cr} = (M + M_{shiv} - Q_{res}) - K(T_{cr} - T_{sk}) - c_{p,bl}(T_{cr} - T_{sk}) = 0 \quad (1)$$

$$S_{sk} = K(T_{cr} - T_{sk}) + c_{p,bl}m_{bl}(T_{cr} - T_{sk}) - E_{sk} - (C + R) = 0 \quad (2)$$

(2) Heat loss from respiration Q_{res}

$$Q_{res} = 0.014M(34 - t_a) + 0.0173M(5.87 - P_a) \quad (3)$$

(3) Sensible heat loss from skin $C+R$

$$C + R = \frac{t_{sk} - t_o}{R_t} \quad (4)$$

(4) Evaporative heat loss from skin E_{sk}

$$E_{sk} = wE_{max} \quad (5)$$

$$E_{max} = \frac{P_{sk,a} - P_a}{R_{e,t}} \quad (6)$$

$$i_m L_R = \frac{R_t}{R_{e,t}} \quad (7)$$

$$w = w_{rsw} + 0.06(1 - w_{rsw}) = 0.06 + 0.94 \frac{E_{rsw}}{E_{max}} \quad (8)$$

$$w_{rsw} = \frac{E_{rsw}}{E_{max}} \quad (9)$$

$$E_{rsw} = m_{rsw} h_{fg} \quad (10)$$

2. 2 Control system of the mathematical model

Based on Gagg's two node model, the controlling of the mathematical model was divided into two parts. In the first part, which recognize the thermal state of the controlled system, the error signal was equal to the difference temperature between the actual temperature in two compartments between the set point temperature, so that the outputs of warm or cold can be determined, it can be expressed by following equations:

$$WSIG_{cr} = \max((T_{cr} - T_{cr,n}), 0) \quad (11)$$

$$WSIG_{sk} = \max((T_{sk} - T_{sk,n}), 0) \quad (12)$$

$$CSIG_{cr} = \max((T_{cr,n} - T_{cr}), 0) \quad (13)$$

$$CSIG_{sk} = \max((T_{sk,n} - T_{sk}), 0) \quad (14)$$

$$WSIG_b = \max((T_b - T_{b,n}), 0) \quad (15)$$

$$CSIG_b = \max((T_{b,n} - T_b), 0) \quad (16)$$

Where,

$$T_b = \xi T_{sk} + (1 - \xi) T_{cr} \quad (17)$$

$$T_{b,n} = \xi_n T_{sk,n} + (1 - \xi_n) T_{cr,n} \quad (18)$$

In the second part, based on the temperature signals, the effector outputs of the controlling system were determined, respectively. The controller equations are as follows:

(1) Vasomotor regulation:

$$m_{bl} = \frac{(6.3 + 200WSIG_{cr})}{(1 + 0.1CSIG_{sk})3600} \quad (19)$$

$$\xi = 0.042 + \frac{0.745}{3600m_{bl} + 0.585} \quad (20)$$

(2) Sweating regulation:

$$m_{rsw} = 4.72 \times 10^{-5} WSIG_b \exp(WSIG_{sk} / 10.7) \quad (21)$$

(3) Shivering regulation:

$$Mshiv = 19.4CSIG_{sk} CSIG_{cr} \quad (22)$$

2.3 The mathematical model of predicting the total insulation value of a bedding system

The total insulation value of a bedding system would be affected by many factors: beddings, the percentage coverage of body surface by beddings and bed with mattress, the insulation of mattress and so on.

The mathematical model of predicting the total insulation value of a bedding system was developed as follows [28]:

$$\frac{1}{R_t} = \frac{\frac{3}{5} \times (A_c - 0.233)}{\left((0.03984 \times H_{fab}) + \frac{1}{h_c + h_r} \right)} + \left(\frac{2}{5} \times (A_c - 0.233) \right) \cdot h_c \times \left[\frac{\left(\frac{2}{(0.03984 \times H_{fab}) + \frac{1}{h_c + h_r}} + \frac{\sqrt{3}}{r_m} \right)}{\left(\frac{2}{(0.03984 \times H_{fab}) + \frac{1}{h_c + h_r}} + \frac{\sqrt{3}}{r_m} + h_c \right)} + \frac{0.233}{r_m} + \frac{(1 - A_c)}{h_c + h_r} \right] \quad (23)$$

To make sure the thermal comfort of a sleeping person, the air velocity around the person would be less than 0.25 m/s, and Air velocity in all the experiments was controlled at not greater than 0.15 m/s. Therefore, the convective heat transfer coefficient was assumed at 5.1 W/(m²·K), then, with a value of 3.235 W/(m²·K) for the radiant heat transfer coefficient, Equation (23) could be simplified to:

$$\frac{1}{R_t} = \frac{\frac{3}{5} \times (A_c - 0.233)}{\left((0.03984 \times H_{fab}) + \frac{1}{8.335} \right)} + \left(\frac{2}{5} \times (A_c - 0.233) \right) \cdot 5.1 \times \left[\frac{\left(\frac{2}{(0.03984 \times H_{fab}) + \frac{1}{8.335}} + \frac{\sqrt{3}}{r_m} \right)}{\left(\frac{2}{(0.03984 \times H_{fab}) + \frac{1}{8.335}} + \frac{\sqrt{3}}{r_m} + 5.1 \right)} + \frac{0.233}{r_m} + \frac{(1 - A_c)}{8.335} \right] \quad (24)$$

3 Validation of the mathematical model

Combining the above equations described in Section 2, the simplified mathematical model was developed and would be used to simulate the thermal physiological responses of a sleeping person in steady-state and uniform conditions.

Figure 1 shows the relationship between air temperature and skin temperature for a naked sleeping person under three humidity levels. It can be that the humidity did not affect significantly the skin temperature, compared with the air temperature. The increase in humidity from 30 % to 70 % resulted only in the increase in skin temperature, which was less than 0.7°C.

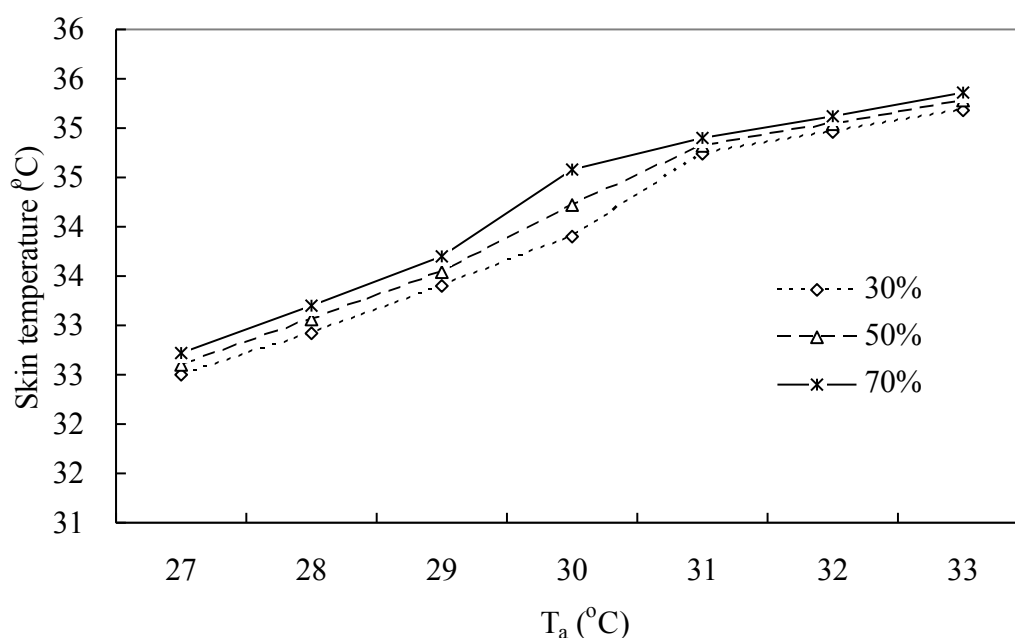


Figure 1 The relationship between air temperature and skin temperature for a naked sleeping person under three humidity levels

For the humidity did not affect significantly the skin temperature, the humidity was assumed to be 50% in the next results analysis. Figure 2 shows the relationship between air temperature and the skin and core temperature for a naked sleeping person. It can be seen that the higher the air temperature, the higher the skin temperature. This suggested that the skin temperature was affected significantly the air temperature. However, the core temperature kept nearly the same with the change in air temperature.

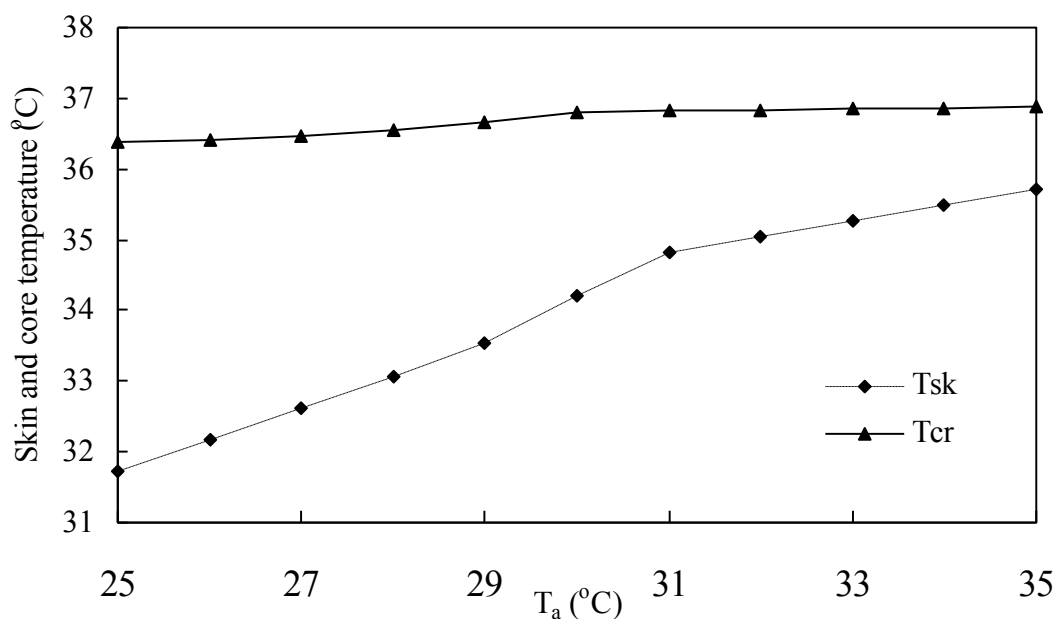


Figure 2 The relationship between air temperature and the skin and core temperature for a naked sleeping person

Figure 3 shows the relationship between air temperature and heat losses for a naked sleeping person. It can be seen that when the air temperature was more than 30°C, the heat loss resulted from evaporation increased, and heat production by shivering became zero. And the heat loss from evaporation kept nearly the same, and heat production by shivering increased with the decrease in the air temperature, when the air temperature was less than 30°C. This suggested that the air temperature at 30°C may be a neutral air temperature for a naked sleeping person, which agreed well with the previous experimental results [16, 22]. For sensible heat loss from skin, $C+R$, it decreased with the increase in the air temperature. Since sensible heat loss was proportionally related to the temperature difference between operative temperature and skin temperature.

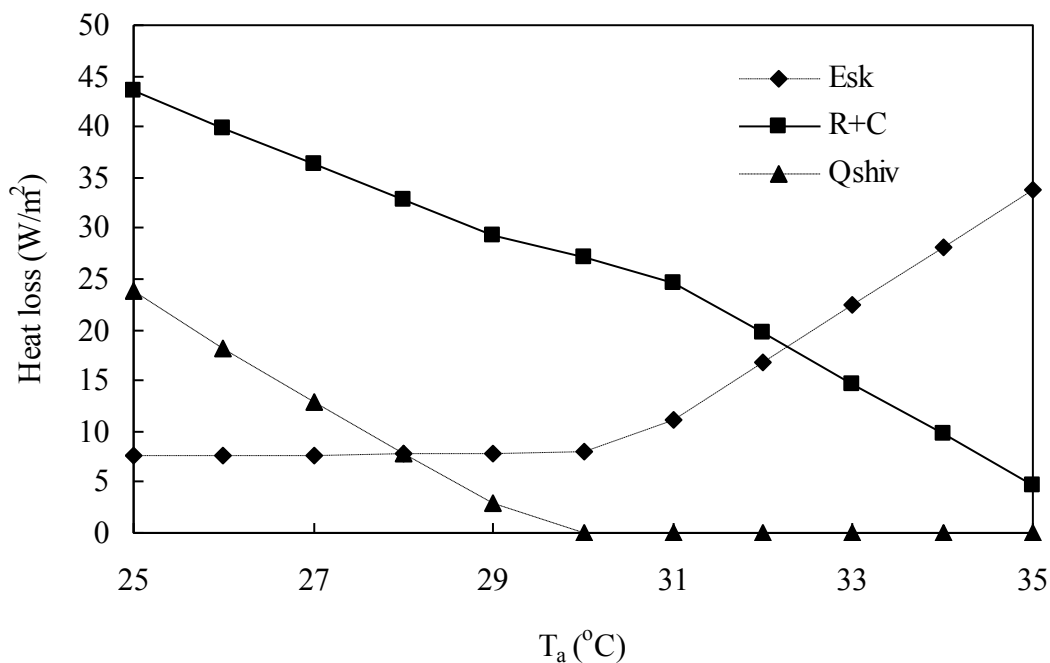


Figure 4 Relationship between air temperature and heat loss for a naked sleeping person

To investigate the total insulation of a bedding system on the thermal physiological responses of a sleeping person, the air temperature was set at 26°C. The details of the beddings used to simulate the mathematical model were described in Section 2. Figure 5 shows the relationship between A_C and skin temperature for a sleeping person covered with three different beddings. It can be seen that the skin temperature was affected significantly by A_C . The increase in A_C from 30 % to 70 % for three beddings B, Q2 and Q1 led to the increase in skin temperature, 0.24°C, 0.32°C and 0.42°C, respectively. However, the increase in A_C from 30 % to 40 % for three beddings B, Q2 and Q1 resulted in the increase in skin temperature, 0.5°C, 0.74°C and 1°C, respectively. This suggested that for a higher A_C , or a thicker bedding, the resultant total insulation of a bedding system was larger, and the heat loss resulted from evaporation would be decrease remarkably. This would lead to a remarkable increase in skin temperature, since the heat could not be effectively transferred by evaporation.

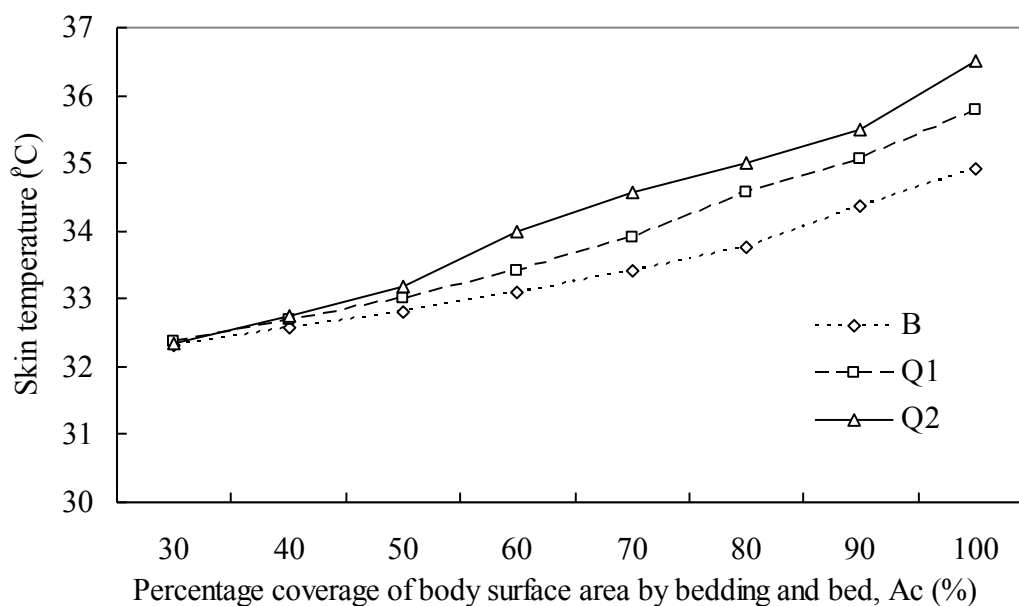


Figure 5 The relationship between A_c and skin temperature for a sleeping person covered with three different beddings

Table 1 summarized the comparisons between the experimental and simulation values for skin and core temperature under various environmental conditions.

Table 1 Comparisons between the experimental and simulation results for skin and core temperature

Case	Researchers	$T_a(^{\circ}\text{C})/h(\%)$	Experimental Results		Simulation Results	
			$T_{sk,ex}$ ($^{\circ}\text{C}$)	$T_{cr,ex}$ ($^{\circ}\text{C}$)	$T_{sk,si}$ ($^{\circ}\text{C}$)	$T_{cr,si}$ ($^{\circ}\text{C}$)
1	Okamoto-Mizuno (10)	29/50	34.2	36.49	34.15	36.8
2	Okamoto-Mizuno (10)	29/75	34.4	36.59	34.6	36.81
3	Tsuzuki (32)	32/80	35.3	37.1	35.31	36.85
4	Okamoto-Mizuno (10)	35/50	35.5	36.91	35.78	36.89
5	Okamoto-Mizuno (10)	35/75	35.9	37.32	36.17	36.96

Figure 6 shows the comparisons between the experimental and simulation results for skin and core temperature for five cases. It can be seen that the simulation results agreed well with the experimental values. The differences between the simulation and experimental results were relatively small, and the errors were within $\pm 1\%$.

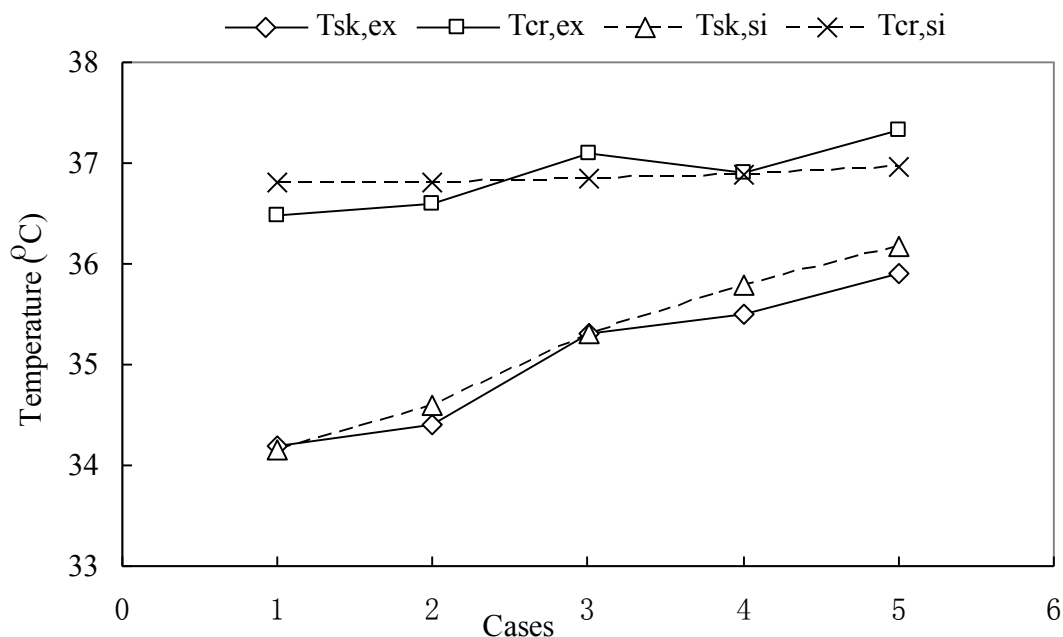


Figure 6 Comparisons between experimental and simulation results for skin and core temperatures

A mathematical model was developed in this section. It was used to predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions.

4 Conclusions

A simplified mathematical model to predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions has been developed and is reported in this paper. The model was validated by comparing the predicted values with the experimental data available in open literature. The comparison results demonstrated that the simplified mathematical model developed could be used to predict the thermal physiological responses of a sleeping person in steady-state and uniform conditions with an acceptable accuracy.

Acknowledgement

The authors would like to acknowledge the financial support from the Hong Kong Polytechnic University Grant G-YL28.

References

- [1] Hobson JA. Sleep. Scientific American Library, A Division of HPHLP, New York, ISSN 1040-3213: 1989.
- [2] Cuellar NG, Ratcliffe SJ, Chien D. Effects of depression on sleep quality, fatigue, and sleepiness in persons with restless legs syndrome. *American Psychiatric Nurses Association* 2006; 12 (5): 262-71.
- [3] Sayar K, Arikan M, Yontem T. Sleep quality in chronic pain patients. *Canadian Journal Psychiatry* 2002; 49 (9):844-8.
- [4] Marc R, Blackman MD. Age-related alternations in sleep quality and neuroendocrine function. *The Journal of the American Medical Association* 2000; 284(7):879-81.
- [5] Muzet A. Environmental noise, sleep and health. *Sleep medicine review* 2007; 11(2):135-42.
- [6] Dauson D, Campbell SS. Time exposure to bright light improves sleep and alertness during simulated night shifts. *Journal of Sleep Research & Sleep medicine* 1991; 14(6): 511-6.
- [7] Tsuzuki K, Okamoto-Mizuno K, Mizuno K, Iwaki T. Effects of airflow on body temperatures and sleep stages in a warm humid climate. *International Journal of Biometeorology* 2008; 52:261-270.
- [8] Haskell EH, Palca JW, Walker JW, Berger RJ, Heller HC. The effects of high and low ambient temperatures on human sleep stages. *Electroencephalography and Clinical Neurophysiology* 1981; (51): 494-501.
- [9] Muzet A, Libert JP, Candas V. Ambient temperature and human sleep. *Experientia* 1984; 40 (5):425-9.
- [10] Okamoto-Mizuno K, Mizuno K, Michie S, Maeda A, Lizuka S. Effects of humid heat exposure on human sleep stages and body temperature. *Sleep* 1999; 22 (6):767-73.
- [11] Henane R, Buguget A, Roussel B, Bittel J. Variations in evaporation and body temperatures during sleep in man. *Journal of Applied Physiology* 1977; 42(1):50-5.
- [12] Sagot JC, Armoros V, Candas V, Libert JP. Sweating responses and body temperatures during nocturnal sleep in humans. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology* 1987; 252: 462-70.
- [13] Palca JW, Walker JW, Berger RJ. Thermoregulation, metabolism and stages of sleep in cold-exposed man. *Journal of Physiology* 1986; 61(3):940-67.
- [14] Haskell EH, Palca JW, Walker JW, Berger RJ, Heller HC. Metabolism and thermoregulation during stages of sleep in humans exposed to heat and cold. *Journal of Applied Physiology* 1981; 51(4):948-54.
- [15] Parmeggiani PL. Thermoregulation and sleep. *Frontiers in Bioscience* 2003; 8: 557-67.
- [16] Sakaguchi S, Glotzbach SF, Heller HC. Influence of hypothalamic and ambient temperatures on sleep in Kangaroo rats. *American Journal of Physiology* 1979; 237: 80-8.
- [17] Hensel H. Neural processes in Thermoregulation. *Physiological Reviews* 1973; 53 (4):948 -1017.
- [18] Atkins AR. An electrical analogue of heat flow in the human body. *The south African Mechanical Engineer* 1963; 13 (4): 40-6.
- [19] Crosbie RJ, Hardy JD, Fessenden E. Electrical analogue simulation of temperature regulation in man. In *temperature-Its Measurement and Control*

- in Science and Industry 1961; 3(3):627-35.
- [20] Smith PE. Analog simulation of the physiological responses of men working in hot environments. In proceedings of the 2nd symposium for biomedical engineering in San Diego 1962; 117-25.
- [21] Gagge AP, Stolwijk JAJ, Nishi Y. An effective temperature scale based on a simple model of human physiological regulatory response. ASHRAE Transactions 1971; 77(1):247-62.
- [22] Stolwijk JAJ, Hardy JD. Temperature regulation in man – A theoretical study. Pflügers Archiv European Journal of Physiology 1966; 291: 129-62.
- [23] Wissler EH. A mathematical model of the human thermal system. Bulletin of mathematical biophysics 1964; 26(2):147-66.
- [24] Smith CE. A transient three-dimensional mode of human thermal system. PhD dissertation, Kansas State University, Manhattan, Kansas. 1991.
- [25] Fu G. A transient 3-D mathematical thermal model for the clothed human. PhD dissertation, Kansas State University, Manhattan, Kansas. 1995.
- [26] Tanabe S, Kobayashi K, Nakano J, Ozeki Y, Konishi M. Evaluation of thermal comfort using combined multi-node thermoregulation (65MN) and radiation models and computational fluid dynamics. Energy and Buildings 2002; 34(6):637-46.
- [27] Lin ZP, Deng SM. A study on the thermal comfort in sleeping environments in the subtropics – Developing a thermal comfort model for sleeping environments. Building and Environment 2008; 43(1): 70-81.
- [28] Pan DM, Lin ZP, Deng SM. A mathematical model for predicting the total insulation value of a bedding system. Building and Environment 2010; 45(8):1866-72.
- [29] Glotzbach SF, Heller HC. Central nervous regulation of body temperature during sleep. Science 1976; 194 (4264):537-9.
- [30] Obal F. Thermoregulation and sleep. In: Borbely A, Valatx JL, eds. Sleep mechanisms. Berlin: Springer-Verlag; 1984, 157-72.
- [31] Gagge AP. A two-node model of human temperature regulation in Fortran. In: Bioastronautics Data Boo; 1973, p.142-148.
- [32] Tsuzuki K, Okamoto-Mizuno K, Mizuno K, Iwaki T. Effects of airflow on body temperatures and sleep stages in a warm humid climate. Int J Biometeorol 2008; 52: 261-270.

WEEE Recycling Network Design in China

Bibo Yang*¹, Renxia Chen*²

*¹The Hong Kong Polytechnic University, Hong Kong, *²Zhongyuan University of
Technology in Zhengzhou, China

0505

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This paper investigates the regulations, recycling and treatment of WEEE (waste electrical and electronic equipment) in China. An online survey about Chinese households' treatment of WEEE is conducted. Optimization models are used to compare the performances of WEEE treatment in two different recycling networks. In the first network, WEEE is collected and sent by recycling stations to licensed WEEE recycling and treatment centers for testing and dismantling. In the second network, WEEE are tested and dismantled at small recycling workshops in residential districts, and then parts/components that require further processing are sent to licensed WEEE recycling and treatment centers. The performances of the two networks are analyzed with linear programming models. The results indicate that the second model is more effective with lower cost and higher recycling efficiency.

Keywords: WEEE; recycling network; China; cost.

1. Introduction

WEEE stands for waste electrical and electronic equipment, it contains highly toxic materials, such as toxic metals, acids, plastic and plastic additives. With these hazardous elements, WEEE causes serious pollution if it is not properly disposed and treated. On the other hand, WEEE contains many precious metals and reusable materials, so it is called “Super Goldmine” if it is recycled properly. Nowadays recycling WEEE becomes a booming business in China. Unfortunately, most recycling work is done in small-scale unlicensed recycling workshops, where WEEE is disassembled manually and recycled with simplistic methods, such as directly burning WEEE and roughly extracting metals from WEEE with acid. This kind of recycling operation incurs low cost but has harmful impacts on the environment and the health of workers. On the contrary, the operation cost of licensed recycling firms is very high since they use advanced recycling technologies and proper methods to protect workers and the environment. Thus licensed firms do not have much advantage over unlicensed workshops in terms of competition. According to a statistics report, there are more than 1,500 unlicensed workshops and only 200 licensed WEEE recycling firms in China, and the former run a more profitable business than the latter.

To improve the recycling and treatment of WEEE in China, the problems of existing recycling networks are investigated. A new network is proposed to recycle and treat WEEE for better regulations and management. The paper is organized as follows. Section 2 reviews relevant literature. In Section 3, an online survey about Chinese households’ treatment of WEEE is conducted. Section 4 presents optimization models to analyze two different recycling and treatment networks. The recycling and treatment of TV sets are used as an example to compare the performances of the two networks. Section 5 concludes the findings of the research.

2. Literature review

The environmental impact of WEEE has drawn attention of many scholars. Wäger et al. [1] presented the results of a combined material flow analysis and life cycle assessment study of Swiss WEEE. Lin et al. [2] implemented the Analytic Hierarchy Process using the information that formed an incomplete hierarchical structure to determine the priority for WEEE recycling in Taipei. Davis and Herat [3] conducted and analyzed a survey of local councils in Australia to determine the current level of understanding and action on e-waste.

A number of researchers studied the recycling and treatment of WEEE in China [4-8]. Yang et al.[9] identified the sources and generation of WEEE in China and recommended increasing the recycling capacity with rising quantity of WEEE. Streicher-Porte and Yang [10] analyzed the costs of collection and transport for five products, including TV sets, refrigerators, washing machines, air conditioners and personal computers, of both formal and informal recycling industries. He et al.[11] presented the status of WEEE and its corresponding responses adopted in 2006 in China. Chi et al.[12] pointed out that the key issue for China’s e-waste management is how to set up incentives for informal recyclers so as to reduce improper recycling activities and divert more e-waste to the formal recycling sector.

The study on the disposal of municipal solid wastes provides good reference for dealing with WEEE. Li and Huang [13] provided an interval-based stochastic programming method for planning the municipal solid waste management with minimal system cost and environmental impact under uncertainty. Costi et al. [14] presented the structure and application of a decision support system designed to help decision makers of a municipality in development of incineration, disposal, treatment and recycling integrated programs. Puig-Ventosa [15] studied the charging systems and pay-as-you-throw experiences for municipal waste management in Spain.

This paper addresses the cost-saving principle and the effective recycling system and reviews the relevant papers. Chang and Chang [16] explored a new idea that an operational program in a solid waste management system should be based on not only the cost-saving principle but also the energy and material recycling requirements. Li and Zhang [17] built a cost-effective recycling model about the reverse logistic process of personal computers. Silveira et al. [18] proposed a deposit/refund advance-recycling fee institution which can be implemented as a voluntary industrial initiative. Xu et al. [19] proposed a WEEE recycling network model in which the manufacturing company is regarded as the WEEE recycling center and the whole society participates extensively. According to the characteristics of WEEE, Han et al. [20] set up an effective 0-1 integer linear programming model, which not only realizes recovery and recycling logistics network planning control, but also optimizes production cost. In this study, a new recycling and treatment network is presented based on the cost-saving principle which considers the reality and customer habits of China. This type of network has not been mentioned in past literature.

3. Situation of recycling and treatment of WEEE in China

The WEEE in China mainly consists of household e-products, office e-products used by enterprises and public institutions, and e-products generated in industrial production [21]. In addition, there is WEEE illegally imported to China.

The recycling of WEEE in China takes two primary ways, namely door-to-door recycling by private collection peddlers, and recycling by retailers. Peddlers often sell WEEE to unlicensed workshops which repair and upgrade the equipment and sell the usable parts to rural areas or secondary e-product markets. For unusable equipment, they extract reusable metal or material from WEEE by simplistic methods (e.g. burning, extracting metals with acids). These simplistic operations cause high safety risk and pollute the environment.

To deal with the problems, the Chinese government has introduced a set of e-waste management methods. The old-for-new policy on home appliances has been effective in 27 provinces and municipalities of China since 2009. This policy has achieved remarkable success. According to the Commerce Department statistics, 62.113 million sets had already been collected by July 28, 2011. Four pilot projects were launched to gain institutional and technical experiences in regulation preparation and recycling network design [12]. Some licensed recycling firms have been built to improve WEEE processing technology and reduce environmental pollution.

However, according to the survey, these licensed recycling and treatment firms collect WEEE far lower than their design capacity allows. Due to the high cost of WEEE processing facilities and the complex processing procedure, these firms make very low profits or even losses.

4. Analysis of WEEE recycling and treatment network

There are two existing WEEE recycling and treatment networks in China. One is a formal network, and the other is informal. The existing WEEE networks are shown in Figures 1 and 2. In the formal network, WEEE is collected by licensed recycling stations set up by the government and sent to licensed recycling and treatment firms for dismantling and recycling. The processing entails fuel cost, labor cost, management cost, disposal cost, etc. The cost is high due to the technology required and safety and environmental regulations. In the informal network, WEEE is collected by recycling vendors and then sent to unlicensed recycling workshops for dismantling and recycling. These workshops do not use expensive technology and proper equipment, and thus their processing cost is low. Due to the low cost, they can offer much higher purchase prices for used equipment than formal collection stations and most of the used equipment is sold to unlicensed firms. However, the simplistic methods and inappropriate processing cause serious pollution problems. At the same time, since most of the WEEE goes to the informal network, licensed recycling firms do not have enough business to cover the high investment cost of facilities and equipment.

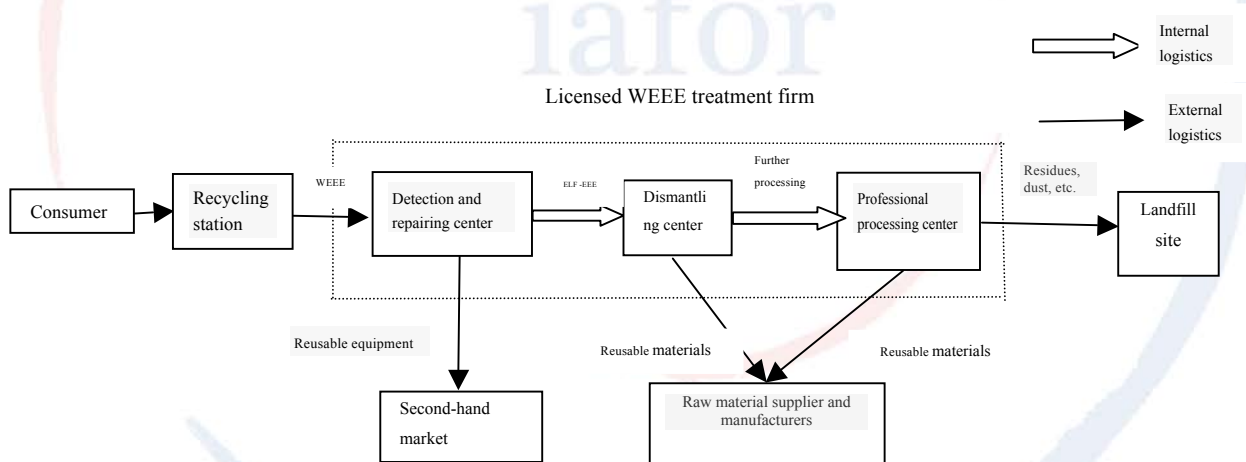


Figure 1: Formal WEEE recycling and treatment network

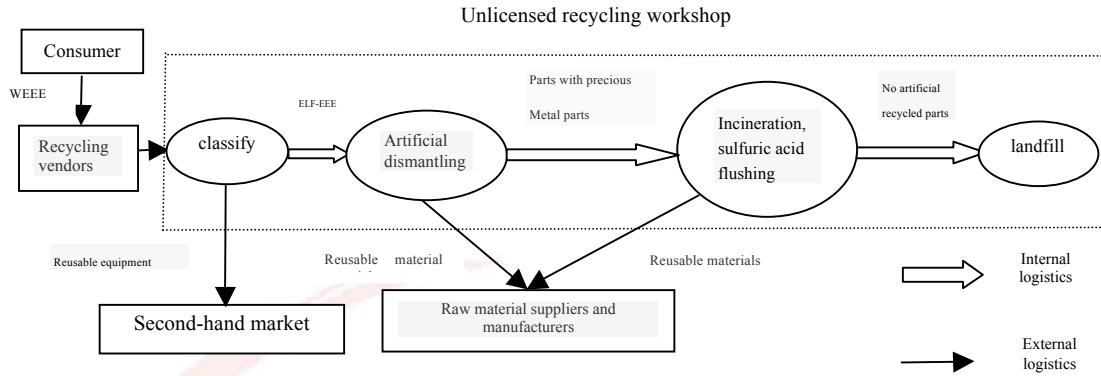


Figure 2: Informal WEEE recycling and treatment network

In order to reduce pollution and increase the recycling volume of licensed recycling firms, a new network is proposed, which uses the convenient collection system of recycling peddlers, and the neatly dismantling skills in unlicensed dismantling workshops to reduce the operation cost. The new network allows small dismantling workshops to disassemble WEEE. Parts or components that need further processing will be sent to professional treatment firms. The new network is shown in Figure 3. In the next section, the existing network will be compared with the proposed network by mathematical models.

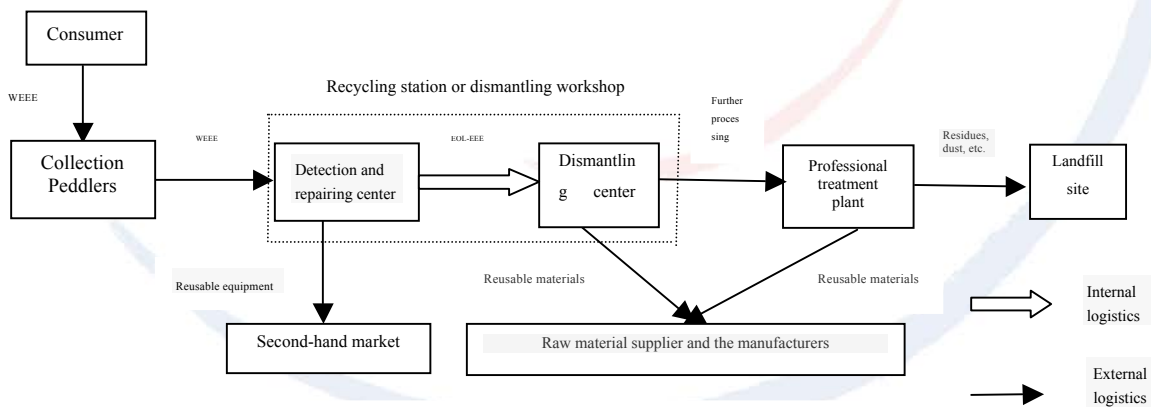


Figure 3: New recycling and treatment network

4.1. Model for the existing formal network

In the existing formal network, recycling stations deliver WEEE to licensed recycling firms which consist of a detection and repairing center, a professional dismantling center, and a further processing center. Before presenting our model, the following notations are defined:

h : the index of a WEEE recycling station, $h = 1, \dots, H$.

c : the index of a WEEE recycling firm, $c = 1, \dots, C$.

u : the index of a WEEE landfill, $u = 1, \dots, U$.

i : the index of a home appliance, $i = 1, \dots, I$.

j : the index of a material derived from WEEE, $j = 1, \dots, J$.

s : the index of a component containing harmful material, $s = 1, \dots, S$.

k : the index of processing equipment, $k = 1, \dots, K$.

D_{hc} : the distance between h and c (km).

D'_{cu} : the distance between c and u (km).

U_{hc} : the unit transportation cost for delivering WEEE from h to c (¥/ton.km).

U'_{cu} : the unit transportation cost of discarded refuse from c to u (¥/ton.km).

c_i : the unit recycling cost of WEEE i (¥/unit).

c'_i : the unit detection cost of WEEE i (¥/unit).

c''_{is} : the unit processing cost of component s containing harmful material in WEEE i (the average fee of breaking, magnetic desperation, etc) (¥/ton).

J_i : the unit manual dismantling cost for WEEE i (¥/unit).

w_i : the average weight of WEEE i (kg).

Y_j : the unit sale price for material j (¥/ton).

W''_{hc} : the total weight of WEEE sent to c from h (ton).

T_u : the unit landfill price for discarded refuse at landfill site u (¥/ton).

Y_i : the unit sale price for WEEE i repaired that can be used again (¥/unit).

β_{ij} : the percentage of recycled material j derived from WEEE i .

z_{is} : the percentage of component s containing harmful material in WEEE i .

M_c : the maximum capacity of WEEE recycling firm c (ton) per year.

M'_u : the maximum capacity of landfill site u (ton) per year.

Q_{hi} : the total quantity of WEEE i recycled at recycling station h (unit).

N_c : the number of workers who operate the equipment at recycling firm c .

P_c : the annual salary of a worker who operates the equipment at recycling firm c .

ε_c : the percentage of harmful material sent to landfill at recycling firm c .

u_{ci} : The upper bound of α_{ci} , $0 < u_{ci} < 1$.

d_{ci} : the lower bound of α_{ci} , $0 < d_{ci} < u_{ci} < 1$.

There are four decision variables for the problem:

W_{hci} : the total weight of WEEE i sent to c from h .

W'_{cu} : the total weight of discarded refuse sent to u from c .

S_{hci} : the quantity of WEEE i sent to c from h .

α_{ci} : the percentage of WEEE i that can be used again at recycling firm c .

F_{ck} : the consumption cost of equipment k at recycling firm c .

The following values are calculated and used in the objective function:

- The total income of the recycling firm: $E = \sum_c (E_{c1} + E_{c2})$,

where E_{c1} is the total income gained from second-hand home appliances sales at recycling firm c : $E_{c1} = \sum_h \sum_i S_{hci} \alpha_i Y_i$.

E_{c2} is the total income gained from recyclable materials sales at recycling firm c : $E_{c2} = \sum_h \sum_i \sum_j w_i S_{hci} (1 - \alpha_i) \beta_{ij} Y_j$.

- The total transportation cost : $T = T_1 + T_2$,

where T_1 is the total transportation cost from h to c : $T_1 = \sum_h \sum_c \sum_i W_{hci} D_{hc} U_{hc}$.

T_2 is the total transportation cost from c to u : $T_2 = \sum_c \sum_u W'_{cu} D'_{cu} U'_{cu}$.

- The total operation cost of all the recycling firms: $O = \sum_c (O_{c1} + O_{c2} + O_{c3} + O_{c4} + O_{c5})$,

where O_{c1} is the operation cost of the detection center at recycling firm c (including recycling fee and detection fee): $O_{c1} = \sum_h \sum_i S_{hci} (c_i + c'_i)$.

O_2 is the operation cost of the dismantling center at recycling firm c : $O_{c2} = \sum_h \sum_i S_{hci} (1 - \alpha_i) J_i$.

O_{c3} is the operation cost of the professional treatment center at recycling firm c : $O_{c3} = \sum_h \sum_i \sum_s S_{hci} w_i (1 - \alpha_i) c''_{is} z_{is}$.

O_{c4} is landfill cost paid by recycling firm c : $O_{c4} = \sum_u W'_{cu} T_u$.

O_{c5} is the total salary for all the workers who operate the equipment at recycling firm c :
 $O_{c5} = N_c P_c$.

- The total fixed cost of all the recycling firms: $F = \sum_c \sum_k F_{ck}$.

The objective function is to maximize the profit, which equals the total income, after subtracting the total transportation cost, the total operation cost and the total fixed cost.

Problem (4.1)

$$\text{Max} \quad E - T - O - F$$

Subject to :

$$\sum_h \sum_i S_{hci} w_i \leq M_c, \quad \forall i, c, h \quad (4.1.1)$$

$$\sum_c W'_{cu} \leq M'_u, \quad \forall c, u \quad (4.1.2)$$

$$\sum_u W'_{cu} = \varepsilon_c \sum_h W''_{hc}, \quad \forall c, u, h \quad (4.1.3)$$

$$\sum_c S_{hci} = Q_{hi}, \quad \forall c, h, i \quad (4.1.4)$$

$$d_{ci} \leq \alpha_{ci} \leq u_{ci}, \quad \forall c, i \quad (4.1.5)$$

$$\text{Equivalent conversion} \quad W''_{hc} = \sum_i W_{hci}, \quad W_{hci} = S_{hci} w_i$$

$$Q_{hi}, W''_{hc}, M'_u, W'_{cu}, M_c, w_i, S_{hci} \geq 0, \quad \forall c, u, h, i \quad (4.1.6)$$

The objective function is to maximize the profits of the recycling firm. Constraint (4.1.1) shows that the total amount accepted by the recycling firm should be less than or equal to the maximum allowable operating capacity of the recycling firm. Constraint (4.1.2) fixes the maximum capacity for the landfill site. Constraint (4.1.3) requires that all wastes produced are correctly disposed. Constraint (4.1.4) is a balance equation: all recycled WEEE has to be finally detected and disposed in recycling firms. Constraint (4.1.5) fixes the range of WEEE that can be used again. All the decision variables are required to be non-negative in Eq. (4.1.6).

4.2. Case study

In order to simplify the model, the following assumptions are made:

- Unit operating cost in the model is the average value of fuel cost, power cost, labor force cost, water and electricity cost, etc.
- Two formal WEEE recycling firms, five recycling stations and two landfill sites are chosen in Shanghai's Pudong New Area. Due to the different distances between the recycling firms

and the landfill sites and the different transport ways, the corresponding unit freight among them is different.

- According to the investigation, the recycling rate is more than 95% of the total recycling volume in the recycling firm, it is assumed that there is always 5% of the total weight to be landfilled, namely $\varepsilon_c = 0.05$.
- The detection, dismantling, processing costs are the same for the two recycling firms, and the scrap rates of the two processing factories are also constant. The data are obtained from China Economic Herald (2011) and the internet.
- The WEEE recycling volume is proportional to the number of consumers. Along with implementation of the “old-for-new” policy, the recycling amount in Pudong New Area is about 163,000 sets, 80% of which are TVs (130,000 sets). The recycling and treatment of TV sets is used as an example.

The average unit recycling price of an obsolete TV is about ¥60. If a TV is repaired properly, which can still be used for some time, it can be sold for ¥90. The unit artificial dismantling cost for an EOL-TV is ¥10. The average weight of a TV set is about 30 kg, (50% glass, about 16% metal and 20% plastic) with harmful material accounting for about 0.4%. Two components with harmful substances in a TV set are the CRT tube and the circuit board, whose unit further processing fees are ¥120 /ton and ¥100 /ton, respectively. The maximum treatment capacities of the two recycling firms are 3,500 ton and 3,000 ton, respectively. There are 70 workers operating the equipment at the two recycling firms and the per capita annual salary is about ¥20,000. The maximum landfill volumes of the two landfill sites are 100 ton and 110 ton per year, respectively. The other relevant data is listed in the appendix.

The LINGO software is used to solve the above linear programming problem. The total profit of the two recycling firms is ¥5,664,162, where $E = ¥16770000$, $T = ¥394222.5$, $O = ¥10043616$. The price of a piece of PCB recycling treatment equipment is about ¥2.1 million and the price of other equipment is about ¥5.632 million is needed of EOL-TVs at the two total profit obtained from make up the equipment is 33,730 sets. According recycling amount can shown in Figure 4.

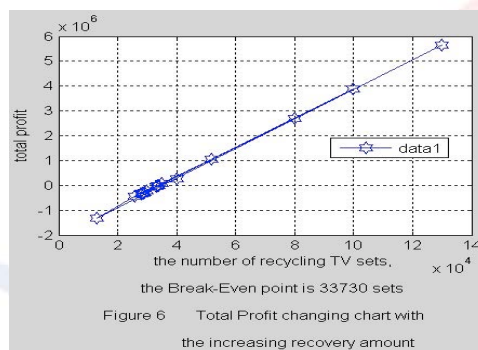


Figure 4: Total profit changing chart with the increasing recovery amount

4.3. The model for the new network

In the existing formal network, the actual recycling volume of WEEE in the licensed recycling center is far lower than the break-even point. Thus, the operation cannot optimize the utility of resources. To solve the problem, a new network (Figure 3) is suggested. Its main difference from the existing formal network is that WEEE is first sent to a small dismantling workshop for dismantling and recycling, and only components with harmful materials are sent to professional treatment firms. This network uses the convenient collection network provided by recycling peddlers and the cheap operation cost of small dismantling workshops so that the operation cost is reduced without causing pollution to the environment.

Some notations are added to the new model:

L_s : the unit treatment fee of component s at the recycling firm (¥/ton).

S_{hi} : the amount of WEEE i recycled at recycling station h .

β'_{is} : the percentage of component s requiring further processing in WEEE i .

z_{sj} : the percentage of material j derived from component s in component s .

u_{hi} : the upper bound of α_{hi} , $0 < u_{hi} < 1$.

d_{hi} : the lower bound of α_{hi} , $0 < d_{hi} < u_{hi} < 1$.

M''_{hi} : the total weight of WEEE i at recycling station/dismantling workshop h .

F_{ck} : the annual consumption cost of equipment k at recycling firm c .

Four direct decision variables are defined for the problem:

W_{hcs} : the total weight of component s sent to c from h .

α_{hi} : the percentage of WEEE i that can be used again at dismantling workshop h .

W'_{cu} : the total weight of discarded refuse sent to u from c .

W''_{hc} : the total weight of components sent to c from h .

The following values are defined and used in the objective function:

- The total income of recycling stations/dismantling workshops and the recycling firm:

$$E = \sum_h E_h + \sum_c E_c,$$

where E_h is the income of recycling station/dismantling workshop h : $E_h = E_{h1} + E_{h2}$.

E_{h1} is the total income gained from the second-hand home appliances sales at recycling station/dismantling workshop h : $E_{h1} = \sum_i S_{hi} \alpha_{hi} Y_i$.

E_{h2} is the total income gained from recyclable materials sales at recycling station/dismantling workshop h : $E_{h2} = \sum_j \sum_i S_{hi}(1 - \alpha_{hi})\beta_{ij}Y_j$.

E_c is the income of recycling firm c : $E_c = \sum_h \sum_s \sum_j W_{hcs}z_{sj}Y_j$.

● The total transportation cost: $T = T_1 + T_2$,

where T_1 is the total transportation cost from h to c : $T_1 = \sum_h \sum_c D_{hc}U_{hc}W_{hc}''$.

T_2 is the total transportation cost from c to u : $T_2 = \sum_c \sum_u D'_{cu}U'_{cu}W'_{cu}$.

● The total operation cost: $O = \sum_h O_h + \sum_c O_c$,

where O_h is the operation cost of recycling station h : $O_h = O_{h1} + O_{h2}$.

O_{h1} is the detection and recycling cost at recycling station/dismantling workshop h :

$$O_{h1} = \sum_i S_{hi}(c_i + c'_i).$$

O_{h2} is the manual dismantling cost of EOL-EEE at recycling station/dismantling workshop h :

$$O_{h2} = \sum_i S_{hi}(1 - \alpha_{hi})J_i.$$

O_{c1} is the processing cost for components for further processing at recycling firm c :

$$O_{c1} = \sum_h \sum_s W_{hcs}L_s.$$

O_{c2} is the annual salary of workers who operate the equipment at recycling firm c : $O_{c2} = N_c P_c$.

● The total fixed cost: $F = \sum_c \sum_k F_{ck}$.

Problem (4.3)

The objective function is to maximize the total profit of the recycling station/dismantling workshop and the recycling firm. The total profit equals the total income, after subtracting the total transportation cost, the total operation cost and the total fixed cost.

$$\text{Max} \quad E - T - O - F$$

Subject to

$$\sum_h W_{hc}'' \leq M_c \quad (4.3.1)$$

$$\sum_c W'_{cu} < M'_u \quad (4.3.2)$$

$$\sum_c W_{hc}'' = \sum_i \sum_s M'_{hc}(1 - \alpha_i)\beta'_{is} \quad (4.3.3)$$

$$\sum_u W'_{cu} = \varepsilon_c \sum_h W''_{hc} \quad (4.3.4)$$

$$d_{hi} < \alpha_{hi} < u_{hi} \quad (4.3.5)$$

Equivalent conversion:

$$\sum_c W_{hcs} = \sum_t S_{hi} (1 - \alpha_i) w_i \beta'_{is}, \quad W''_{hc} = \sum_s W_{hcs}, \quad M''_{hi} = S_{hi} w_i.$$

$$Q_{hi}, W_{hc}, M'_u, W'_{cu}, M_c, w_i, S_{hci} \geq 0, \quad \forall c, u, h, i$$

(4.3.6)

The objective function is to maximize the total profit. Constraint (4.3.1) indicates that the total weight of parts/components accepted by the recycling firm should be less than or equal to its maximum allowable operating capacity. Constraint (4.3.2) fixes the maximum capacity of the landfill site. Constraint (4.3.3) requires that all the components containing toxic materials must be correctly disposed in the formal processing center. Constraint (4.3.4) shows that all the refuse produced in the treatment center should be disposed at the landfill site. Constraint (4.3.5) fixes the range of WEEE that can be used again. All the decision variables are required to be non-negative in Eq. (4.3.6).

The same data is used as in Section 4.2. The total profit is ¥7,190,320. The overall operation cost is reduced by ¥601,660. The break-even is about 17000 sets, the revenue is as shown in Figure 5.

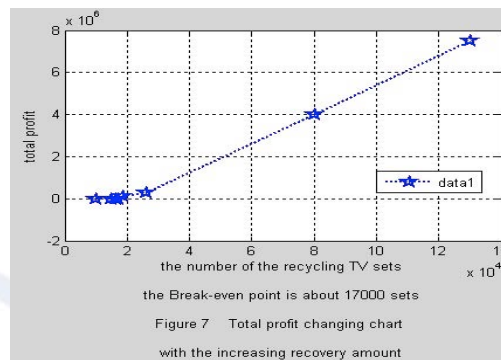


Figure 5: Total profit changing chart with the increasing recovery amount

The break-even point is far lower than the break-even point of the existing model (Figure 4). Compared to the model in Section 4.2, the value of a TV is unchanged, which means E is the same. However, the weight sent to the specialized disposal plant reduces, and the total freight is reduced by ¥251,999.1. Meanwhile, because of cheap methods and low cost employed by small dismantling workshops, dismantling efficiency is improved, the unit manual dismantling cost for

EOL-TV is reduced by 20%, and the total manual dismantling cost can be saved up to ¥208,000. Since only components containing harmful substances need further processing, they are transported to professional recycling firms. Hence, part of WEEE processing can be done at dismantling workshops, and the rest can be treated at licensed recycling firms which can make full use of the previously established recycling treatment systems. Since there are at least 5 million EOL-TV sets in China, we can save at least ¥58.7 million. The cooperation between dismantling workshops and professional recycling firms reduces not only cost but also pollution.

When compared with the exiting formal network, the new network can reduce the total social cost and increase the profit of licensed recycling firms. It can also remove the existing informal network which is illegal and harmful to the environment. Currently a large number of unlicensed recycling workshops run business across the country. More manpower, financial and material resources are needed to manage unlicensed workshops. It is estimated that at least 500 people should be hired to handle unlicensed workshops. The salary of each supervisory staff member is at least ¥500 per month and the total investment in supervising workshops will be about ¥3 million per year. In the new network, no attempts are made to close down small dismantling workshops and they are allowed to do dismantling work of parts without harmful material, and parts/components with harmful material are sent to professional recycling firms for further processing. As a result, workers in small workshops can keep their jobs and WEEE can be processed in a proper and healthy way.

5. Conclusions

The impact of WEEE on the environment has become a global issue. The situation in China is particularly serious. The recycling and treatment of WEEE in China just begins and needs improving. There are formal and informal recycling networks in China. Both of them have drawbacks. Our proposed new network uses the convenient collection system of recycling peddlers and the cheap operation of small dismantling workshops, and ensures parts/components containing harmful material are sent to professional recycling firms for processing. This new network also combines the advantages of both the formal and informal networks. Linear programming models are used to analyze and compare the networks. This research proves that this new network can improve environment protection and also reduce operation cost. It also provides valuable advice for establishing WEEE recycling and treatment management policies in China.

Acknowledgement: This work is supported by PolyU RGC Direct allocation fund PD1Z.

References

- [1] P.A. Wäger, R. Hischer, M. Eugster, “Environmental impacts of the Swiss collection and recycling systems for Waste Electrical and Electronic Equipment(WEEE): A follow-up,” *Science of the Total Environment*, Vol. 409, 2011, pp. 1746-1756.
- [2] C.H. Lin, L. Wen, Y.M. Tsai, “Applying decision-making tools to national E-waste recycling policy: An example of analytic hierarchy process,” *Waste Management*, Vol. 30, 2010, pp. 863-869.
- [3] G. Davis, S. Herat, “Opportunities and constraints for developing a sustainable E-waste management system at local government level in Australia,” *Waste Management & Research*, Vol. 28, 2010, pp.705-713.
- [4] C. Hicks, R. Dietmar, M. Eugster, “The recycling and disposal of electrical and electronic waste in China—legislative and market responses,” *Environmental Impact Assessment Review*, Vol. 25, 2005, pp.459– 471.
- [5] Z.H. Luo, G.M. Zhou, “Study on the current situation of Electronic Waste in China,” *Jiangsu Environmental Science and Technology*, Vol.19, No.2, 2006, pp. 104-107(in Chinese).
- [6] Y.W. Li, J. Yang, H. Li, “Study on domestic and foreign environmental management and treatment technology of waste electronics,” *Environment Science Trends*, Vol.3, 2004, pp.36-37(in Chinese).
- [7] X. Chen, J. Fu, J.H. Cheng, Q.F. Zhou, “The recycling situation and counter-measures of waste electrical and electronic equipment in China,” *Renewable Resources and Recycling Economy*, Vol. 2, No. 7, 2009, pp. 34-38 (in Chinese).
- [8] S.C. Dong, Z.J. Fan, “Research on the E-waste circular industry in China,” *Resource Science*, Vol. 27, No. 1, 2005, pp.39-45(in Chinese).
- [9] J.X. Yang, B. Lu, C. Xu, “WEEE flow and mitigating measures in China,” *Waste Management*, Vol. 28, 2007, pp. 1589-1597.
- [10] M. Streicher-Porte, J.X. Yang, “WEEE recycling in China,” *Present situation and main obstacles for improvement*, 2007, IEEE 1-4244-0861-X/07.
- [11] W.Z. He, G.M. Li, X.F. Ma, H. Wang, J.W. Huang, M. Xu, C.J. Huang, “Review WEEE recycling strategies and the WEEE treatment status in China,” *Journal of Hazardous Materials*, Vol. B136, 2006, pp.502–512.
- [12] X.W. Chi, M. Streicher-Porte, M.Y.L. Wang, M.A. Reuter, “Informal electronic waste recycling: A sector review with special focus on China,” *Waste Management*, Vol. 31, 2011, pp.731-742.
- [13] Y.P. Li, G.H. Huang, “An interval-based possibilistic programming method for waste management with cost minimization and environmental-impact abatement under uncertainty,” *Science of the Total Environment*, Vol. 408, 2010, pp.4296-4308.
- [14] P. Costi, R. Minciardi, M. Robba, M. Rovatti, R. Sacile, “An environmentally sustainable decision model for urban solid waste management,” *Waste Management*, Vol. 24, 2004, pp. 277-295.
- [15] I. Puig-Ventosa, “Charging systems and PAYT experiences for waste management in Spain,” *Waste Management*, Vol. 28, 2008, pp. 2767-2771.

- [16] Y.H. Chang, N.B. Chang, “ Optimization analysis for the development of short-term solid waste management strategies using presorting process prior to incinerators,” *Resources, Conservation and Recycling*, Vol. 24, 1998, pp. 7-32.
- [17] J. Li, J.H. Zhang, “Reverse logistic game about obsolete computer and the cost-benefit recycling model,” *China Resources Comprehensive Utilization*, Vol. 26, No. 4, 2008, pp.10-14(in Chinese).
- [18] G.T.R. Silveira, S.-Y. Chang, “Cell phone recycling experiences in the United States and potential recycling options in Brazil,” *Waste Management*, Vol. 30, 2010, pp.2278-2291.
- [19] J. Xu, Y.L. Zhang, Y.R. Jin, “Study of old and useless electronic products return network,” *Logistics Technology*, Vol. 28, No. 3, 2005, pp. 56-59(in Chinese).
- [20] X.B. Han, H.Q. Ou Yang, X.Y. Zhu, “Programming of reverse distribution network for the recycling of WEEE by OEMs,” *Machinery & Electron*, Vol. 10, No.7 2005, pp. 3-6(in Chinese).
- [21] Y.J. Ge, Y.Y. Jin, Y.J. Nie, “Study on the WEEE recycling management,” *Environmental Sciences & Technology*, Vol. 29, No. 3, 2006, pp. 61-63 (in Chinese).

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is enclosed within a large, faint circular graphic composed of two overlapping arcs: a red one on the left and a blue one on the right, which together form a partial circle around the text.

Appendix :

Table 1: Distance from h to c (km)

$c \setminus h$	$h1$	$h2$	$h3$	$h4$	$h5$
$c1$	10	6	30	24	21
$c2$	4	16	30	20	20

Table 2: Unit transportation cost from h to c (¥/ton.km)

$c \setminus h$	$h1$	$h2$	$h3$	$h4$	$h5$
$c1$	8	12	9	7	6
$c2$	8	6	8	5	4

Table 3: Distance from c to u (km)

$u \setminus c$	$c1$	$c2$
$u1$	20	19
$u2$	31	3

Table 4: Unit transportation cost from c to u (¥/ton.km)

u / c	$c1$	$c2$
$u1$	8	7
$u2$	6	9

Table 5: Unit landfill cost (¥/ton)

Landfill site	$u1$	$u2$
T_u	200	210

Table 6: Unit cost of recycled materials derived from EOF-TV ($10,10^3$ ¥/ ton)

Materials	Glass	Plastic	Copper	Iron	Aluminum	Lead	Phosphor
Y_j	0.012	0.6	4	0.3	1.6	1.5	0

Table 7: Recycling amount of every recycling station ($10,10^3$ sets)

s	s_1	s_2
w_s	0.2	0.25

Table 8: Percentage of components with harmful materials to the environment

Recycling bin	h1	h2	h3	h4	h5
Recycling amount Q_{hi}	3	4	2	1	3

Table 9: Equipment cost in one professional treatment plant

Equipment name	Television disassembling line	HA shell crusher	Electronic glass to be automatic cutting machine for CRT	Heater strip	Full set of processing equipment for circuit board	Explosion-proof belt
Unit Cost	168000 (¥/set)	168000 (¥/set)	260000 (¥/set)	300(¥/kg)	2100000 (¥/set)	120000 (¥/set)
Life spans	About 7(years)	About 8 (years)	About 13 (years)	500 CRT tube handled by 1kg Heater strip	About 10 (years)	About 6 (years)
Fee for every year	24000 (¥/year)	21000(¥/year)	20000 (¥/year)	(the number of the TV /500) *300	210000 (¥/year)	20000 (¥/year)

*Border Adjustments under Unilateral Carbon Pricing: The Case of Australian
Carbon Tax*

Mahinda Siriwardana, Sam Meng, Judith McNeill

University of New England, Australia

0520

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

In the absence of a global agreement to reduce emissions, Australia has adopted a carbon tax unilaterally to curb its own emissions. During the debate prior to passing the carbon tax legislation, there were concerns about the challenge that Australia's emissions intensive and trade exposed (EITE) industries may face in terms of decreasing international competitiveness due to the unilateral nature of the tax and hence the potential for carbon leakage. In order to address these concerns, this paper explores possible border adjustment measures (BAMs) to complement the domestic carbon regulation in Australia using the multi-sector computable general equilibrium (CGE) approach. We consider four border adjustments: border adjustments on imports based on domestic emissions; border adjustments on exports via a rebate for exports; a domestic production rebate; and full border adjustment on both exports and imports. We compare the numerical simulation results of these scenarios with a no border adjustments scenario from the standpoint of welfare, international competitiveness, and carbon leakage. The key finding is that BAMs have a very small impact on the overall economy and on EITE sectors. In other words, the different BAMs are unlikely to change the outcomes of carbon pricing policy in Australia in any significant way. This finding is consistent with studies for EU, US, Canada and other countries. We conclude with the consideration of whether the border adjustments are warranted in the Australian case.

JEL Classification: Q56, F18

Keywords: CGE modelling; Emissions; Carbon tax; Carbon leakage; International competitiveness; Border adjustments; Australia.

1 Introduction

In the absence of a global agreement to reduce emissions, Australia has adopted a carbon tax unilaterally to curb its own emissions and to counter climate change. During the debate prior to passing the carbon pricing legislation, there were concerns about the challenge that Australia's emissions intensive and trade exposed (EITE) industries may face having to experience decreasing international competitiveness due to the unilateral nature of the tax and hence the potential for carbon leakage. Domestic climate policies to limit carbon emissions can put extra pressure on industries that use emission-intensive energy sources in their production leading to cost differentials between domestic production and production in countries where carbon emissions are not constrained. It has been argued that such climate policy differences could place Australian industries at a competitive disadvantage in both home and foreign markets. Another concern is the carbon leakage, which generally occurs due to increase in emissions in countries without strong climate policies when countries with climate policies reduce emissions.

The potential adverse impact on Australia's competitiveness and seemingly inevitable carbon leakage has been used by opponents to undermine the carbon pricing strategy in Australia. While border adjustment has been proposed as a possible countermeasure in the policy debate in Australia, the impact of adopting border adjustments and the empirical question as to whether they are in fact warranted in the Australian case has not been widely analysed. The exceptions are Saddler et al. (2006), which examined the issue in a rather broad framework without a formal model and Clarke and Waschik (2012), discussed below.

In this paper we use a multi-sectoral computable general equilibrium (CGE) model developed for carbon pricing policy analysis of Australia (Meng et al., 2013) to simulate the impact of different border adjustment measures (BAMs) and compare them with no border adjustment outcome. In particular, four BAMs are evaluated using the CGE model: (1) border adjustment on exports; (2) border adjustment on imports; (3) border adjustment through production rebate (subsidy) to all domestic producers; and (4) full border adjustment (both exports and imports).

The rest of the paper is organised as follows. Section 2 briefly reviews previous climate change policy related studies on border adjustments. Section 3 describes the CGE model and data used in the present analysis. Section 4 outlines the emissions intensity and trade exposure of Australian industries. The basis of the BAMs used in the paper is justified in section 5. Section 6 presents results and discusses the major findings from different border adjustment measures that have been simulated. Section 5 concludes the paper.

2 Literature on Border Adjustments

There is a growing body of literature on the issue of using BAMs to alleviate the decrease in competitiveness and carbon leakage due to adopting a particular carbon pricing strategy. Climate change related BAMs are primarily proposed to restore competitiveness of the domestic economy and to combat carbon leakage while promoting deeper reductions in domestic emissions. Such policies are also considered

as incentives to other countries to participate in an international effort to reduce emissions.

CGE models have been used over the last decade to establish the economic and environmental effectiveness of adopting different BAMs such as export rebates, carbon or 'green' tariffs, production rebates and forcing importers to surrender carbon allowances in a cap-and-trade system. Mckibbin and Wilcoxon (2009) used the G-Cubed model to examine how large green tariffs (i.e, import border adjustments) would need to be to offset the costs of adopting climate policies, and whether the tariffs are effective in combating competitive disadvantage and reducing carbon leakage. Their study focussed on the United States and Europe under various climate policy scenarios. They found that the effects of such tariffs would be small in protecting the domestic import competing sector, and would reduce leakage very modestly. Bernard and Vielle (2009), in analysing the EU emissions trading system (ETS), found that carbon leakage may affect some specific sectors while the aggregate impact would be rather small. Kuik and Hofkes (2010) also explored some implications of BAMs in the EU ETS and concluded that some sectors may benefit, but from an environmental point of view, BAMs are not a very effective measure.

Fischer and Fox (2009) compared the effects of four BAMs (a border tax on imports, a border rebate for exports, full border adjustment, and a domestic production rebate) in a setting of a unilateral emissions pricing scheme for the US and Canada. They illustrated the results for different energy-intensive sectors in the two economies and found that such policies have varying, but rather small, impacts. According to their findings, BAMs are ineffective instruments for improving the competitiveness reduced by emissions control policies and for tackling leakage effects. Domestic production rebates were preferred to other alternatives.

Alexeeva et al. (2008) have undertaken a comparison of BAMs versus an integrated emissions trading scheme where foreign competitors must purchase permits to import into the EU. They found BAMs were more effective in protecting domestic production and integrated emissions trading is better at reducing foreign emissions. Winchester (2011) used a CGE model to compare different BAMs with alternative firm behaviours. In a study encompassing North America, Europe, and some developing countries, Mattoo et al. (2009) examined a range of border adjustment policies in combination with environment policies. They found that border adjustments by high income countries would address most of their competitiveness and environmental concerns at the expense of serious consequences for trading partners.

Burniaux et al. (2010) use the OECD's ENV-Linkages model (a dynamic global model of 12 world regions and 22 sectors) to assess the economic effects of BAMs under alternative coalitions of countries acting to cut emissions. These authors conclude that BAMs can reduce carbon leakage for small coalitions of acting countries such as the EU because when the coalition is small, the leakage occurs mainly through the short term competitiveness channel, rather than through the fossil fuel price channel. Burniaux et al. (2010) also found that the economic effects of BAMs are small.

In a recent study, Takeda et al. (2012) isolated the effects of BAMs accompanying a carbon tax policy in Japan using a multi-regional CGE model developed using the

GTAP-E database. They particularly analysed welfare decline, competitiveness loss and carbon leakage and concluded that 'no single policy is superior to the other policies' in terms of addressing simultaneously all three issues. They do note that export border adjustment is more effective in restoring the export competitiveness of Japanese industries while reducing significantly the carbon leakage

Carbon motivated BAMs have been analysed in a study by Dong and Walley (2012) by developing a highly aggregated multiregional model of China, EU-27, and the US. A range of carbon prices (US\$25/ton to US\$200/ton) were imposed on the model to predict the impact of border adjustments. They found the regional impact of welfare, trade, and emissions of BAMs is rather small concluding that emissions intensity of different sectors matters in relative price adjustments.

Clarke and Waschik (2012) employ a static CGE model using GTAP7 data for Australia to examine the effects of a carbon tax and assess whether the scale of carbon leakages and loss of competitiveness in Australian industry sectors warrant concern. Clarke and Waschik (2012) simulate a 27% carbon emissions abatement (in order to draw comparisons with Australian Treasury modelling on the effects of a carbon tax) and this needs a carbon price of US \$26.41 in the modelling. They assume Australia acts unilaterally to achieve the 27% carbon abatement and that there is no compensation to the EITEs and no BAMs.

Examining the impact of the carbon price on domestic demand, production, exports and imports in the key EITE sectors, Clarke and Waschik (2012) find small impacts and therefore no case for compensating the Australian non-metallic mineral sector (including cement) or the iron and steel sectors. They argue there is a case for protecting the Australian non-ferrous metals sector (aluminium) because of a loss of competitiveness resulting in potentially significant carbon leakage. The present study extends the Clarke and Waschik (2012) study by directly simulating and analysing the effectiveness of a range of BAMs following the introduction of a carbon tax in Australia.

3 Model Structure and Database

3.1 Model

The purpose of this study is to assess the effect of border adjustment policies when a carbon tax is in place rather than forecasting the performance of the whole economy overtime under the tax. Hence the model used for this study is a static CGE model (Meng et al., 2013), based on ORANI-G (Horridge 2000). The comparative static nature of ORANI-G helps to single out the effect of carbon tax and border adjustment policies while keeping other factors intact. The model employs standard neoclassical economic assumptions: a perfectly competitive economy with constant returns to scale, cost minimisation for industries and utility maximisation for households, and continuous market clearance. In addition, zero profit conditions are assumed for all industries because of perfect competition in the economy.

The Australian economy is represented by 35 sectors that produce 35 goods and services, one representative investor, ten household groups, one government and nine occupation groups. The final demand includes households, investment, government

and exports. With the exception of the production function, the model has adopted the functions in the multi-households version of ORANI-G.

Overall, the production function is a five-layer nested Leontief-CES function. As in the ORANI-G model, the top level is a Leontief function describing the demand for intermediate inputs and composite primary factors and the rest is various CES functions at lower levels. However, we have two important modifications to demand functions for electricity generation and energy use.

The functions for final demands are similar to those in the ORANI model (Dixon et al. 1982). For example, investment demand is a nested Leontief-CES function and the household demand function is a nested LES-CES function. Export demand is dependent on the price of domestic goods, and government demand follows household consumption. However, unlike the assumption of exogenous household consumption (either total or supernumerary) in ORANI-G, we assume that total consumption is proportional to total income for each household group.

3.2 Database and parameters

The main data used for the modelling include input-output data, carbon emission data, and various behaviour parameters. The input-output data used in this study are from Australian Input-Output (I-O) Tables 2004–2005, published by ABS (2008). There are 109 sectors (and commodities) in the original I-O tables. For the purpose of this study, we disaggregate the energy sectors and aggregate other sectors to form 35 sectors (and commodities). Table 1 lists the 35 sectors of the model ranked according to emission intensity. The table also displays export shares in output, import shares in the domestic market (import penetration) and the sectoral classification according to their respective trade exposure.

Utilising the household expenditure survey data by ABS (2006), household income and consumption data were disaggregated into ten household groups according to income level. Similarly, the labour supply was disaggregated into nine occupation groups.

The carbon emissions data are based on the greenhouse gas emission inventory 2005 published by the Department of Climate Change and Energy Efficiency. As noted earlier, there are two kinds of emissions: on-site input (fuel) emissions and on-site activity emissions. For the former, the Australian Greenhouse Emissions Information System provided emission data by sector and by fuel type. We map these data into the 35 sectors (and commodities) in our study.

Most of the behavioural parameters in the model are adopted from ORANI-G, e.g. the Armington elasticities, the primary factor substitution elasticity, export demand elasticity, and the elasticity between different types of labour. The changed or new elasticities include the household expenditure elasticity, the substitution elasticities between different types of electricity generation, between different energy inputs and between composite energy and capital. Since we included in the model 10 household groups and 35 commodities, we need the expenditure elasticities for each household group and for each of the commodities. Cornwell and Creedy (1997) estimated Australian household demand elasticities by 30 household groups and 14 commodities. We adopted these estimates and the mapping into the classifications in our model.

Table 1 Sector Classification of the Model

Symbol	Sector	Emissions intensity ¹	Share of exports ² (%)	Share of imports ³ (%)	Trade exposure ⁴
EBR	Electricity-brown coal	25.84	0.0	0.0	L
EBL	Electricity-black coal	19.43	0.0	0.0	L
EOI	Electricity-oil	11.45	0.0	0.0	L
BRC	Brown coal	10.85	0.3	1.3	L
EGS	Electricity-gas	8.82	0.0	0.0	L
AFF	Agriculture, Forestry	3.29	16.4	31.2	H
GAS	&Fishing	1.73	43.1	3.4	H
CEM	Gas	1.18	0.3	2.0	L
BLC	Cement	1.14	88.8	0.1	H
IRS	Black coal	1.12	16.3	22.1	H
GAD	Iron & steel	1.12	0.0	0.2	L
CME	Gas distribution	1.02	0.3	0.0	L
RTS	Commercial Electricity	0.83	16.1	2.8	H
KER	Road transport services	0.82	25.8	17.0	H
LIP	Kerosene	0.78	31.4	14.4	H
CHP	Liquefied petrol	0.64	15.0	39.6	H
OMP	Chemical products	0.50	40.2	10.8	H
WSS	Other metal products	0.43	0.1	0.2	L
OIL	Water & sewerage services	0.39	51.8	45.5	H
ACR	Oil	0.38	24.4	7.1	H
ATP	Accommodation &	0.32	3.9	17.5	H
PRP	restaurants	0.32	6.5	22.0	H
OMI	Automotive petrol	0.30	37.5	7.7	H
OTS	Plastic & rubber products	0.29	24.2	11.7	H
WPP	Other mining	0.15	5.8	15.9	H
FBT	Other transport services	0.15	23.9	25.9	H
TCF	Wood, paper & printing	0.13	28.4	50.4	H
OPC	Food, beverage & tobacco	0.10	11.5	53.4	H
PUS	Textile, clothing &	0.08	3.3	0.9	L
OMF	footwear	0.07	14.5	51.9	H
OSS	Other petroleum and coal	0.06	1.6	2.9	L
TRS	products	0.05	5.9	0.3	L
COM	Public services	0.04	1.9	1.8	L
COS	Other manufacturing	0.03	0.1	0.0	L
ERN	Other services	0.00	0.3	0.0	L
	Trade services				
	Other business services				
	Construction services				
	Electricity-renewable				

Notes:

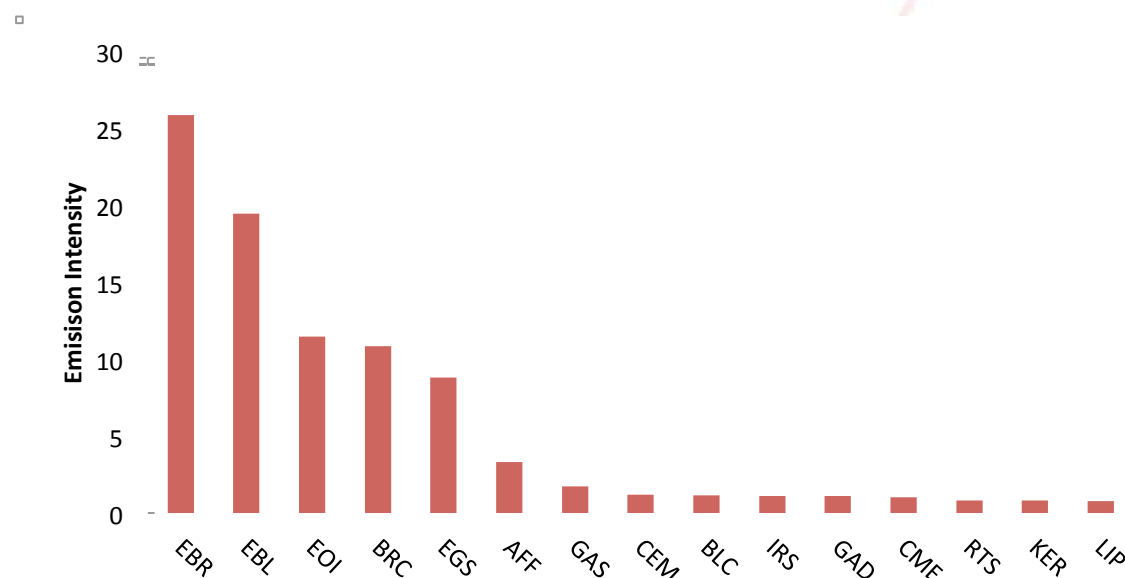
1. Emissions intensity is defined as emissions (kilo tonnes) per million A\$.
2. Export as a share of the total output of a sector.
3. Imports as a share of total supply (imports plus domestic output) of a sector.
4. H=either export or import share is >15%; L=both export and import shares are <15%.

4 Emission Intensity and Trade Exposure

The way in which carbon pricing affects international competitiveness and carbon leakage is not straightforward. An important factor is the emission intensity of individual sectors when there is a price for carbon to pay. As can be seen from Table 1, there is a wide variation in emissions intensity across industries in Australia. This is determined by the use of emission-intensive inputs both directly and indirectly in their production. Naturally, highly emission-intensive sectors incur significant cost increases under the carbon tax. Figure 1 depicts the emissions intensity (kilotonnes per A\$ million) of 19 most polluting sectors out of 35 sectors in our model. Not surprisingly, electricity generating sectors (EBR, EBL, EOI, EGS) are highly carbon intensive in Australia according to Figure 1. In addition, some of the energy production sectors (BRC, GAS, KER, LIP, GAD, ATP, BLC, OMI, OIL), manufacturing sectors (CEM and IRS) and agriculture (AFF) are high in carbon emissions. These are the sectors that will be affected significantly under carbon pricing.

Figure 2 shows the export and import shares of Australia according to the destination and source respectively. Among Australia's eleven major trading partners, Japan, United States, United Kingdom and New Zealand belong to Annex 1 countries of the Kyoto Protocol having obligations to reduce emissions. However, Australia's primary Asian trading partners including China, South Korea, India and the rest of Asia are not obliged to cut emissions. This would imply that the Australian carbon tax to regulate emissions may hurt the competitiveness of EITE sectors in Australia relative to those in China, South Korea, India and rest of Asia.

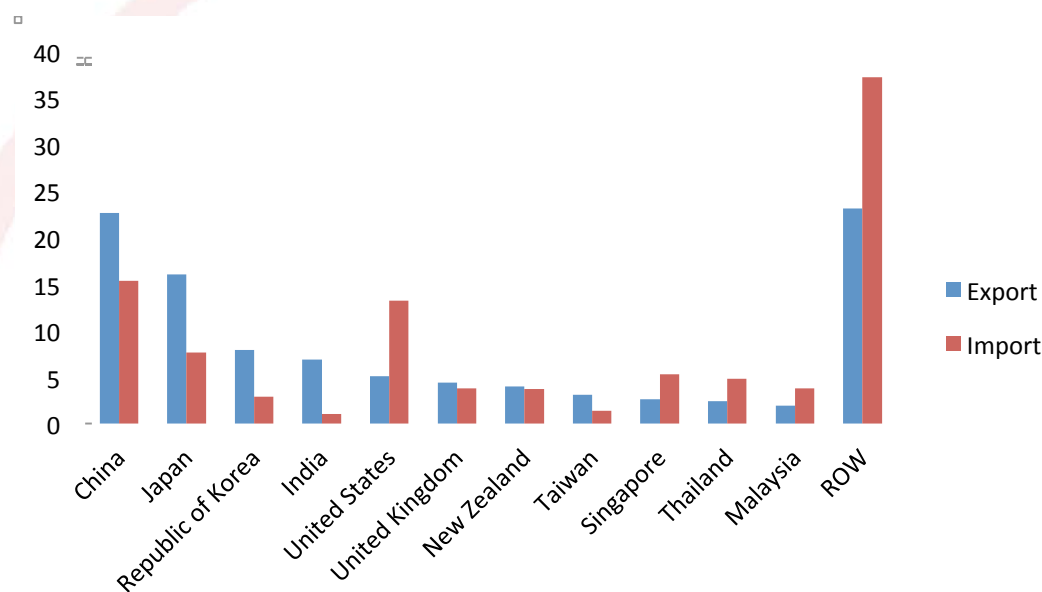
Figure 1 Carbon Emissions Intensity by Sector in Australia (kilotonnes/A\$million)



Source: Calculated from data obtained from the Department of Climate Change and Energy Efficiency (DCCEE).

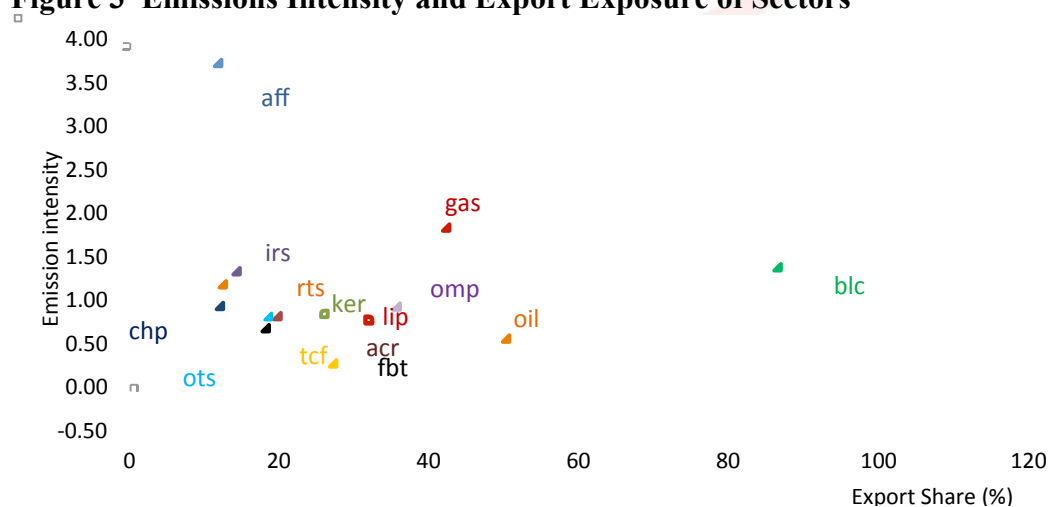
Figure 3 displays three dimensions, which are important determinants of relative competitiveness of individual sectors under climate policy: emission intensity, export exposure and output. Using data from Table 1, we have selected 15 sectors that have export shares above 15% as export intensive and are likely to be affected by the cost increases under the carbon tax policy, depending on their respective emissions intensity. The size of the ‘bubble’ represents output. As can be seen from the figure, there is a wide range of variability in the three dimensions while many sectors cluster towards the horizontal axis of the diagram implying low to moderate emissions intensity and high trade intensity.

Figure 2 Export and Import Shares of Australian Trade(%)



Source: Calculated from data obtained from the Department of Foreign Affairs and Trade (DFAT).

Figure 3 Emissions Intensity and Export Exposure of Sectors

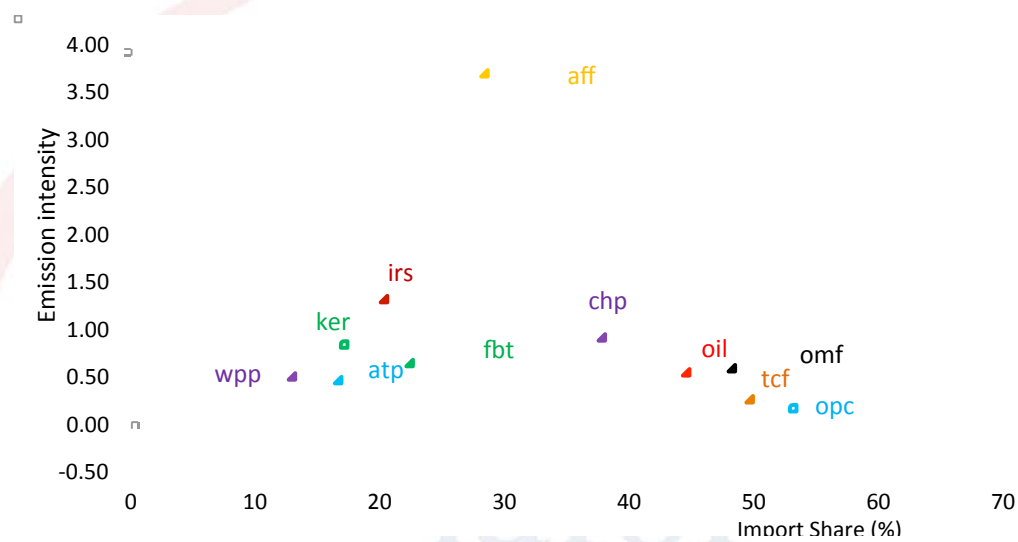


Note: Size of bubble represents output

Source: Calculated from data obtained from DCCEE, DFAT, and ABS.

A similar observation can be made from Figure 4 where emissions intensity, import exposure and output are displayed simultaneously. There are 12 sectors that face import competition and may have been disadvantaged under the policy of domestic emissions control. A majority of these import competing sectors experience low to moderate emissions intensity accompanied by high import penetration. These imports are primarily sourced from countries which are not under obligation to cut emissions.

Figure 4 Emissions Intensity and Import Exposure



Note: Size of bubble represents output

Source: Calculated from data obtained from DCCEE, DFAT, and ABS.

5 Carbon Tax and Border Adjustment

This section describes the basis of our model simulations to examine the impact of different BAMs. The Australian government has implemented the carbon tax at the rate of A\$23 per tonne of CO₂-equivalent with the exemption of agriculture, road transport and household sectors. We have used this carbon tax rate in each simulation scenarios. The government has proposed a number of compensation plans outlining the ways the revenue collected through the tax will be used. They include compensation to selected manufacturers and exporters, reform of income tax thresholds, and family tax benefits such as a clean energy advance, clean energy supplement, and single income family supplement. These measures are quite complex and it is hard to capture them all in a single model. In the model simulations we adopt a modest and simplified compensation plan. We use in each scenario a revenue-neutral straightforward household compensation plan: that is, we transfer all of the carbon tax revenue in equal lump sums to households of the poorest six income deciles of the Australian economy.

Table 2 Border Adjustment Scenarios

Scenario	BA for exports	BA for imports	BA for production
NBA	None	None	None
BAE	All sectors	None	None
BAI	None	All sectors	None
BAP	None	None	All sectors
BAEI	All sectors	All sectors	None

In general, BAMs are used to compensate countries where environmental taxes are levied. For example, exporting countries may give a rebate (subsidy) to exporters to relieve them from increased cost due to a carbon tax, which would otherwise make them uncompetitive in global markets, and importing countries may impose carbon tariffs (green tariffs) equivalent to what would have been charged had the products been produced domestically. The export rebate and carbon tariffs are to be determined according to the carbon content of exports and imports to maintain a levelled playing field and to ensure the effectiveness of border adjustment policies.

We have adopted four border adjustment scenarios as summarised in Table 2. No border adjustment (NBA) scenario is the base simulation where \$23 carbon tax is imposed. The BAE scenario involves providing an export rebate when the carbon tax is in place, whereas BAI introduces a carbon tariff on imports. In addition, we can use a policy to mitigate the impact of carbon regulation on domestic costs of production by giving rebates to all domestic producers, not only exporters. In Table 2, BAP refers to this border adjustment policy. The final measure, BAEI, is the full border adjustment where both export rebate and carbon tariffs are applied to both exports and imports simultaneously to mitigate the domestic impact of carbon tax.

For the purposes of this study, all BAMs have been based on the direct emissions (on-site fuel and activity emissions, as explained above) plus our separate calculations of indirect emissions (emissions embodied in energy inputs, e.g., the use of electricity generated off-site). As our concern is the short-run impact of border adjustments, we have used the short-run closure of the model in all simulations. The underlying features of the closure include fixed real wages and capital stocks, free movement of labour but immobile capital between sectors, and government expenditure to follow household consumption. In addition, a flexible exchange rate regime is used in order to be consistent with Australia's exchange rate policy.

6 Simulation Results

This section compares the results of the BAMs (BAE, BAI, BAP and BAEI) simulations with the no border adjustments (NBA) option when the carbon tax is in place at \$23 per tonne. The general presumption is that the policy of carbon control with the tax will hurt EITE sectors in the Australian economy hence some measures of compensation are needed to ensure a levelled playing field with their overseas competitors. Applying the CGE model outlined earlier, we examine the economic and environmental effects of BAMs. Particularly, we focus on changes in Australia's GDP and employment level, aggregate trade outcomes, domestic emissions reductions, and sectoral outputs, exports, and imports.

6.1 Macroeconomic and Trade Impact of BAMs

The results from border adjustment policy simulations are reported in Table 3 for key macroeconomic variables, and trade aggregates. It is not surprising to see that carbon pricing lowers Australia's real GDP by 0.53 percent in the NBA scenario. The emission controlling new tax distorts resource allocation to some degree causing inefficiency. Facing an increase in production costs, the industries will respond to the tax by reducing outputs which has a direct negative impact on Australia's real GDP. Due to the reduction in real GDP, aggregate employment in the economy tends to be lower by 0.83 per cent compared to the baseline. These consequences may partly be attributed to losing competitiveness due to the environment tax to reduce domestic emissions without a global agreement.

The impact of the four BAMs on real GDP and employment are shown in the second and third rows of Table 3. How does each border adjustment policy fare in the economy is an interesting question. As Australian industries are compensated for their loss in competitiveness through these measures, one should expect some improvement according to the economic analysis of border adjustments. It appears that the domestic production rebate (BAP) and export border adjustment (BAE) have a modest cushioning effect (i.e. GDP and employment reduction is less than in NBA). Interestingly, however, there seems to be no discernible benefit to the economy by using import border adjustment or green tariffs (BAI). The simultaneous use of BAE and BAI (the BAEI scenario) does not improve the outcome beyond what BAE does.

Table 3 Key Macroeconomic and Trade Results from the Simulations

	NBA	BAE	BAI	BAP	BAEI
Carbon tax (A\$/tCO ₂)	23	23	23	23	23
Real GDP	-0.53	-0.41	-0.54	-0.42	-0.42
Aggregate employment	-0.83	-0.65	-0.84	-0.65	-0.66
Export volume	-4.98	-4.42	-5.07	-4.48	-4.5
Import volume	0.80	0.87	0.75	0.83	0.82
Export price	-0.73	-0.70	-0.73	-0.70	-0.70
Import price	-1.25	-1.16	-1.26	-1.17	-1.17
Terms of trade	0.53	0.47	0.54	0.47	0.48
Nominal exchange rate	-1.25	-1.16	-1.26	-1.17	-1.17
Real devaluation	-1.28	-1.18	-1.30	-1.19	-1.20
Equivalent Variation (A\$ m.)	5066.9	5264.1	5058.9	5498.2	5256.9

Source: Model simulations.

Notes: (1) All projections are in percentage changes from the base period except the equivalent variation (EV). (2) Export price and Import price are measured in terms of domestic currency terms.

We next consider what happens to trade aggregates when BAMs are in place to support the EITE sectors in the economy. The policy of export rebate (BAE) is targeted to assisting exporters where the additional costs of production incurred due to the carbon pricing policy are rebated when goods are exported from Australia. Our projections show that the reduction in export volume is lowered by using BAE and BAP to some degree, but again, it is interesting to note that the adoption of green tariffs in Australia is likely to further deteriorate exports as shown by a 5.07 percent reduction in the export volume compared to the NBA outcome (-4.98 percent). The imposition of tariffs makes inputs to export producers more expensive. Hence there is a squeeze in the profit margins in the absence of their ability to pass on the increased costs to customers. As can be seen from Table 3, carbon regulation causes a rise in export prices and BAI has no impact towards easing them. Again, BAE, BAP and BAEI (reflecting the BAE component of BAEI) cause a very modest easing of export price increases.

In our model simulations we have adopted a flexible exchange rate and hence the carbon tax tends to appreciate the nominal rate by 1.25 percent. In general, importers benefit from the carbon tax (NAB scenario) as there appears to be a real appreciation of the Australian dollar. Local consumers are encouraged by the extra purchasing power created by the stronger Australian dollar initiating additional demand for imports. The end result of this would be that domestic import competing sectors lose competitive advantage, adding to carbon leakage. As seen from Figure 2, Australia's major sources of imports include many Asian countries (China, South Korea, India, Taiwan, Singapore, Thailand, and Malaysia) which do not have commitments to reduce emissions. Hence the increased demand for imports by Australia from these sources is likely to contribute to carbon leakage under a unilateral carbon tax. The policy of green tariffs (BAI) appears ineffective in preventing such carbon leakage according to our model projections.

Table 3 also shows the impact on welfare measured in terms of the equivalent variation (EV) as a result of carbon tax and BAMs. Although the carbon tax raises domestic prices in general, Australia's welfare rises in NAB scenario. This is due to the improved terms of trade and the household compensation mechanism by which entire carbon tax revenue is transferred to households of the poorest six income deciles in equal lump sums. Even though the original border adjustment policies were not designed for improving welfare but to sustain the competitiveness of domestic EITE industries while limiting the carbon leakage, results reported in Table 3 demonstrate that export rebates (BAE) and production rebates (BAP) can improve the welfare impact of carbon mitigation.

6.2 Environmental Impacts

The simulated environmental impacts of BAMs are compared with the base simulation (NBA) in Table 4. According to model projections, the introduction of the carbon tax is effective as it reduces Australia's emissions by about 70 Mt. Given Australia's aggregate emissions base of 587Mt in 2004-05, this gives a 12 percent reduction rate. The real question is how far this domestic emissions cut contributes to carbon leakage. As our model is a single country model and has no disaggregation to include Australia's trading partners, we cannot project the carbon leakage rate. Nevertheless, it is reasonable to speculate that a considerable leakage may occur

given that more than a third of Australia’s imports are sourced from developing countries in Asia which do not face mandatory emission cuts.

A closer observation of the impact of BAMs on emission reduction reveals that export and production rebates work against the environmental objectives of the carbon pricing. That is both of these policies tend to discount Australia’s effort to cut emissions compared to the base case scenario (NBA). While these two measures are appealing for reducing potential carbon leakage and mitigating the loss of competitiveness, they do tend to undermine Australia’s effort to reducing its own emissions. Nevertheless the modest increase in carbon tax revenue due to using such measures to assist domestic industries may provide a slight conciliation to their proponents.

Table 4 Selected Projections on Environmental Variables

	NBA	BAE	BAI	BAP	BAEI
Carbon tax (A\$/tCO ₂)	23	23	23	23	23
Aggregate reduction of carbon emissions (Mt)	-70.3	-67.3	-70.2	-67.2	-67.3
Percentage reduction of emissions	11.97	6.2	6.1	6.2	6.2
Carbon tax revenue (A\$ billions)	6.1				

Source: Model simulations.

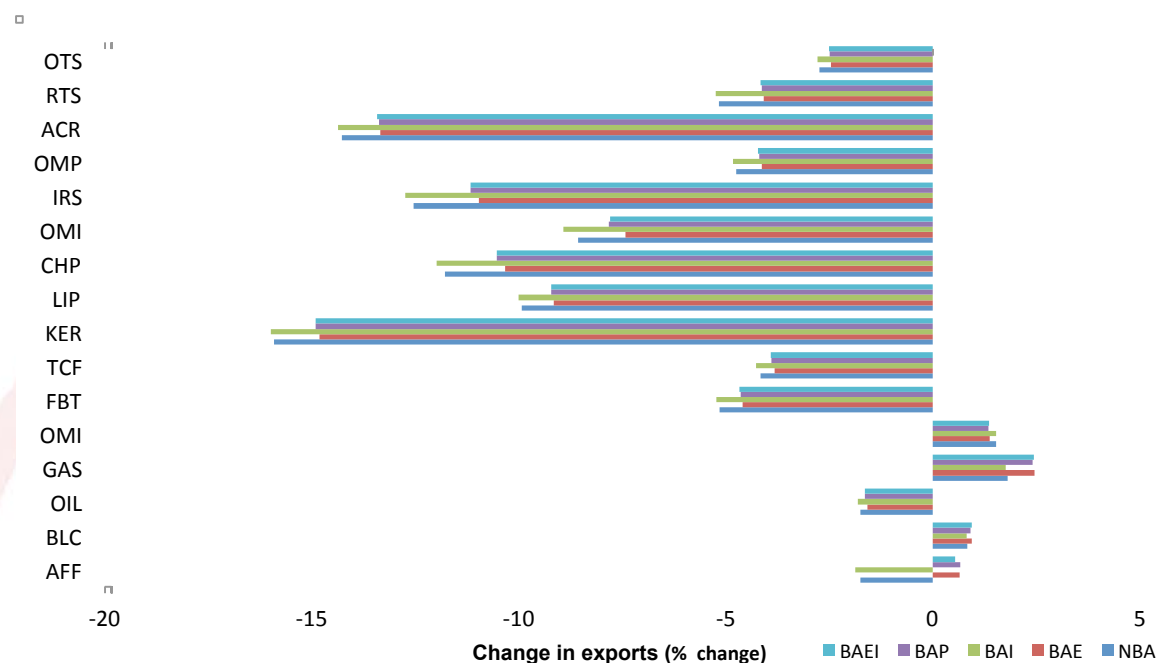
6.3 Impact on Competitiveness of EITE sectors

Thus far our focus of the analysis is on aggregate impacts of border adjustments on Australia’s macro-economy, trade, and environmental concerns. In this section we consider the impact on competitiveness of sectors using changes in sectoral exports, imports and outputs. The adjustments to the economy are based on carbon emissions by sectors (emission intensity) in the border adjustments framework and therefore relative price movements play a key role in the sectoral behaviour in response to the policy.

Figure 5 displays the changes in export volumes by EITE exporting sectors under the policy of carbon tax and their response to border adjustments. The first thing to notice is most of these export intensive sectors experience a significant reduction in export volumes when emissions are controlled with the tax (NBA scenario). The heavily affected sectors are Kerosene (KER), Accommodation and restaurants (ACR), Iron and steel (IRS), Chemical Products (CHP) and Liquefied petrol (LIP). These sectors have relatively high export shares and any increase in domestic cost creates a loss of competitiveness in the foreign markets. There are a further seven sectors (OMP, FBT, RTS, TCF, OTS, OIL, and AFF) that are projected to be losing export competitiveness and hence experience reduced export volumes. Energy goods sectors, Gas (GAS), Other mining (OMI), and Black coal (BLC), are exceptions. As carbon pricing is introduced, these sectors experience reductions in domestic demands but foreign demand rises as these energy goods are becoming relatively cheaper to foreign customers. Unilateral domestic policy to control emissions tends to reduce domestic

consumption of energy intensive goods putting a downward pressure on prices for such goods at the global level.

Figure 5 Percentage Change in Export Volumes by Sector

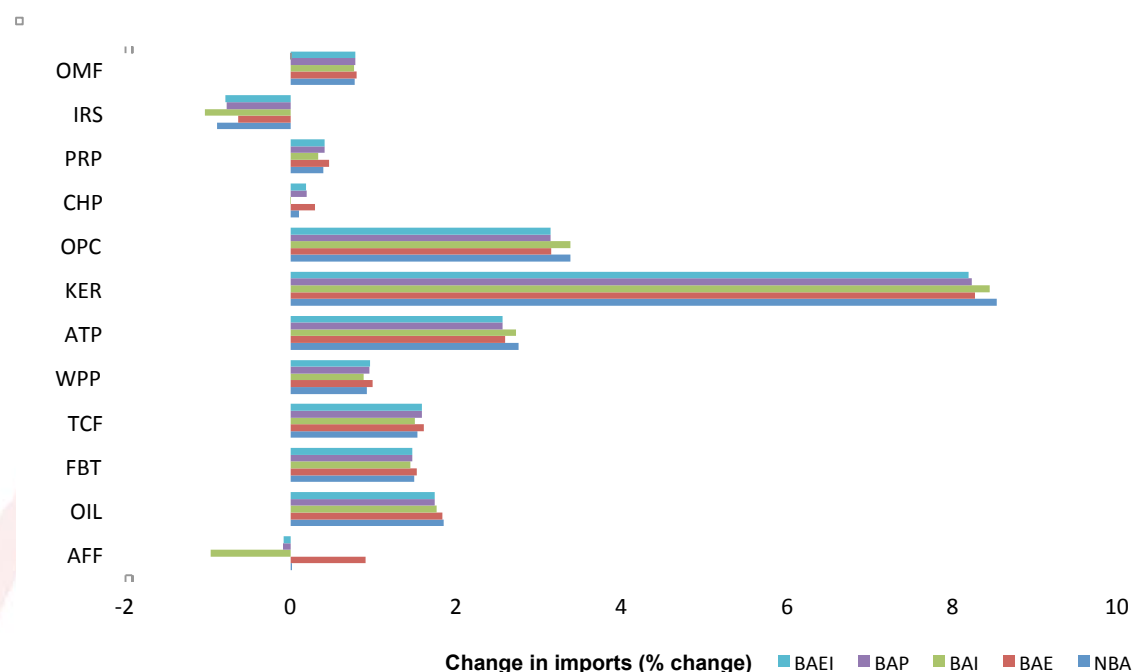


Source: Model simulations.

The application of BAMs affects exports of different sectors by small margins according to our findings. The BAMs (excluding BAI) work modestly to reduce the sectoral export volume declines of the NBA. The Agriculture, forestry & fishing (AFF) sector appears to be improving its exports more significantly under BAP, BAE (and BAEI) in comparison to many other exports. Again, however, the green tariffs (BAI) make exports from EITE sectors even lower than in NBA. The competitiveness of exportable goods deteriorates as a result of imposing green tariffs on imports. This is attributed to additional costs experienced by exporting industries due to the tax.

Figure 6 depicts the change in import volumes under different BAMs in comparison to NBA. We have identified 12 sectors that are exposed to import competition and carbon pricing leads to an increase in imports in 10 of them, and with Kerosene (KER) imports, in particular. The two exceptions are the Iron and steel sector (IRS), which experiences a lower level of imports when emissions control is in place, and Agriculture, Forestry & Fishing (AFF), for which there is almost no change under NBA. In general, and with the exception of BAI, the BAMs tend to reduce the increase in imports very slightly in most of the sectors. Although marginal, this is the desired effect because imports are becoming less competitive in the domestic market when border protections are imposed, than in NBA case.

Figure 6 Percentage Change in Import Volumes by Sector



Source: Model simulations.

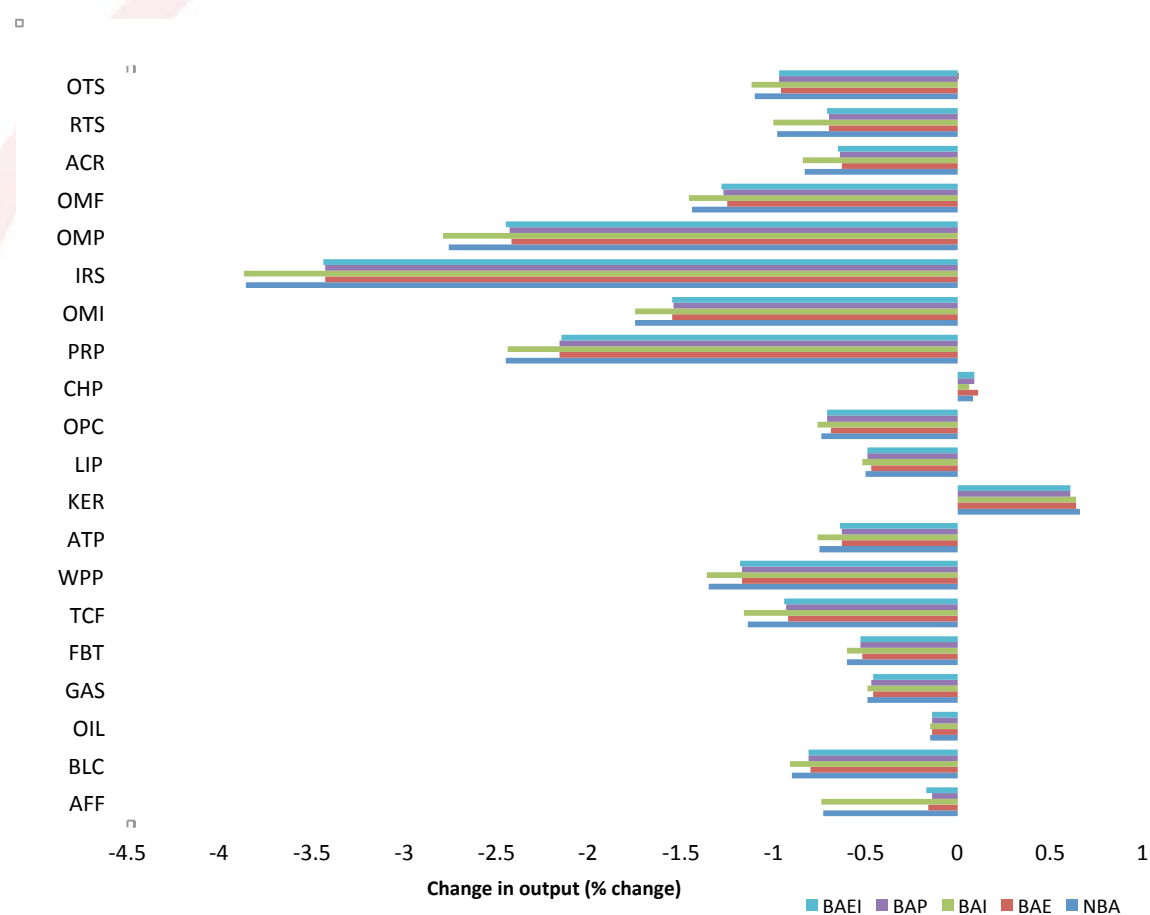
The change in outputs of EITE sectors of the Australian economy under a carbon tax are compared with outcomes of BAMs in Figure 7. Under NBA, output declines due to the import competition and decreases in exports, showing a wide range of deviation across sectors. The highest reduction in output is projected in Iron and steel (IRS), followed by Other metal products (OMP), Plastic and rubber products (PRP) and the Other Mining (OMI) sectors. As noted before, a border adjustment policy of green tariffs (BAI) has no alleviating effects on the decline in exports and may even cause exports to decrease further. On the other hand export and production rebates ease the decrease in exports to some degree, making output reductions slightly smaller than in NBA.

7 Conclusions

In this paper we have analysed possible carbon motivated border adjustment policies in Australia using a multisectoral general equilibrium model of the Australian economy. The model was first simulated under a \$23 carbon tax to produce the benchmark solution (NBA). Then we introduced four BAMs to compare with the NBA scenario to examine how such measures could affect macroeconomic, and trade outcomes. With these projections, the analysis was then directed to assessing the key issues of competitiveness and carbon leakage in relation to the performance of the EITE sectors in the Australian economy. The most important finding from this analysis is that border adjustment policies have a very small impact on the overall economy and on EITE sectors. In other words, the different BAMs that we have considered are unlikely to change the outcomes of carbon pricing policy in Australia in any significant way. This finding is consistent with studies for EU, US, Canada and other countries.

Among the four policies analysed, production and export rebates are somewhat appealing even though their effects towards easing the negative impact on EITE sectors are fairly small. The green tariffs do not appear to be playing any significant role at all to alleviate the import competition in the domestic economy and thus have no discernible influence on reducing carbon leakage. They do, in fact, cause Australia's exports to decrease further due to a cost-price squeeze. Full border adjustment with green tariffs and export rebates is unlikely to change the outcomes beyond what export rebates may achieve alone.

Figure 7 Percentage Change in Outputs by Sector



Source: Model simulations.

When BAMs are based on Australia's (importing country) emissions, a small impact implies that barriers imposed are small. If all sectors had the same carbon intensity then we could expect a neutral relative price effect. Contrary to this, our results do indicate that BAMs are not neutral due to sector specific tax adjustments leading to relative price shifts, even though the impact is rather small.

As analysed in the results section, BAMs do produce slight GDP improvements (except in the BAI scenario). However this improvement comes at the expense of the

emissions reduction effects of carbon pricing. When border adjustments reduce the overall emissions reduction rate, carbon tax revenue to the government becomes greater. Thus such higher revenue enables the government to compensate poor households better than before, improving the welfare outcome of the carbon pricing strategy.

The smallness of numerical findings confirm that BAMs would be unimportant as part of environmental policy in Australia even though critics of the carbon pricing policy, along with industry lobby groups, pressured the Australian government to introduce such measures to support EITE sectors in the economy. Hence, a key policy implication of the analysis presented in this paper is that border adjustments are not warranted in the Australian case to safeguard EITE industries. They make no significant difference to Australia's commitment to a low carbon economy.

The findings are subjected to some limitations of the underlying features of the CGE model used in the analysis. Since we have used a single country model, it is not possible to project what would be the experience and reaction of the rest of the world to Australia's carbon pricing strategy and border adjustments. To mitigate this limitation, it is necessary to use a multi-country model such as GTAP-E for assessing BAMs, incorporating Australia's trading partners' behaviour.

References

- ABS (2006), Household Expenditure Survey Australia, 2003–2004. Catalogue No. 6530.0, ABS, Canberra.
- ABS (2008), Australian National Accounts: Input-output tables, 2004–2005. Catalogue No. 5209.0.55.001, ABS, Canberra.
- Ahammad, H., and Mi, R. (2005), "Land use change modelling in GTEM—accounting for forest sinks", ABARE Conference Paper 05.13, ABARE, Canberra
- Alexeeva-Talebi, V., Loschel, V.A., and Mennel, T. (2008), "Climate policy and problem of competitiveness: Border tax adjustments or integrated emissions trading?", <ftp://ftp.zew.de/pub/zew-docs/dp/dp08061.pdf>.
- Bernard, A., and Vielle, M. (2009), "Assessment of European Union transition scenarios with a special focus on the issue of carbon leakage", *Energy Economics*, Vol.31, pp.274-284.
- Burniaux, J., Martin, J., and Nicoletti, G. (1992) "Green—A multi-sector, multi-region general equilibrium model for quantifying the costs of curbing CO₂ emissions". OECD Working Paper, No.116, Paris.
- Clarke, H., and Waschik, R. (2012) "Australia's carbon pricing strategies in a global context", *The Economic Record*. Vol. 88.Special Issue, June, pp.22-37.
- Cornwell, A., Creedy J. (1997), "Measuring the welfare effects of tax changes using the LES: an application to a carbon tax" *Empirical Economics*, Vol. 22, pp.589-613
- Devarajan, S., Go, D., and Robinson, S.(2009), "Tax policy to reduce carbon emissions in South Africa", Policy Research Working Paper WPS4933, The World Bank, Africa Region.
- Dong, Y., and Whalley, J. (2012), "How large are the impacts of carbon motivated border tax adjustments?", *Climate Change Economics*, Vol. 3, DOI:10.1142/S2010007812500017.

- Fischer, C., and Fox, A.K. (2009), "Comparing policies to combat emissions leakage: Border tax adjustments versus rebates", Discussion Paper DP 09-02, Resources for the Future, Washington DC.
- Horrige, M. (2000), "ORANI-G: a general equilibrium model of the Australian economy", Centre of Policy Studies/IMPACT Centre Working Papers op-93, Monash University
- Kuik, O., and Hofkes, M. (2010), "Border adjustment for European emissions trading: Competitiveness and carbon Leakage", *Energy Policy*, Vol.38, Issue 4, pp.1741-1748.
- Mattoo, A., Subramanian, A., Mensbrugghe, D van der, and He, J. (2009), "Reconciling climate change and trade policy", Policy Research Working Paper No. WPS 5123, World Bank.
- McKibbin, W.J., and Wilcoxon, P.J. (2009), "The economic and environmental effects of border tax adjustments for climate policy", CAMA Working Paper 9, The Australian National University, Canberra.
- Meng, S., Siriwardana, M., and McNeill, J. (2013), "The environmental and economic impact of the carbon tax in Australia", *Environmental and Resource Economics*, Vol. 54, No. 3, pp.313-332.
- Saddler, H., Muller, F., and Cuevas, C. (2006), "Competitiveness and carbon pricing: Border adjustments for greenhouse policies", Discussion Paper Number 86, The Australia Institute, Canberra.
- Takeda, S., Testsuya, H., and Arimura, T. H. (2012), "A Computable General Equilibrium analysis of border adjustments under the Cap-and-Trade System: A case study of the Japanese Economy", *Climate Change Economics*, Vol.3. DOI:10.1142/S2010007812500017.
- Winchester, N., (2011), The impact of border carbon adjustments under alternative producer responses, Report no. 192, MIT joint program on the science and policy of global change.
- Zhang, Z. ,(1998), "Macro-economic and sectoral effects of carbon taxes: a general equilibrium analysis for China", *Economic Systems Research*, Vol.10, pp.135-159

Energy Efficient Building Design: Revisiting Traditional Architecture

Naseer M A

National Institute of Technology Calicut, India

0526

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org



1. Introduction

Energy Efficient design of buildings and their operations are becoming more and more important in the world. A building is a system that is linked to its surrounding environment and is subject to a range of interactions between the external conditions and the indoor comfort condition. Buildings are major consumers of energy in both their construction and operation. They account for 40% of world's energy use. It is estimated that 40-60% of this goes for heating and ventilating the indoors.

Modern architecture - to a large extent - does not respect the environment in creating built spaces. Often, the indoors thus created are not comfortable and require artificial means to condition them. These artificial systems are causing significant environmental problems across the globe.

Traditionally, the buildings were designed for the most comfortable indoors condition, irrespective of the outdoor hostile environment. Environmental factors have been a major determinant in the development of traditional architecture. Traditional built forms have been developed on the principles of passive design by continuous process of experimentation and improvement.

Study of traditional architecture proves that it is possible to create a built space that respects the environment by natural means through a judicious design that is sustainable.

This paper reviews the concepts of passive design and the sustainable practices in traditional buildings from different countries and discusses the findings of a research conducted in South-Indian peninsula.

2. Energy Consumption: Global Scenario

The International Energy Outlook 2013 (IEO2013) projects that world energy consumption will grow by 56% between 2010 and 2040 [1]. Much of the growth in energy consumption occurs in countries outside the Organization for Economic Cooperation and Development (OECD) known as non-OECD, where demand is driven by strong, long-term economic growth. Energy use in non-OECD countries increases by 90 percent; in OECD countries, the increase is 17 percent. The share of residential sector in the energy consumption in the year 2011 is 22% as compared to 31% by the industrial sector, which is the largest consumer [2]. Growth in population, increasing demand for building services and comfort levels, together with the rise in time spent inside the buildings is today a prime objective for energy policy at regional, national and international level [3]. Among building services, HVAC systems uses the maximum energy [2,3].

The growing concern worldwide for environmental conservation calls for immediate intervention in making buildings energy efficient thus reducing the energy consumption. Energy efficiency in buildings can be achieved through a multipronged approach involving adoption of energy efficient building design, use of energy-efficient building systems and low energy materials coupled with reduction of transportation energy, and effective utilization of renewable energy sources to power the building [4].

3. Energy Efficient Building Design

The concept of energy efficiency in building design is related to the energy required to achieve desirable environmental conditions that minimize energy consumption [5].

The most important design parameters affecting indoor thermal comfort and energy conservation in buildings are the following [6]:

1. Orientation of the building
2. Building form
3. Size and position of openings
4. Thermal performance of the building envelope

3.1. Orientation of the building

The level of direct solar radiation received on the building facade depends on the azimuth in the wall, and thus, on the orientation angle of the building [7]. The orientation of the facade also influences other parameters of passive design, such as shading or the performance of the solar envelope [8, 9].

3.2. Building form

Heat exchange between the external environment and the indoors occurs primarily through the skin of the building. Configuring the geometry of the building suitably can control the heat exchange. The ratio of the surface area to the volume (S/V) determines the magnitude of the heat transfer in and out of the building. The larger the S/V ratio, greater would be the heat gain or loss for a given volume of space. Hence the overheating through the building surfaces could be minimized by keeping the surface area to the minimum in tropical climate [10].

The shape of the building also plays a major role not only in terms of heat exchange but also for ventilation due to wind effect. The pressure gradient created between the windward and leeward faces of the building can induce air flow for better ventilation. The building envelope could be suitably shaped for this effect [11].

3.3. Size and position of openings

Arrangement of openings on the external surfaces of the building can influence the air flow indoors. The size of the openings both on the windward and leeward side can induce and channelize the air flow as established in various studies [11, 12].

The size of the window openings is critical in tropical climate. The indoors in such a climate require high rate of ventilation for the removal of perspiration due to higher humidity. This may be achieved by increasing the size of the openings thereby allowing a large volume of air to pass through the interior spaces. But the outdoor air admitted in large volume can bring a lot of heat to the indoors as the outdoor air temperature in such climate especially during summer (when the ventilation is most essential) is more than the body temperature. This will in turn create uncomfortable situation than a soothing one. Hence, this kind of situation demands an optimum arrangement of openings in terms of size and positions.

3.4. Thermal performance of building envelope

The building envelope consisting of walls, roof, doors, and windows and the period of the heating are the factors that have the greatest impact on the total energy consumption of the building [13]. The envelope determines interior climate conditions, and thus, the additional energy demand for heating and cooling [14].

The heat gain in the indoors is of major concern in the tropical climate especially in summer as the outdoor air temperature is higher than the occupants' body temperature for a larger period of the time. The days are hotter and the air temperature drops down only in the night, a few hours after the sunset.

Though there are means of reducing the heat gain by orienting the building suitably, by modifying the building configuration and by arranging the internal spaces, the indoors can still be at a temperature higher than the optimum. This situation demands modification of the building envelope itself by incorporating various means of thermal insulation. Thermal insulation of the building envelope can be achieved by appropriate use of building materials and by employing suitable techniques of insulation. Building thicker walls, cavity walls and use of infill are suitable for reducing the heat gain through conduction. The roof of the building (the surface that receive the maximum solar radiation) require special attention for suitable thermal insulation. Roof with suitable external finishes for maximum reflection and thereby minimum heat absorption, installation of insulative materials, use of cavity layers etc. can be employed to reduce the heat flow indoors.

4. Lessons from Traditional Architecture

Contemporary architecture is frequently seen as the example of an internationalism, which eradicates local traditions and transforms the globe into a faceless urban sprawl [15]. It is often forgotten and even ignored that architectural traditions are rich in content, given that they have found the right harmony between the necessities of living, the environment, material resources and ideas on the use of space [16].

It is commonly acknowledged that traditional architecture represents local tradition, culture and climates, thus the difference between regions lead to the diversity of vernacular architecture. In despite of the diversity, traditional building around the world share the common characters of energy-saving and environment friendly, which are approached by local building material and climate responsive strategies etc. By the fact that no electric power could be used to achieve thermal comfort in ancient time, passive means are mainly applied in building to provide thermal comfort by intellectual manipulation of spatial form and building elements which utilize the advantages of climate or resist the disadvantages [17].

Studies on passive environment control methods of achieving thermal comfort in buildings and studies for extracting methods and techniques from traditional buildings have been conducted in various countries around the world. [19–25].

The following section gives an overview of a few selected studies conducted on traditional houses from across the world. Among the available literature, only those studies where the climatic parameters were actually measured on-site and analysed have been presented.

4.1. Japanese Traditional House

The indoor climate of a traditional house located in Hokuriku district was studied in summer and winter. The three room type house called “Horiguchi” has mud walls and floor and a roof with reeds [26].

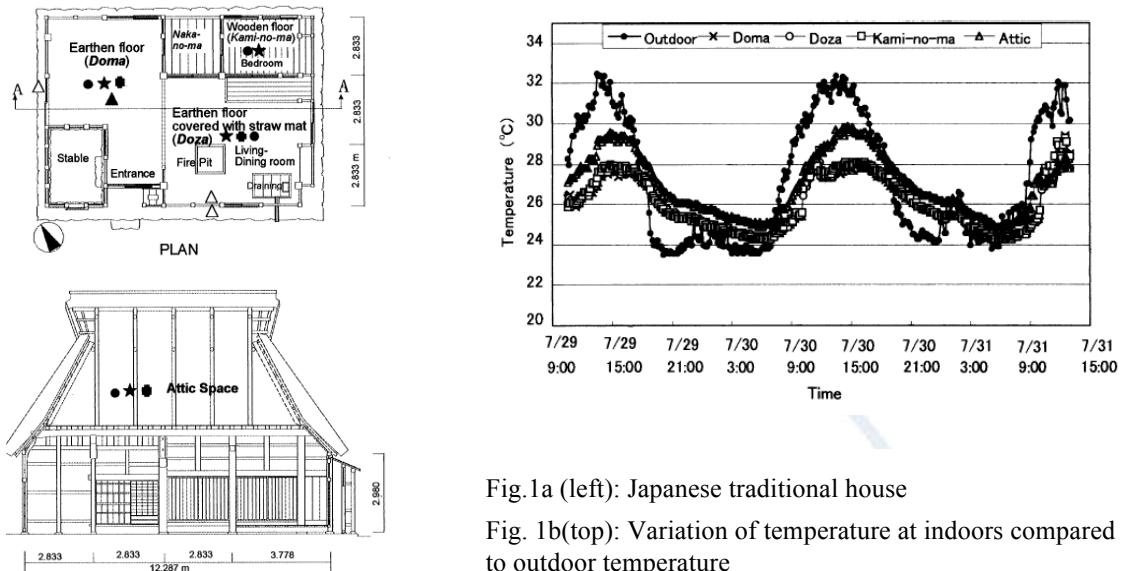


Fig. 1a (left): Japanese traditional house

Fig. 1b(top): Variation of temperature at indoors compared to outdoor temperature

The observation proved that the temperature indoors was maintained between 24 and 28°C while the temperature outdoors was between 23.5°C and 32.5°C.

4.2. Traditional Houses of Thailand

The study was conducted to compare the thermal performance of a contemporary house with that of traditional houses from three different regions [27].

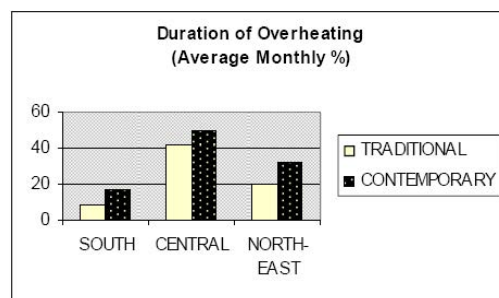
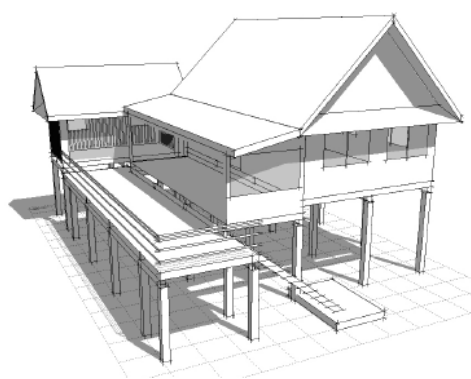


Fig.2a (left): Thai traditional house

Fig.2b(top): Indoor overheating in contemporary house vis-a-vis traditional houses from different regions

It was revealed that the cooling load of the contemporary house was significantly higher than the traditional houses.

4.3. Traditional Houses of Korea

Traditional houses in Tumakgyp in Ullung island made of timber logs with mud infill provide a very comfortable indoor environment from a snowy and cold outdoor climate [28].

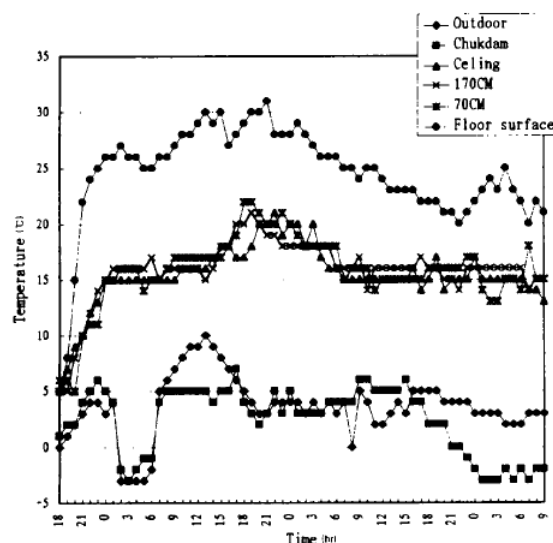
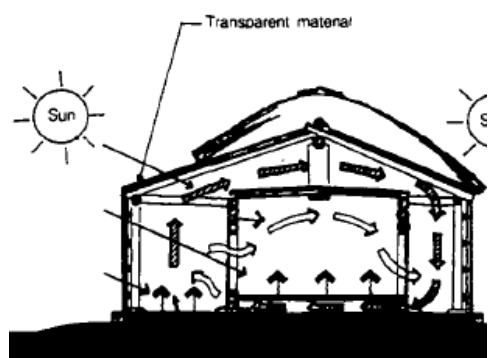


Fig.3a (top): Korean traditional house
 Fig.3b(right): Indoor temperature at different locations in comparison to outdoor

The highly insulative building envelope made of wooden logs is responsible for the indoor environment

4.4. Traditional Malay house

Malay houses are designed to respect nature. The stilted houses made of timber and roofed with locally available coconut leaves and hay are best suited for warm-humid climate [29]

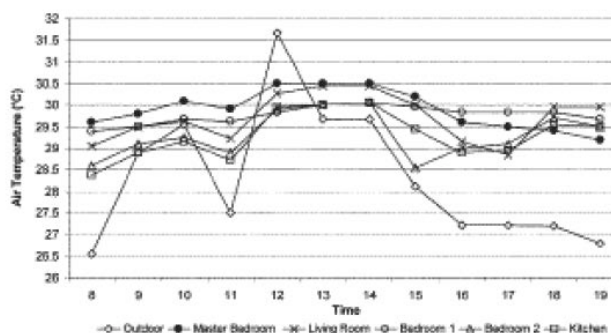


Fig.4a (left): Traditional Malay house; Fig.4b(right): Indoor temperature at different locations in comparison to outdoor

4.5. Traditional houses of Turkey

Traditional houses of Diyarbakir in Turkey are typical examples of buildings adapted to a hot dry climate. These houses are built around a courtyard [30]. The walls are

made of basalt stone and the roof is of timber. The arrangement of the blocks around the court and the semi-open room are carefully designed for cooling for the hot dry climate. The orientation and interior plans shows that dominant hot period conditions were considered in the design of the buildings. The compact and low buildings with small courtyards provide protection from solar radiation and shelter from hot dusty winds. The massive buildings with a high volume to surface ratio are advantageous since this will reduce the high range of external air temperatures between night and day.

It is not surprising that these studies conducted in different parts of the globe have returned similar kind of results proving the efficiency of traditional system in maintaining the required comfort conditions indoors irrespective of the outdoor conditions prevailing at various times of the year [31].

In order to understand the performance of traditional architecture in providing sustainable solution, a detailed investigation was conducted on traditional residential buildings of Kerala, located at southern end of Indian peninsula.

5. Traditional buildings of Kerala

The land of Kerala lies between the Arabian Sea on the West and the Western Ghats on the East stretching from 8^o18^o to 12^o 48' N Latitude. It's warm-humid climate is characterized by heavy rainfall and high relative humidity, and relatively moderate temperature. The monthly normal climate is given in Table 1 [32]. Temperature vary from 21^o C to 33^o C and relative humidity (RH) varies from 65% and will be above 70% in most of the seasons.

Table 1
 Monthly normal climate of Kerala [18].

Months		January	February	March	April	May	June	July	August	September	October	November	December
Temperature (°C)	Max	32	32	33	33	32	29	28	28	29	30	31	32
	Min	21	22	24	25	25	24	23	23	23	23	23	21
Rainfall (mm)		14	15	31	108	247	556	502	304	208	277	172	49
No. of rainy days		1	1	2	6	11	21	20	16	11	12	8	3
Relative humidity (%)		65	70	75	80	77	85	90	90	86	83	80	65

The traditional houses of Kerala are built according to the principles of Vaastushastra, the Indian discipline on architecture [33]. The basic module of traditional house is known as nalukettu with four blocks built around an open courtyard. They are generally rectangular or square in plan with blocks topped with a sloping roof on all four sides while the courtyard is left open to the sky for letting air and light inside. There is an internal verandah around the courtyard for protection from rain and sun. A typical layout of a traditional Kerala house is shown in Fig. 5.

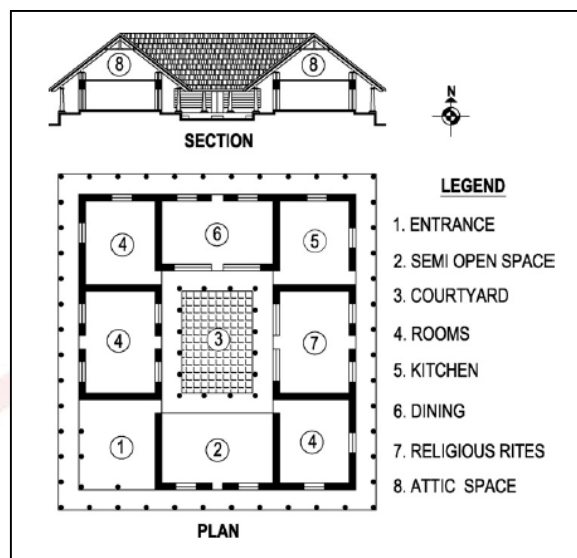


Fig. 5: A typical layout of traditional Kerala house

Depending on the size and importance of the household, the buildings may have one or two storey or further modules with enclosed courtyards. The enclosed courtyard is usually sunken. The verandahs opening to the courtyards prevent the intense solar radiation entering the rooms. The roofs have steep slopes up to almost 45° and the gables are provided at the ends of roof to enhance ventilation and to allow the warm air to escape. The attic space that is formed by the wooden false ceiling over the rooms is ventilated.

5.1. Energy Efficient Characteristics of Kerala Traditional Building

The traditional houses of Kerala are designed strictly based on the parameters of energy efficient design. The principles followed in their design are explained in detail in the following section.

5.1.1 Orientation of the building

The traditional houses of Kerala are oriented strictly according to the cardinal directions as per Vaastushastra. This makes them more perfect to control its environment with maximum comfort in different seasons. The cardinal directions are determined correctly using traditional techniques based on solar path and shadows [33]. The entry to the house is provided from South or East. The spaces that are used during the day time are mostly placed on the North and South sides while those used during the nights are on the West.

The positioning of spaces is very much important in spatial planning. The living spaces which are semi-open are on the Southern side with optimum number of openings for ventilation. The rooms are positioned on the western side in order to capture the prevailing wind from the south-west. The kitchen is positioned at the North-East corner of the house as the wind from south-west would help to drive the hot air from kitchen to the outside and prevent spreading to other spaces. All other spaces are arranged around the courtyard in such a way as to permit adequate air movement in all seasons wherever required.

5.1.2 Building Form

The traditional houses are generally rectangular or square in plan with blocks topped with a sloping roof on all four sides arranged around a courtyard that is left open to the sky for letting air and light inside. An internal verandah is provided around the courtyard for protection from rain and sun. The internal functional spaces can be suitably arranged depending on the requirement of such spaces for heating, cooling or ventilation. For example the spaces such as store which is not habitable can be placed on the face of the building that is subject to heating and spaces such as toilets and kitchen that require the ventilation and removal of foul air or fumes can be placed on the leeward side so that they do not vitiate other indoor spaces.

5.1.3 Size and position of openings

Most of the traditional houses in Kerala are set amidst large parcels of land. Hence they are opened up for better air movement. Open planning and free spaces between houses help to capture wind and achieve good ventilation. They have large number of openings in the form of windows and ventilators. Provision of open or semi-enclosed spaces also gives ample scope for air movement. Another remarkable feature in the traditional architecture of Kerala is the provision of open gables in the roof and the provision of wooden jalli in the external walls at appropriate positions. These wooden jalli in the external walls helps to draw external air with the effect of courtyards.

5.1.4 Thermal performance of building envelope

The thermal insulation in Kerala traditional houses is achieved by the effective use of materials and the techniques used in the construction of walls and roof. The external walls of traditional houses are usually very thick up to a maximum of 750 mm with double layer of laterite masonry with a gap in between that is filled with fine sand. This makes the external wall highly insulative. In order to achieve thermal insulation from the roof, wooden ceiling (tattu) is also provided beneath the roof. This provides a large air space at the attic which acts as an insulation layer against the conduction of external heat through the roof. Further, the breathing space that exists between the clay roofing tiles helps in ventilating the underside of the roof reducing the temperature.

5.2 Discussions on the Outcome of the Investigation

The investigation showed a very low diurnal variation of indoor temperature (26° to 30° C) compared to that of outdoor ambient air temperature (22° to 34° C) due to high thermal insulation property of the building envelope. The absence of conductive heat gain and time lag between outdoor and indoor air temperatures proved the thermal insulation property of the building envelope and the high degree of natural ventilation maintained through the building.

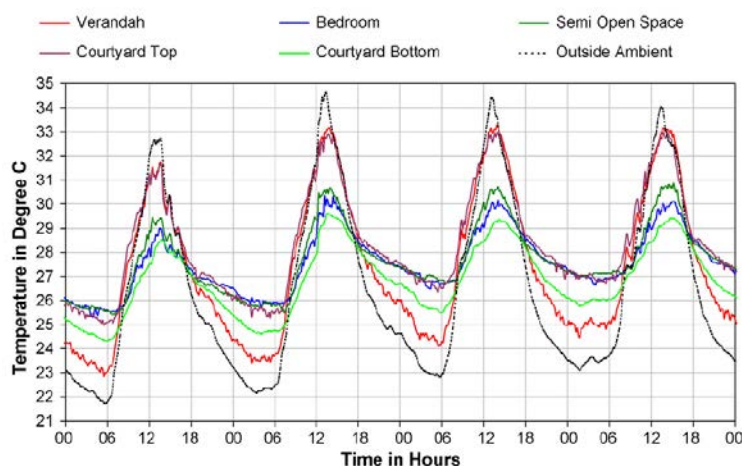


Fig 6. Indoor temperature at different locations in comparison to outdoor

The air movement recorded clearly showed that the building system was maintaining a continuous and controlled air flow indoors. This accelerates the evaporative cooling by continuous exchange of air that is in contact with the occupant's body especially when the RH is higher (77 to 84%) along with high temperature. This was achieved due to the influence of internal courtyard.

The building was thus able to provide a condition well within the comfort region of the bioclimatic chart and very near to the comfort zone. The PMV-PPD analysis also confirmed the effectiveness of the passive control system of traditional building in providing the comfortable indoor environment during various seasons of the year [34].

6. Conclusion

Traditional built forms have been developed out of constant and continuous process of experimentation and improvement for more perfect solutions. Traditional architecture throughout the world thus gives us sustainable solutions with minimum adverse impact on the environment while providing the most energy efficient built environment. The researchers in the field of energy efficient and sustainable design in various parts of the world are therefore extracting the time tested sustainable design techniques embedded in the traditional architecture. This paper reveals the passive control system of traditional architecture of Kerala in providing thermal comfort to the occupants that is highly energy efficient.

In the context of modern architecture that does not respect the environment to a large extent by creating spaces that are not really comfortable, but later on conditioned by using artificial means, a judicious use of suitable traditional techniques using appropriate materials is required for a sustainable, energy efficient and comfortable human life. Therefore it's time to revisit the traditional wisdom that was probably lost in a haste to blindly follow that was modern.

7. References

1. US Energy Information Administration, "International Energy Outlook 2013", as available in the website <http://www.eia.gov/forecasts/ieo/>
2. US Energy Information Administration, "Annual Energy Review 2011", September 2012.
3. Luis Perez Lombard, Jose Ortiz and Christine Pout, "A review on buildings energy consumption information", *Energy and Building*, 2008, 394-398.
4. Ministry of New and Renewable Energy, "Representative Design of Energy Efficient Buildings in India", Tata Energy Research Institute, 2001.
5. Wang W, Rivard H, Zmeureanu R., "Floor shape optimization for green building design", *Advanced Engineering Informatics*, 2006;20:363-78.
6. Z Yilmaz, Evaluation of energy efficient design strategies for different climatic zones: Comparison of thermal performance of buildings in temperate-humid and hot-dry climate, *Energy and Buildings*, 2007; 39; 306-316.
7. Mingfang T. Solar control for buildings. *Building and Environment*, 2002; 37; 659-64.
8. Capeluto IG. Energy performance of the self-shading building envelope. *Energy and Buildings*, 2003; 35; 327-36.
9. Morrissey J, Moore T, Horne RE, "Affordable passive solar design in a temperate climate: an experiment in residential building orientation", *Renewable Energy*, 2011; 36; 568-77.
10. J K Nayak, J A Prjapati, "Handbook on Energy Conscious Buildings", Bureau of Energy Efficiency, 2006.
11. Bureau of Indian Standards, "Handbook on Functional Requirement of Buildings (SP41)", BIS, 1987.
12. O. H. Koenigsberger, et al., *Manual of tropical Housing and Building—Climatic Design*, Orient Longman Private Limited, 2007.
13. Manioglu G, Yilmaz Z., Economic evaluation of the building envelope and operation period of heating system in terms of thermal comfort, *Energy and Buildings*, 2006; 38; 266-72.
14. R. Pacheco, J. Ordóñez, G. Martínez, Energy efficient design of building: A review, *Renewable and Sustainable Energy Reviews*, 2012; 16; 3559- 3573.
15. M.Umbach and B.Huppauf, "Vernacular Modernism: Heimat, Globalization, and the Built Environment", 2005, Stanford University Press.
16. A. Tzonis, L. Lefaivre and B. Stagno, "Tropical Architecture: Critical Regionalism in the Age of Globalization", 2001, Wiley-Academy.
17. Lingjiang Huang and Fangfang Liu, "Thermal Analysis of Tibetan Vernacular Building - Case of Lhasa", *Engineering and Technology*, World Academy of Science, 2010; 68.
18. K.H. Lee, D.W. Han, H.-J. Lim, "Passive design principles and techniques for folk houses in Cheju Island and Ullng Island of Korea", *Energy and Buildings*, 1996; 23; 207-216.
19. F. Wang, Y. Liu, "Thermal environment of the courtyard style cave dwelling in winter", *Energy and Buildings*, 2002; 34; 985-1001.
20. R. Ooka, Field study on sustainable indoor climate design of a Japanese traditional folk house in cold climate area, *Building and Environment* 37 (2002)319-329.
21. L. Borong, et al., Study on the thermal performance of the Chinese traditional vernacular dwellings in summer, *Energy and Buildings* 36 (2004) 73-79.
22. D.-K. Kim, The natural environment control system of Korean traditional architecture: comparison with Korean contemporary architecture, *Building and*

- Environment 41 (2005) 1905–1912.
23. M.S. Sozen, G.Z. Gedik, Evaluation of traditional architecture in terms of building physics: old Diyarbakır houses, *Building and Environment* 42 (2007) 1810–1816.
 24. Y. Ryu, S. Kim, D. Lee, The influence of wind flows on thermal comfort in the Daechung of a traditional Korean house, *Building and Environment* 44 (2009) 18–26.
 25. T.J. Kim, J.S. Park, Natural ventilation with traditional Korean opening in contemporary house, *Building and Environment* 45 (2010) 51–57.
 26. Ryoza Ooka, Field study on sustainable indoor climate design of a Japanese traditional folk house in cold climate area, *Building and Environment* 37 (2002) 319–329.
 27. Paruj Antarikananda, Elena Douvrou and Kevin McCartney, Lessons from traditional architecture: Design for a climatic responsive contemporary house in Thailand, *Proceedings of the 23rd Conference on Passive and Low Energy Architecture*, Geneva, Switzerland, September 2006.
 28. Kyung-Hoi Lee, Dong-Wook Han, Ho-Jin Lim, IG, Passive design principles and techniques for folk houses in Cheju Island and Ull ng Island of Korea, *Energy and Buildings* 23 (1996) 207-216.
 29. Climate Responsive Building Design, as available in the website: <http://www.gobookee.net/climate-responsive-building/>
 30. Mujgan S-erefhanog lu So zen, Gu lay Zorer Gedik, Evaluation of traditional architecture in terms of building physics: Old Diyarbakır houses, *Building and Environment* 42 (2007), 1810–1816.
 31. Paruj Antarikananda, Elena Douvrou and Kevin McCartney, “Lessons from traditional architecture: Design for a climatic responsive contemporary house in Thailand”, *PLEA2006: The 23rd Conference on Passive and Low Energy Architecture*, Geneva, Switzerland, 6-8 September 2006.
 32. Meteorological Data, India Meteorological Department, Meteorological Centre, Thiruvananthapuram, 2009, No. C. 201 (A)/729.
 33. A. Achyuthan, B.T.S. Prabhu, An Engineering Commentary on Manusyalayacandrika of Tirumangalat Nilakantan musat, *Vastuvidyapratisthanam*, Calicut, Kerala, 1998.
 34. A.S. Dili, M.A. Naseer, T. Zacharia Varghese, “Passive control methods for a comfortable indoor environment: Comparative investigation of traditional and modern architecture of Kerala in summer”, *Energy and Buildings* , 2011; 43; 653–664.

*Environmental Impact Evaluation Using Cost Benefit Analysis and Multi Criterion
Analysis: A Case Study of Rayong Province, Thailand*

Nattarin Ueasin, Suthin Wianwiwat

Khon Kaen University, Thailand

0527

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Rayong province is a major industrial area in Thailand. For more than 30 years this province has served the demand of Thailand's petro-chemical industries, mainly in the Map Ta Phut industrial zone. However, the industrialization of the area has resulted in many serious environmental and health problems, causing distrust and protests from the local people, and a subsequent delay in the expansion of the capacity of the industrial sector. To solve this problem, the government must find a way to expand the industrial sector that satisfies all stakeholders. Thus, focus stakeholder group meetings and the Delphi technique are utilized to form possible alternatives of investment in expanding factories. Several economic indicators including the net present value provided from a cost benefit analysis were then analyzed via the Multi Criterion Analysis (MCA) technique to indicate the best way to develop the industrial area. This study found that the best alternative is to allow the expansion of industrial capacity without exceeding acceptable levels of pollution, requiring comprehensive town planning, the implementation of existing laws and particular measures, and the consideration of the Eco-industry concept.

Keyword: Benefit Transfer, Multi Criterion Analysis, Eco-Industry, Cost Benefit Analysis

1. Introduction

The National Economic and Social Development Plan intends to extend industrial development from Bangkok and nearby areas to the east of the country. Rayong, the province in the Eastern area of Thailand, has high potential to meet the high demand of industry because Rayong is not too far from Bangkok and it is very suitable to build a large seaport to import and export industrial products. One of the most important projects in Rayong is the Petro-Chemical Industry Development Plan (PCIDP), which aims at developing petro-chemical industries to meet the high petro-chemical industry demand of Thailand. This plan is currently in phase 3 (2004 – 2019) in which about 400,000 million baht will be invested in this area. About 100,000 million baht has been already invested. Therefore, a dramatic increase in industry in this area has occurred, and Rayong has become one of most important industrial areas in Thailand and has amongst the highest per capita income in the country. However, with the development of industrialization, many negative impacts have been caused such as high pollution, health problems, labor immigration, insufficient public welfare etc.

Considering the negative impacts, the government announced the Rayong industrial zone as a pollution control area in 2009 (Office of Natural Resources and Environmental Policy and Planning, 2009) and endorsed Rayong's Pollution Reduction and Elimination Plan in 2010 (Office of Natural Resources and Environmental Policy and Planning, 2009). In addition, the heavy pollution areas (for example the Mab Ta Phut industrial zone and vicinity) have taken some specific measures, such as town planning management (approach to mitigate pollution) and the establishment of a protection zone in this area. Moreover, the Industrial Estate Authority of Thailand and the Ministry of Industry launched a policy that is based on the eco-concept named "Eco-Industry or Green Industry" to invite every industrial estate to follow the development policy. Eco-industry focuses on how to increase productivity and competitiveness based on environmental considerations, sanitation, safety and social responsibility in five dimensions (economic, environmental, social, physical and management). Unfortunately, there are still some environmental issues in Rayong industrial zones identified by the National Environmental Board (NEB) at the meeting on July 8, 2010 (Office of Natural Resources and Environmental Policy and Planning, 2009) The important issues are: 1) highly volatile organic compounds in rivers, underground water and air, 2) highly toxic chemicals in seafood, and 3) exploitation of protection zone problems etc. Therefore, this study aims to scrutinize and propose alternatives that are appropriate for industries and other economic development by considering the environmental protection of Rayong province. In this study, there are four parts: introduction, methodology, results of the study and the conclusion.

2. Methodology

This study is being conducted during PCID phase 3 from 2004 – 2018 which has an investment plan of about 400,000 million baht; however, from 2004-2012, about 100,000 baht has already been invested. Therefore, this study assumes there to be new investment which means an increase in investment in the petro-chemical industry of about 300,000 million baht in Rayong province. This study is designed in three stages as follows:

1) Set alternatives, review and collect data

First, by considering alternatives in this study to evaluate the optimal alternative from four choices rather than employing the Delphi technique as follows:

- I. Not to allow new investment,
- II. Allow to expand industrial capacity to within 50% of pollution capacity,
- III. Allow to expand industrial capacity without exceeding pollution capacity, requiring comprehensive town planning, and the implementation of existing laws and particular measures,
- IV. Allow to expand industrial capacity without exceeding pollution capacity, requiring comprehensive town planning, the implementation of existing laws, and particular measures while considering the eco-industry concept.

This study employs thirteen indicators which came from the collection of primary and secondary data which have been ranked by the Delphi technique. Secondary data were collected from data bases in both government and non-government agencies. The eight types of secondary data used as indicators in this study are 1) Gross Domestic Product growth (GDP Growth). 2) Gross Provincial Product growth (GPP Growth). 3) inflation rate. 4) tax income. 5) unemployment rate. 6) industrial sector growth rate. 7) agricultural sector growth rate. 8) service sector growth rate. Four types of primary data which were collected from industries, business, and the non-registered population (100 samples each) are 1) the tax income of the non-registered immigrant population, 2) the proportion of local raw materials used in production, 3) the proportion of the local workforce used in production, and 4) the proportion of logistics cost of production.

One of the important indicators is Total Economic Value (TEV). It was calculated by employing the Benefit Transfer technique (BT) and was used in both primary and secondary data. On one hand, the benefits from investment which are based on the current capacity, enactments, measurements and policies of each alternative should be considered. On the other hand, the cost of investment was calculated based on the greenhouse gas effect, the unregistered immigrant effect, and the cost of medical care, which are different for each alternative.

2) Weighting analysis of all indicators

After the thirteen indicators were obtained, they were arranged in a Multi-Criterion Table in which the vertical and horizontal axes are the same indicators, which were then ranked by employing the Delphi technique. In order to score the alternatives, the experts need to consider the following

- When the vertical indicator is much more important than the horizontal indicator; the score is 5 marks,
- When the vertical indicator is more important than the horizontal indicator, the score is 4 marks,
- When the vertical indicator is equal to the horizontal indicator, the score is 3 marks,
- When the vertical indicator is not as important as the horizontal indicator, the score is 2 marks,

- When the vertical indicator is less important than horizontal indicator, the score is 1 mark,
- When the vertical and horizontal indicators are the same indicator, the score is 0 marks.

It is then necessary to sum up the compared weight score of each indicator and derive the total compared Weight Score of each indicator in each dimension.

3) Assessing the Impact Levels of each alternative

To assess the Impact Levels, the impact of each indicator was rated by comparison with base data, and Impact Levels were obtained from formulas as follows:

$y = a(b - c)/d$: This formula is applied for every indicator except for inflation rate, unemployment rate, and the proportion of logistics cost of production¹,

$y = a(c - b)/d$: This formula is applied (except for three indicators)

When

y : Impact Level of each indicator, every indicator is compared in five ranges as follows:

- 0.00-0.20 means the impact level has the highest negative impact,
- 0.21-0.40 means the impact level has a high negative impact,
- 0.41-0.60 means the impact level has a moderate negative impact,
- 0.61-0.80 means the impact level has a low negative impact,
- 0.81-1.00 means the impact level has the lowest negative impact.

The three excepted indicators are rated as having an impact in five ranges as follows:

- 0.00-0.20 means the impact level has the lowest negative impact,
- 0.21-0.40 means the impact level has a low negative impact,
- 0.41-0.60 means the impact level has a moderate negative impact,
- 0.61-0.80 means the impact level has a high negative impact,
- 0.81-1.00 means the impact level has the highest negative impact.

a : the interval range, in this case is 0.2 and there are five intervals for each indicator.

b : the impact level of each indicator.

c : the impact level of the three excepted indicators.

d : the interval range value in each indicator.

After Weight Score and Impact Levels are calculated, multiply Weight Score with Impact Level of each indicator and sum all thirteen indicator results together; finally, the evaluation result for each alternative is obtained.

¹ The reason why these three indicators needed to be calculated with another formula is because when they increase, the negative impact will also increase.

4) Evaluating the alternatives

When the alternative results are obtained, the scores of the alternatives are compared and the best alternative is selected; it is also necessary to add a factor where there is not enough information, or where there are factors that are difficult to quantify, in terms of their positive and negative impact from industrial development in this area to help to provide a more precise evaluation.

3. Results Of The Study

3.1 Results from each indicator

1) GDP growth

Thailand's economy in 2004, the initial PCIDP phase 3, had GDP equal to 6,489,476 million baht and this increased to 10,540,134 million baht by 2011 (about a 3.6% annual GDP growth rate). For the proportion of GDP by sector (industry: service: agriculture) it had changed from 43.3%: 46.3%: 10.3% in 2004 to 43.7%: 43.0%: 13.3% respectively in 2011. Comparing the average annual GDP growth rate in Thailand with the average annual GDP growth rate in the world during 2004-2010, the GDP growth rate (3.6%) was higher than the world's GDP growth rate (2.7%). A significant increase in the proportion of agricultural sector income came from an increasing agricultural product demand for agro-industry, food and alternative energy industry products.

2) GPP growth

The GPP of Rayong province during the study period 2004-2011 was about 364,552 million baht and the largest proportion of GPP by sector was in the industrial sector which was about 87.6% in 2004 and 87.2% in 2011. Therefore, we can conclude that economic development in Rayong depended on the industrial sector, which was 3.8% of the average annual GPP growth rate during 2004-2011 and a little higher than the average annual GDP growth rate of Thailand, which was about 3.6% per year.

3) Headline Inflation Rate

The headline inflation rate shows the purchasing power of people and how the change in the cost of living relates to the price of goods. During 2004-2011, the average inflation rate in Rayong province was quite high (5.1%) compare with Thailand's average inflation rate (3.2%). Considering the food and beverage price index, the index is significant because it mainly affects people who have low income. Rayong's food and beverage price index (8.7% on average) was higher than Thailand's food and beverage price index (5.9% on average). This situation shows the degree of effect on the cost of living of people with low income in Rayong, where the development of the industrial sector gave rise to such changes.

4) Tax income

In this study, two types of tax income were identified as Revenue Department Tax (RT) and Excise Department Tax (ET). Bangkok RT, in 2004, collected about 772,316 million baht or 65.9% of the whole country, followed by Chonburi with about 5.7%, and Rayong with about 3.9%. In 2011, the sequence of tax income was the

same: Bangkok, Chonburi, and Rayong provinces had percentage income from tax of about 65.3%, 7.9% and 5.0% respectively.

For ET, the most income, in 2004, was Bangkok with about 20.6% and Rayong province with about 15.5%. Almost all of Rayong ET was collected from petro-chemical products. In 2011, the sequence of ET income was the same: Bangkok followed by Rayong province with about 19% and 13.5% respectively from all of the ET income in the whole country.

5) Unemployment rate

In 2004, Rayong province had about a 1.6% unemployment rate and had a labor force of 309,980. In 2011, the unemployment rate was lower than before because an increase in economic growth.

6) Industrial sector growth

In 2004, the Value Added of the industrial sector of Rayong province was about 276,939 million baht or about 9.8% of the whole country. Unfortunately, because of the world economic crisis in 2009 and a big flood in central Thailand in the fourth quarter of 2011, the industrial sector of the whole country was seriously affected. However, the industrial sector in the whole country remained about 4% per year and it was higher than Rayong province, where it was about 2.8% during 2004-2011.

7) Agricultural sector growth

In 2004, the Value Added of the Rayong agricultural sector was about 11,359 million baht or about 1.7% of the whole country. In 2004, the Rayong agricultural sector was affected by drought and Bird Flu. However, during 2004 – 2011, the Rayong agricultural sector maintained about a 1.3% increase per year, at the same time, the Thai agricultural sector as a whole, increased 1.2% per year.

8) Service sector growth

In 2004, the Value Added of the Rayong service sector was about 34,218 million baht or about 1.1% of the whole country. Because a tsunami hit the southern part of Thailand, it encouraged tourists to change destination from the southern to the eastern part of the country, including Rayong province. For this reason, during 2004-2005, the service sector growth rate was dramatically high. Therefore, the Rayong service sector growth rate during 2004-2011 was about 7.3% per year, a little bit higher than usual.

9) Total Economic Value (TEV)

On one hand, in general, if the alternative with TEV in NPV is a positive number, it is counted as an alternative; on the other hand, if TEV in NPV is a negative number, it is not counted as an alternative. The net present value (NPV) of TEV in the first, second, third, and fourth alternatives are zero, 65,677 million baht, 61,955 million baht, and 66,416 million baht respectively. For the first alternative, the NPV is equal to zero because there is no cost or benefit; however, this case is used as a base case to compare with other cases.

For the second alternative (allowing the expansion of industrial capacity without exceeding 50% of the pollution capacity), the alternative is assumed as a new investment which is 50% of capital accumulation (about 300,000 million baht). This

number is based on the capital accumulation of the petro-chemical industry investment from the beginning of PCIDP phase 1 to phase 3 (1982-2011) and the total capital accumulation was about 630,000 million baht. This alternative assumes that the PCIDP phase 3 investment will be continued for 7 years (2012-2018) until the end of plan in 2018 and 10 years of the factory operating (2019-2029) and after 2029 everything will stop operation. The benefits from new investment are equal to 605,002 million baht and the cost of new investment is equal to 300,000 million baht, 14,699 million baht from greenhouse emission controls, 116,912 million baht from non-registered immigration population affecting cost, and 10,706 million baht from medical care.

For the third alternative (allowing the expansion of industrial capacity without exceeding the pollution capacity, requiring comprehensive town planning, and the implementation of existing laws and particular measures), the alternative assumes that new investment is about 400,000 million baht, and about 100,000 has already been invested. Therefore, 300,000 million baht is assumed to be the new investment in the petro-chemical industry for 7 years continuously (2012-2018), and 10 years of the factory operating (2019-2029) and after that everything will stop operation. Moreover, this alternative an 80:20 measure² is added into social benefit by calculating 6% of the new investment from the economic model. Considering the benefits and costs of investment, the Value Added from industrial development to Rayong's economy is equal to 573,673 million baht and the social benefit from specific measures is about 3,600 million baht. On the other hand, the cost of new investment is equal to 270,000 million baht ($3000,000 - (300,000 \times 6)$), 18,000 million baht from greenhouse gas release prevention cost, 109,898 million baht for non-registered immigrant population cost, and 10,064 million baht for medical care.

For the fourth alternative, (allowing the expansion of industrial capacity without exceeding the pollution capacity, requiring comprehensive town planning, the implementation of existing laws and particular measures and considering the eco-industry concept), the alternative assumes that the new investment is about 400,000 million baht, and about 100,000 has already been invested. Therefore, 300,000 million baht is assumed to the new investment in the petro-chemical industry for 7 years continuously (2012-2018), and 10 years of the factory operating (2019-2029), and after that, everything will stop operation. In this alternative, it an 80:20 measure is added into social benefit by calculating 6% of the new investment from the economic model. Moreover, considering in eco-concept, every new investment needs to allocate 10% for eco-industry. The cost of medical care is already added into the cost of Eco-industry cost in a social dimension. Considering the benefits and costs of investment, the value added from industrial development in Rayong's economy is equal to 523,533 million baht and the social benefit from specific measures is about 33,240 million baht. On the other hand, because it is necessary to contribute 10% of the total investment to invest in green production and 6% of the new investment to spend in the 80:20 measure, the cost of new investment is equal to 253,800 million baht. The investment cost of eco-industry is equal to 30,000 million baht, the cost for the greenhouse gas release prevention is 16,200 million baht, and the cost for the non-registered immigrant population is 98,908 million baht.

² The 80:20 measure is a particular measure for new investment in pollution control areas like Rayong province, and 80:20 means for every new investment, a factory must reduce pollution releases by 20% of the new capacity and 80% is allowed to be released.

10) Income tax from the non-registered immigrant population

In this study, 100 samples of non-registered immigrants were collected to identify expense behavior and tax expenses because these data can be used to evaluate how much benefit Rayong province can gain from immigrants. The results show that one immigrant received about 185,491 baht in income, expended about 106,214 baht, paid income tax of about 4,330 baht, and paid VAT of about 3,710 baht in 2011. From the data of the Office of the National Economic and Social Development Board (NESDB), about 524,221 persons are non-registered immigrants (NESDB, 2009); moreover, the data of the National Statistics Office shows that about 69.6% of the Rayong population was over the age of 20 (the National Statistics Office, 2009). Therefore, about 1,580 million baht ($4,330 \times 524,221 \times 0.696$) or about 25.8% of total income tax of Rayong province derives from immigrant labour. From survey data, the average annual expenditure of people over 20 years old is equal to 106,214 baht and about 38,753 million baht ($106,214 \times 524,221 \times 0.696$) is the total annual expenditure of the non-registered immigrant population. From the estimated percentage of VAT that is RT, about 5.5% is income from VAT. Therefore, about 2,130 million baht ($38,753 \times 0.055$) is the total VAT income or 4% of the total income from the VAT the Rayong province has collected.

11) The proportion of local raw materials used in production

The proportion of local raw materials used in production was collected from 100 samples in the agricultural, industrial, and service sectors in Rayong province. The agricultural sector imported 14.60% of its raw materials from foreign countries about and therefore used about 85.40% of local materials in production. Similarly, the service sector greatly depends on local materials at about 88.6% of total materials used in production. The industrial sector, on the one hand, greatly depends on foreign raw materials in the production process (69.30%), and about 30.70% of the raw materials used in production are local.

12) The proportion of local workforce used in production

In this study, we collected data about the proportion of local labor in production from agricultural, service and industrial firms (100 samples in each sector). The results from the survey data shows that for every 100 baht of agricultural firm labor cost, about 11.8 baht is paid to local labor and about 88.2 baht is paid to immigrant labor. For the service sector, for every 100 baht of total labor cost, about 57.5 baht is paid to local labor. For the industrial sector, for every 100 baht of total labor cost, about 16.6 baht is paid to local labor. These data show that labor in the agricultural and industrial sectors represent a small proportion of the Rayong population because most Rayong people have their own businesses. After weighting all of economic sectors, each sector uses about 25% of local labor in their production and 75% is immigrant labor.

13) The proportion of logistics cost of production

Because the data could not be collected directly, we calculated Rayong's logistics cost of production by comparisons with the logistic and inventory costs of the whole country from the Input-Output table of Aat Pisanwanich's study (Aat Pisanwanich, 2010) and the Office of the National Economic and Social Development Board (NESDB, 2010). Because of structural changes in Thailand's industrial cost of production, it made industries consider other products that had lower logistics costs; however, the industries in Rayong still produce the same products as in the past. The

results show that Rayong's logistics cost is about 252,418 million baht or 12.6% of production cost and is a little higher than the whole country, where it is 11.9% of production cost.

3.2 The results from MCA

After the thirteen indicators were obtained they were then ranked by employing the Delphi Technique. The results of the ranking table are shown in the table below:

Table 1: Results from MCA

Indicators	1. Gross Domestic Product growth rate (GDP Growth)	2. Gross Provincial Production growth rate (GPP Growth)	3. Inflation rate	4. Tax income	5. Unemployment rate	6. Industrial sector growth rate	7. Agricultural sector growth rate	8. Service sector growth rate	9. Total Economic Value (TEV)	10. Tax income of non-registered	11. Proportion of local raw materials used in	12. Proportion of local workforce used in	13. Proportion of logistics cost of
1. Gross Domestic Product growth (G P Growth)	0	3	4	4	4	3	3	3	5	4	4	4	4
2. Gross Provincial Production growth (GPP Growth)	3	0	3	2	3	2	2	2	4	2	3	3	3
3. Inflation rate	2	3	0	2	3	2	2	2	4	2	3	3	3
4. Tax income	2	4	4	0	4	4	4	4	5	2	4	4	4
5. Unemployment rate	2	3	3	2	0	3	3	3	4	2	3	4	3
6. Industrial sector growth rate	3	4	4	2	3	0	2	3	4	2	3	3	2
7. Agricultural sector growth rate	3	4	4	2	3	4	0	4	4	2	4	3	4
8. Service sector growth rate	3	4	4	2	3	3	2	0	4	2	4	4	4
9. Total Economic Value (TEV)	1	2	2	1	2	2	2	2	0	1	2	2	2
10. Tax income collected from the non-registered immigrant population	2	4	4	4	4	4	4	4	5	0	4	4	4
11. Proportion of local raw materials used in production	2	3	3	2	3	3	2	2	4	2	0	4	2
12. Proportion of local workforce used in production	2	3	3	2	2	3	3	2	4	2	2	0	2

13. Proportion of logistics cost of production	2	3	3	2	3	4	2	2	4	2	4	4	0
Total compared Weighted Score of each indicator	27	40	41	27	37	37	31	33	51	25	40	42	37
Weighted score = 100	5.7 7 ³	8.5 5	8.7 6	5.7 7	7.9 1	7.9 1	6.6 2	7.0 5		10.9	5.3 4	8.5 5	7.9 8

After specialists gave many reasons for the importance of each indicator, important reasons are provided by grouping Weighted Score of group indicators. The highest Weighted Score is the TEV indicator (51) because this indicator not only be used to calculate the market value but can also be used to calculate the non-market value of environmental impact, health impact, and social impact. The proportion of local workforce used in production, the inflation rate, the GPP Growth, and the proportion of local raw materials used in production are high Weighted Score indicators at 42, 41, 40, and 40 respectively. The main reasons that indicate these four indicators have high Weighted Scores are the significant impact on Rayong people's standard of living, the main cost of every sector in Rayong province, and the wide impact on Rayong's economy. The unemployment rate, the industrial sector growth rate, the proportion of logistics cost of product have moderate Weighted Score indicators because the unemployment rate is low, the industrial sector is the main sector in the province's economy, and the logistics cost is the main cost of the business. The service sector growth rate and the agricultural sector growth rate are have low Weighted Score indicators because of main reasons. Although they are the main sector in Rayong's economy, they have low impact on the local economy. Furthermore, GDP Growth and Tax income collected from the non-registered immigrant population have the lowest Weighted Score indicators because GDP reflects only the impact on the whole country and the tax income has a low impact on Rayong's economy. The results of the assessment of the economic impact of each alternative are shown in the table below:

³Total compared Weight Score of each indicator, GDP growth = 27
 Total compared Weight Score of all indicators = 27+40+41+27+37+37+31+33+51+25+40+42+37 = 468
 Score weight of GDP growth = (27/468) x 100 = 5.77

Table 2: Assessment of the Economic Impact of Each Alternative

Indicators	Weight Score	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		Impact Level	Impact Score	Impact Level	Impact Score	Impact Level	Impact Score	Impact Level	Impact Score
1. Gross Domestic Product growth (GDP Growth)	5.77	0.67	3.87 ⁴	0.75	4.33	0.74	4.27	0.74	4.27
2. Gross Provincial Product growth (GPP Growth)	8.55	0.53	4.53	0.74	6.32	0.73	6.24	0.71	6.07
3. Inflation rate	8.76	0.59	5.17	0.44	3.85	0.45	3.94	0.47	4.12
4. Tax income	5.77	0.82	4.73	0.96	5.54	0.95	5.48	0.94	5.42
5. Unemployment rate	7.91	0.72	5.69	0.87	6.88	0.87	6.88	0.85	6.72
6. Industrial sector growth rate	7.91	0.35	2.77	0.58	4.59	0.57	4.51	0.55	4.35
7. Agricultural sector growth rate	6.62	0.54	3.58	0.48	3.18	0.48	3.18	0.54	3.58
8. Service sector growth rate	7.05	0.62	4.37	0.77	5.43	0.76	5.36	0.82	5.78
9. Total Economic Value (TEV)	10.9	0.50	5.45	0.94	10.24	0.91	9.92	0.94	10.24
10. Tax income collected from the non-registered population	5.34	0.50	2.67	0.94	5.02	0.92	4.91	0.87	4.65

⁴Score weight x Impact level = Impact score of each indicator

Alternative 1 impact score of gross domestic productivity (GDP Growth) = 5.77 X 0.67 = 3.87

11. Proportion of local raw materials used in production	8.55	0.55	4.70	0.48	4.10	0.49	4.19	0.49	4.19
12. Proportion of local workforce used in production	8.97	0.41	3.68	0.34	3.05	0.34	3.05	0.35	3.14
13. Proportion of logistics cost of production	7.91	0.54	4.27	0.42	3.32	0.43	3.40	0.43	3.40
Total Impact Score	100.0		55.47		65.86		65.32		65.93

According to the summary of all indicators for each alternative, the total Impact Scores are equal to 55.47, 65.86, 65.32, and 65.93 marks for alternatives 1, 2, 3 and 4 respectively.

3.3 The evaluation of the alternatives and the impacts from development

After the results of each alternative were obtained, it can be concluded that the fourth alternative is the best way to cope with industrial development demand of the country and the environmental consideration in Rayong province. However, after the total Impact scores of alternatives 2,3 and 4 were compared, they were found to be close to each other; therefore, it cannot be strongly concluded that the fourth alternative is the best alternative in this study.

4. Conclusions And Remarks

Rayong province has a high capacity for industrial development; however, some areas especially industrial estates such as Mab Ta Put industrial estate have excessive limitations of environmental capacity. To cope with the environmental problems, four alternatives were provided. Finally, the best solution was obtained, which is to allow the expansion of industrial capacity without exceeding the pollution capacity, requiring comprehensive town planning, the implementation of existing laws and particular measures, and the consideration of the eco-industry concept. However, the total Impact Score of alternatives are close to each other; therefore, future study needs to determine find more alternatives, indicators, and techniques that can calculate the best alternative without any questions.

5. Acknowledgements

We would like to thank the Department of Industrial Works and the Ministry of Industry for research funds. Many thanks are also due to the Environmental Research Center, the Faculty of Engineering, Khon Kaen University and the Air Save Company for regarding us as economics experts. Moreover, we would like to thank every stakeholder for their help and providing information to us, especially the Indo – China

Country International Trade and Economic Research Sector, Faculty of Integrated Social Sciences, Khon Kaen University, Nong Khai Campus, Thailand.

6. References

Aat Pisanwanich. (2010), **A Study of the Logistics Cost Structure in Thailand and an Impact Analysis of Oil**. Journal of University of the Thai Chamber of Commerce. Volume 30, No 1st, 38-53.

Office of Natural Resources and Environmental Policy and Planning. (2009), **the National Environment Board Notice Volume 32, 2009**. Accessed 15th January 2013, from http://www.onep.go.th/neb/6.%20Laws/data/annoucement_neb/neb_annoucement32.pdf

Office of Natural Resources and Environmental Policy and Planning. (2009), **the National Environment Board Resolution 3rd, 2009**. Accessed 15th January 2013, from <http://www.onep.go.th/neb/3.%20Resolution/data/2553/mati%203-53%20Final.pdf>

Office of the National Economic and Social Development Board. (2010), **Non-register Immigrant of Rayong Province (Preliminary)**. Accessed 2nd February 2013, from http://www.nesdb.go.th/Portals/0/eco_datas/area/data/data_0438181010.pdf

Office of the National Economic and Social Development Board. (2010), **Input-Output Tables**. Accessed 2nd February 2013, from <http://www.nesdb.go.th/Default.aspx?tabid=97>

The National Statistics Office. (2009), **Statistic Data**. Accessed 7th December 2012, from <http://service.nso.go.th/nso/nsopublish/BaseStat/basestat.html>

*The Potential of Tourist Attractions: A Case Study of 2 Rural Connecting Districts in
the Western Part of Thailand*

Areerut Patnukao, Sirivilai Teerarojanarat

Chulalongkorn University, Thailand

0533

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The area along the Thai-Burmese border in the western part of Thailand is dominated by mountain ranges lying in a north-south direction. This area is enriched with national parks, wildlife sanctuaries, and diversity of ethnic minority groups. Some of these places are promoted to be tourist attractions. However, sustainable tourism is still in its infancy. The project entitled “Geographical Techniques for the Study of Cultural Diversity and Tourism Development” was launched in 2010. The study area covered the connecting area of two rural districts - Dan Chang district, Suphan Buri province and Ban Rai district, Uthai Thani province. This paper presents the first stage of this project aiming to explore and identify the potential of tourist attractions in the study area. Methodology involved field survey, classification and assessment of potential of tourist attractions, development of GIS tourism databases, and implementation of SWOT analysis. Results showed that tourist attractions are based almost entirely on their cultural and natural heritages. Based on the SWOT analysis, their *strengths* are in term of the cultural uniqueness and the richness of forestry and wildlife. Their major *weaknesses* are the incompleteness of physical transportation and facilities and the uncooperative attitudes between the relevant government agencies. The *opportunity* is that these areas can be promoted to become new tourist attractions at both domestic and international levels. The *threat* is that the natural resources, especially wildlife sanctuaries and forests have been destroyed continuously by swidden agriculture. Further study in sustainable tourism is needed to maintain fragile and valuable resources.

Keywords: tourist attraction, SWOT Analysis, Thailand, GIS

I. Introduction

Since the 1960s, Thailand has been known as a tourism country. Thailand is one of the major tourist spots in Asia. According to Lonely Planet, Thailand ranks second of "Best-value destinations for 2010" after Iceland.¹ It is considered one of the cheapest long-haul holidays for Europeans. According to the Ministry of Tourism and Sports, tourist arrivals increased steadily at 7.5 percent a year on average from 11.5 million in 2005 to 15.8 million in 2010. Thailand's tourism income over the past five years also grew by 11.9 percent on average, from about 367.4 billion baht in 2005 to almost 586 billion baht in 2010. The country's income from tourism came mainly from Europe, followed by East Asia, ASEAN, the Americas, Oceania, South Asia, the Middle East, and Africa.² However, the major tourism places for foreign tourists are mostly clustered on a center or sub-centers of the country such as Chang Mai (North), Phuket (South), Chonburi-Pattaya (East) and Bangkok (Central) while other regions - the West and the Upper-central - are not well-known (Figure 1).

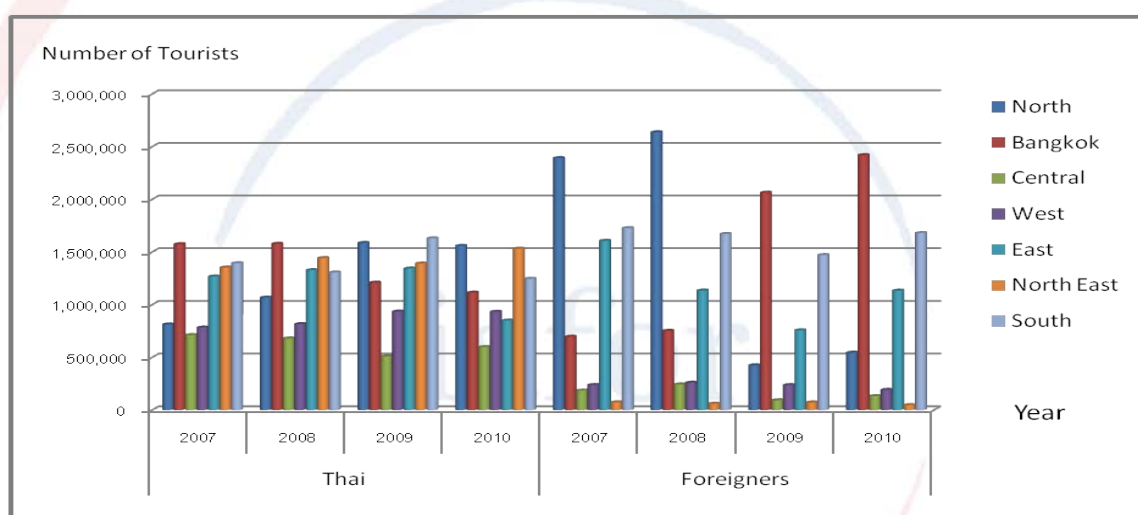


Figure 1. Guest arrivals at accommodation in each region of Thailand in 2007 to 2010 during January-March, Ministry of Tourism and Sports, Thailand.

Some research works, under the sponsorship of the Tourism Authority of Thailand (TAT)³, have been conducted continuously since 1989 in an attempt to set a tourism plan and promote the tourist attractions in these less-popular tourism regions especially in the West and the Upper Central areas such as the Upper Central-west region covering Nakhonsawan, Uthaithani, Chainat and Singburi province in 1989, the Central-west region covering Suphan Buri, Ang Thong, Lopburi, and Saraburi province in 1990, a West region covering Kanchanaburi, Uthaithani, Ratchaburi, Suphanburi, Ratchaburi and Prajuabkhirikhan provinces in 1996. These studies have shown that the western part of Thailand is full of natural resources. Being along the Thai-Burmese border and dominated by mountain ranges lying in a north-south direction, this area is enriched with national parks and wildlife sanctuaries.

Apart from these research studies, it was reported by the Ministry of Social Development and Human Security of Thailand (2003) that diversity of ethnic minority groups such as Khamu, Karen, Lao Krung and Lawa are dominant in this region. These groups of people live peacefully with Thai people and still follow their

¹ <http://www.lonelyplanet.com/iceland/travel-tips-and-articles/18862>

² http://thailand.prd.go.th/view_news.php?id=5525&a=2

³ The government organization responsible for promoting tourism industry in Thailand.

cultural traditions such as costumes and hand-woven fabrics, and their own ways of life, rituals and rites. These cultural uniquenesses, however, have never been observed and mentioned in those previous research works as tourism resources.

In 2010, the project entitled “Geographical Techniques for the Study of Cultural Diversity and Tourism Development” was launched under the sponsorship of the Integrated Academic Innovation Initiative, Chulalongkorn University's Academic Development Plan (CU Centenary) with a main aim to explore and identify the potential of tourist attractions both in terms of natural and cultural resources. The connecting area of two rural districts - Dan Chang district, Suphan Buri province and Ban Rai district, Uthai Thani was chosen as a study area because of two main reasons – (1) natural and cultural uniqueness and (2) possibility of one or two-day trip from Bangkok. This paper presents the first stage of this project aiming to explore and identify the potential of tourist attractions in the study area. Methodology involving field survey, classification and assessment of potential of tourist attractions, development of GIS tourism database, and implementation of SWOT analysis is given.

II. Study Area

The study area, the connecting area of Amphoe Dan Chang, Suphan Buri and Amphoe Ban Rai, Uthai Thani, lies between latitude 14°42' N to 15° 47' N and longitude 98° 59' E to 99°49' E. It occupies an area of 4,815.091 square kilometers and is about 200 kilometers from Bangkok. The study area borders Nakhon Sawan to the north, Kanchanaburi to the south, Tak and Kanchanaburi to the west, and Chainat to the east. The area lies on the edge of the Tanaosi mountain ranges. The elevations of this area are from 100 (to the east) to 1,130 meters (to the west) above mean sea level. The area consists of the ranges of mountains to the west; the most significant is Phu Toei National Park and Huai Kha Khaeng wildlife sanctuary.

Amphoe Dan Chang is the largest and northwestern most district (Amphoe) of Suphanburi province. It occupies an area of 1,193.599 square kilometers. The district is subdivided into 7 subdistricts (Tambon), which are further subdivided into 93 villages (Moobaan). There are 7 Tambon Administrative Organizations (TAO); Nong Makha Mong, Dan Chang, Huai Khamin, Ong Phra, Wang Khan, Nikhom Krasiao and Wang Yao.

Amphoe Ban Rai is a district of Uthai Thani. It occupies an area of 3,621.492 square kilometers which is more than half of the whole province. Most of the district is part of the Huai Kha Khaeng Wildlife Sanctuary. The district is subdivided into 13 subdistricts, namely Ban Rai, Thap Luang, Huai Haeng, Khok Khwai, Wang Hin, Mueang Ka Rung, Kaen Makrut, Nong Chok, Hu Chang, Ban Bueng, Ban Mai Khlong Khian, Nong Bom Kluai and Chao Wat which are further subdivided into 134 villages.

In terms of historical background, archeological evidences implied that prehistoric people lived in this area could date back to around 4,000 years ago in the time of Neolithic or the New Stone Age (The Second Regional Office of Fine Arts, Supanburi, 2009)⁴. Many ancient tools such as hand-adzes, bifacial tools and chopping tools have been found and it is assumed that these ancient people might have settled at the same time of pre-historic Ban Kao, Kanchanaburi in Central

⁴ <http://www.fad2.go.th/>

Thailand. Based on the report of Archaeological excavations pre-historic Ban Kao, Kanchanaburi, Central Thailand (2009), there are currently 22 archaeological sites in Amphoe Dan Chang and neighboring areas.



Figure 2. Chopping tools of the New Stone Age found in Amphoe Dan Chang stored at Phu Nam Ron Temple

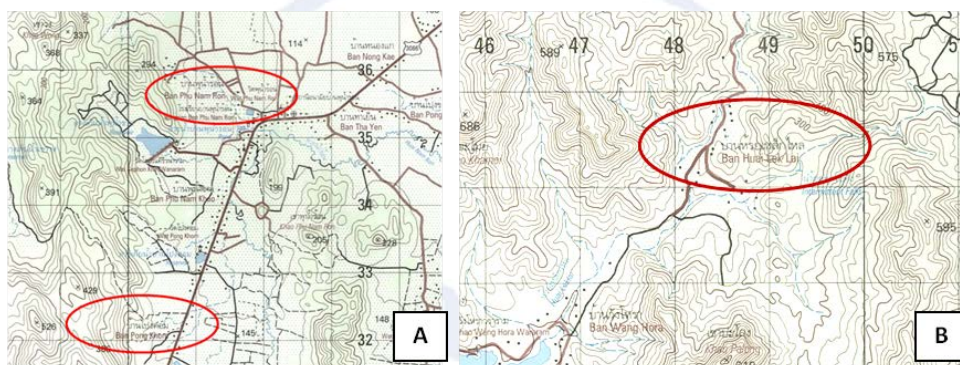


Figure 3. Map of the New Stone Age sites found in Amphoe Dan Chang

Geographically, this area can be divided into two parts; high mountains on the western side and plains on the eastern side (Figure 4). Huai Kha Khaeng Wildlife Sanctuary dominates the western side. It was declared as a UNESCO World Natural Heritage site on 13 December 1991. The wildlife sanctuary covers an area of about 1,737,587 rai (2,780.14 square kilometers)⁵ and is part of a larger area of National Parks and Wildlife Reserves. The Wildlife Reserve itself connects to Thung Yai Naresuan National Park in the neighboring Kanchanaburi province and forms the largest protected wildlife area in mainland Southeast Asia. The plain on the eastern side is mostly used for settlement and plantation. In the study area, the weather is quite cool and suitable for temperate plants such as lily, tulip and strawberry.

⁵ <http://www.huaikhaeng.net/profile/index.html>

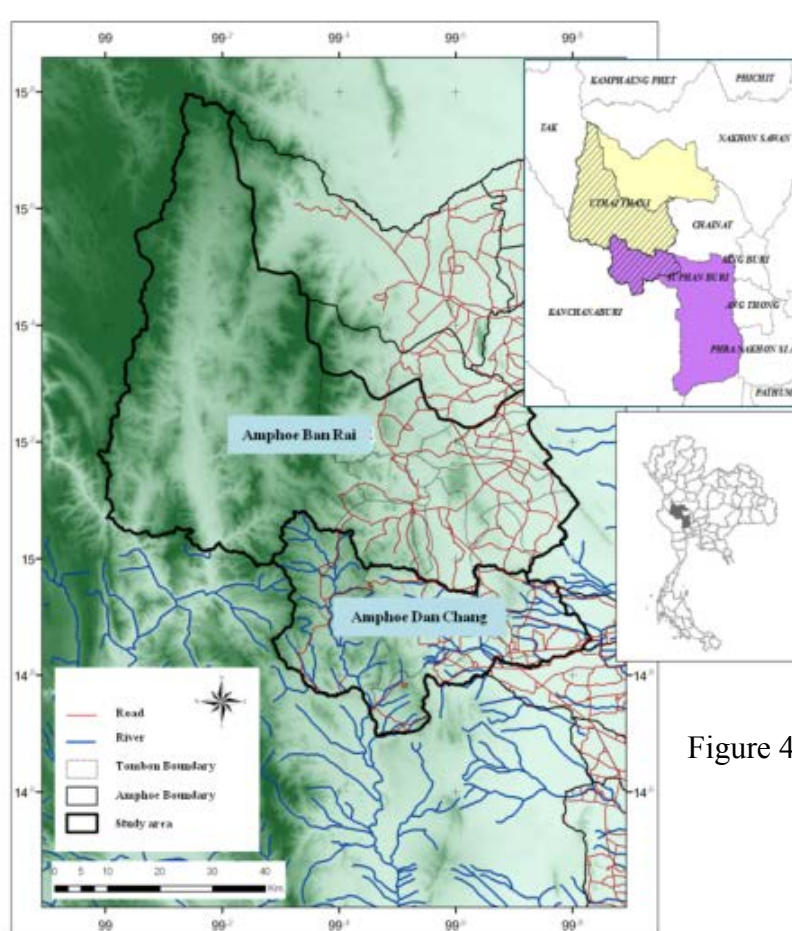


Figure 4. Physical Map of the study area

Ethnic minorities are also dominant in this area. Ethnic minorities in Thailand may be broadly divided into two main groups, namely, those who live in the highlands and those who live in the lowland mixing to a large extent with the mainstream “Thai population” (Jian Hu and Chai Podhisita, 2008).

Based on the survey of the Department of Social and Welfare Development (2002), “Karen” and “Lawa” highland tribal groups reside in three Tambons of Amphoe Dan Chang, namely Wang Yao, Ong Phra and Hui Khamin. “Karen” and “Khamu” highland tribal groups reside in four Tambons of Amphoe Ban Rai namely Kaen Makrut, Ban Rai, Chao Wat and Khok Khwai (see Figure 5 and 6). In the lowland area of Amphoe Ban Rai, there are mixing groups of Lao Krung and mainstream Thai populations but statistics on the number and proportion of lowland minorities are not available.

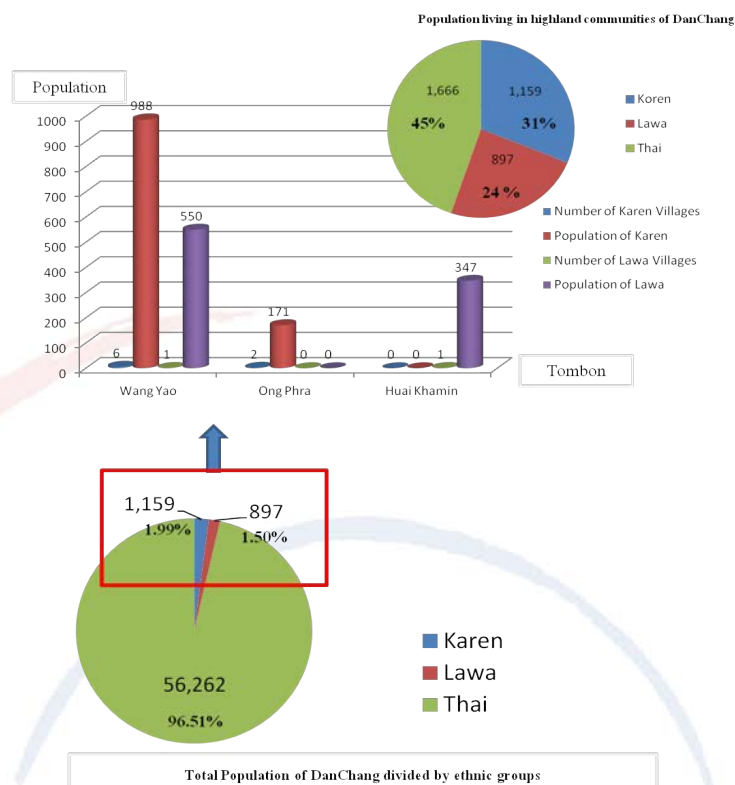


Figure 5. Statistics on numbers and proportion of highland minorities in Amphoe Dan Chang, Department of Social and Welfare Development, 2002

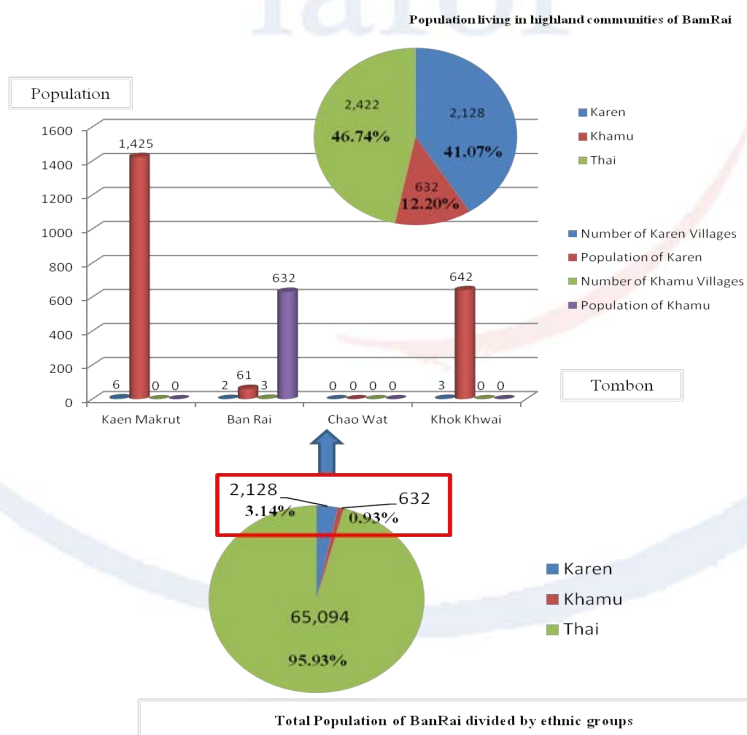


Figure 6. Statistics on number and proportion of highland minority in Amphoe Ban Rai, Department of Social and Welfare Development, 2002

III. Methodology

Methodology in this study can be broken down into four parts. The first part involves data collection. The second part is the classification of potential of tourist attractions. The third part is the development of GIS database and map production. The last part is the implementation of SWOT analysis.

In the first part, data collection is mainly based on collection of secondary data from local, provincial and relevant national governments and previous researches as well as field surveys. The field surveys were carried out three times between January 2011 and January 2012 by a group of researchers from the Faculty of Arts, Chulalongkorn University. Visual observing and mapping tourist places as well as interviewing local people and relevant local government agencies were carried out. A hand-held global positioning system (GPS) was used to locate and check the exact position of tourism sites. It was also found that 1 of 4 tourist places provided by TAT tourist map could not be found or were unknown by local people.

In the second part, classification of potential tourist attractions was performed. The study applied the potential assessment forms of tourist attractions created by the Environmental Research Institute Chulalongkorn University (2006) to investigate the potential of tourist attractions. To evaluate, data was first classified into five categories: “natural tourist attraction,” “cultural tourist attraction,” “agricultural tourist attraction”, “historical tourist attraction” and “recreational tourist attraction”. It should be noted that classification of each tourist place could account for more than one category, e.g., a place can be both “natural and recreational tourist attraction”, and “natural and cultural tourist attraction”. For each category, potential of tourism assessment was divided into three levels - low, medium and high. The potential assessment of the tourist attraction involved compilation of a matrix to evaluate and classify the resources. Three major indicators included: potential of tourist resource attraction, carrying capacity of tourism, and tourism management. For each group, a set of indicators were created and weighed differently to score the importance of the indicators. A high score indicated high importance while a low score indicated low importance. The assessment criteria of all five categories were created. However, this paper will give an example only of the assessment criteria for cultural tourist attraction as presented below:

Assessment category 1: potential of tourist resource attraction (50 points)

Resources of cultural tourist attractions in the study area were evaluated based on the dominant attraction at a particular site using the two major indicators: 1) cultural value (35 points) which included seven sub-indicators (5-points each): lifestyle and wisdom uniqueness, continuing traditions, cultural beauty, local wisdom, cultural source, local relation, and identity conservation; 2) physical potential and activities (15 points); 3 sub-indicators (5-points each): accessibility, safety, and variety of activities.

Assessment category 2: carrying capacity of tourism (10 points)

The carrying capacity of tourism attractions was evaluated based on two major indicators: infrastructure development (5 points), external factor development (5 points).

Assessment category 3: tourism management (40 points)

There are two major types of indicators used to evaluate the cultural resource management as follows: 1) conservation of tourism resources (15 points) which included three sub-indicators (5-points each): conservation and recovery tourism resource, land use management, undertaking resource management, 2) tourism management (15 points) which included five sub-indicators (5-point each): service and public utilities, activities, tourism value consciousness, community-based resource management, and community income.

The maximum score a site could be assigned was 100. Sites with scores below 50 were assigned as low, from 51-70 were assigned as medium, and more than 71 were assigned as high potential attraction.

The third part involved the development of GIS database and map production. Tourist places collected during field surveys were entered and stored in a Geographic Information System (GIS). A tourist map was produced. The scoring system applied in the previous part was then calculated and coded as a tourist assessment map according to the assessment potentials given as shown in Table 1.

Table 1. Example of a list of 28 tourist attractions classified by type and potential

No.	Name	Type of Tourist Attraction					Potential of Tourist Attraction*		
		C	H	R	N	A	Low	Medium	High
1	Hadsay Huay Krasiao			X			X		
2	Pha Thang Temple	X							X
3	Phu Nam Ron				X		X		
4	Krasiao Dam			X				X	
5	Weluvan Cave				X			X	
...
28	Huai Kha Khaeng wildlife sanctuary				X				X

Remark: The abbreviation “C” stands for Cultural, “H” stands for Historical, “R” stands for Recreational, “N” stands for Natural and “A” stands for Agricultural

* The assessment of the potential of tourist attractions was adapted from those created by the Environmental Research Institute Chulalongkorn University, Thailand

Finally, the SWOT analysis was conducted to analyze the strengths, the weaknesses, the opportunities, and the threat of tourist attractions for future tourism development in the study area.

IV. Results And Discussion

According to the study, 78% of the total tourist attractions in the study area were used for the analysis. As previously mentioned, the missing 22% from the total is due to the fact that some tourist places could not be found or were unknown by local people. Among these available visited places (see Figure 7. and 8.), 12 places can be classified as natural tourist attractions, 10 places as culture-based tourist attractions, 3 places as recreational tourist attractions, 2 places as agricultural tourist attractions, and 1 place as an historical tourist attraction.

Based on the assessment of potential results (see Figure 9, 10 and Table 2), 25% of the overall tourist places are considered high potential. Among the highest ones, four

places (57%) are cultural tourist attractions. They are Wat Thum Khao Wong, Wat Phathang, Baan Pha Tang Local Weaving Center and Paijit Hand Weaving Group. Two places (about 29%) are natural tourist attractions. They are Phu Toei National Park and Huai Kha Khaeng wildlife sanctuary. The remaining place (14%) is an agricultural tourist attraction. It is E-mart, E-sai Cultural Center. The description of these high potential seven tourist places are given in an appendix part.

Table 2. Type and Potential of Tourist Attraction in the study area

Type of Tourist Attraction	Potential of Tourist Attraction			Total
	Low	Medium	High	
Cultural tourist attraction	1	5	4	10
Historical tourist attraction	1	0	0	1
Recreational tourist attraction	1	2	0	3
Natural tourist attraction	3	7	2	12
Agricultural tourist attraction	0	1	1	2
Total	6	15	7	28
%	21	54	25	100

iafor

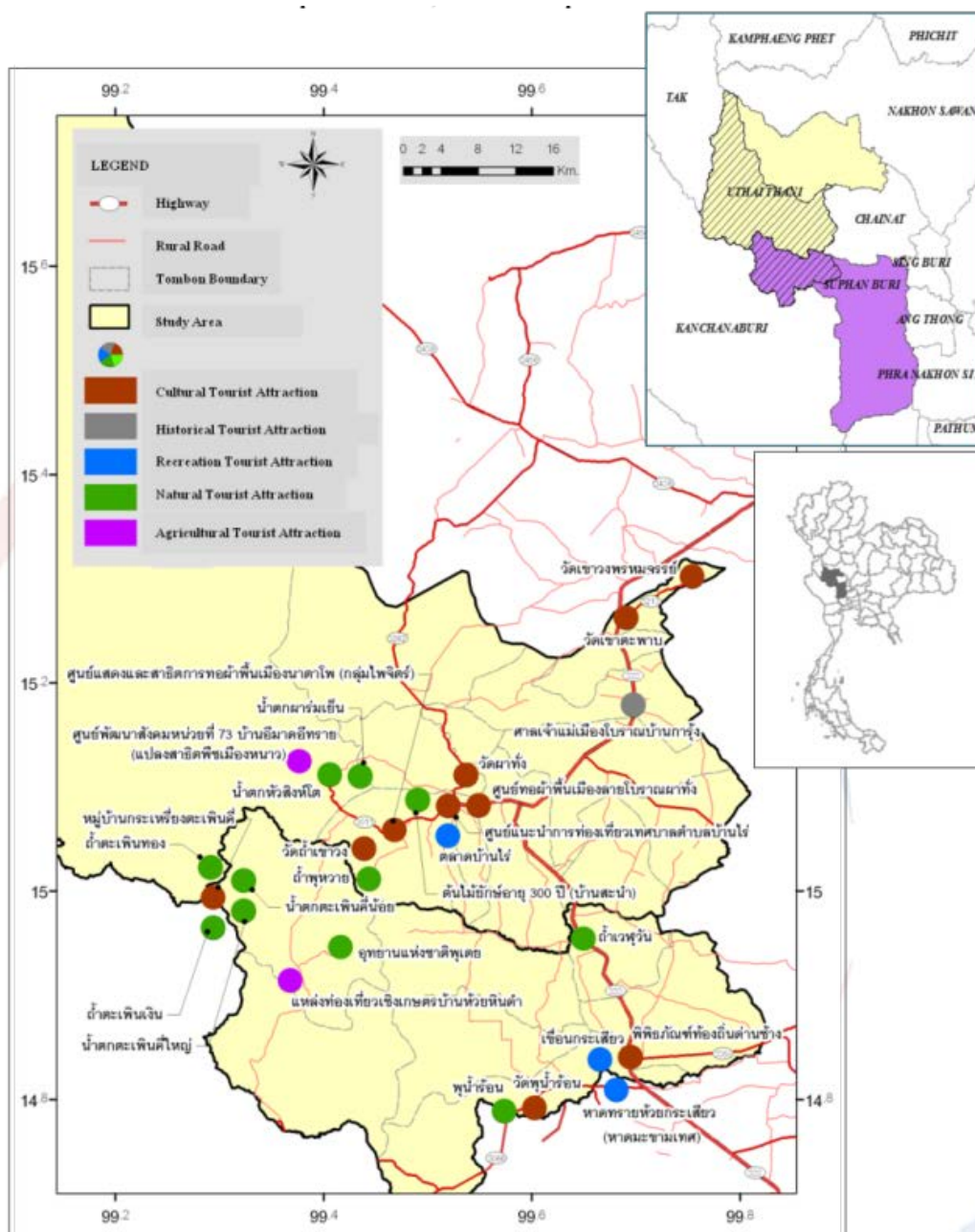


Figure 7. Map of Tourist Attractions in the study area

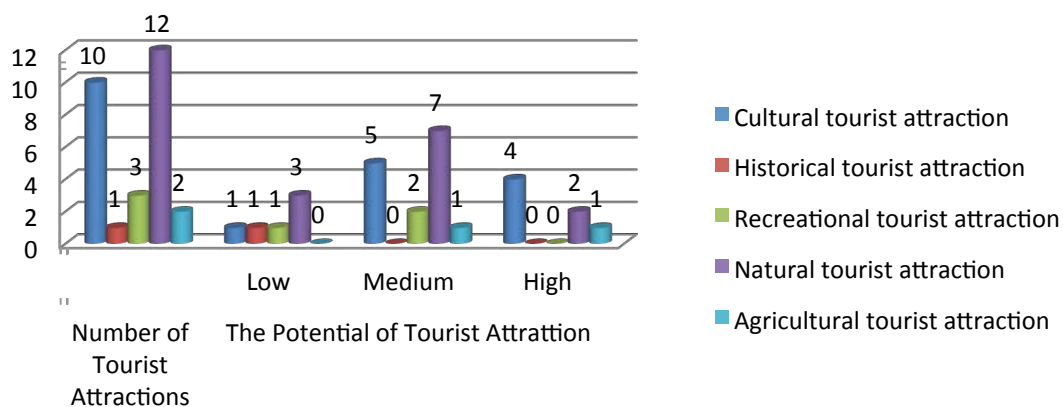


Figure 8. Potential and Types of Tourist Attractions in the study area

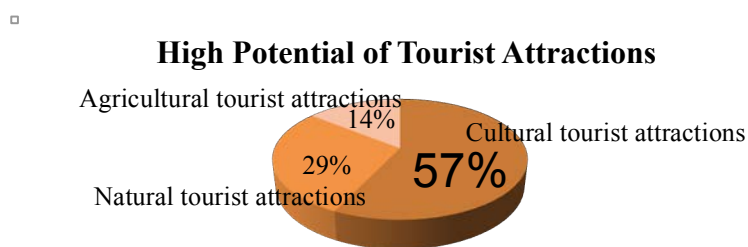


Figure 9. The percentage of seven high potentials of Tourist attractions in the study area

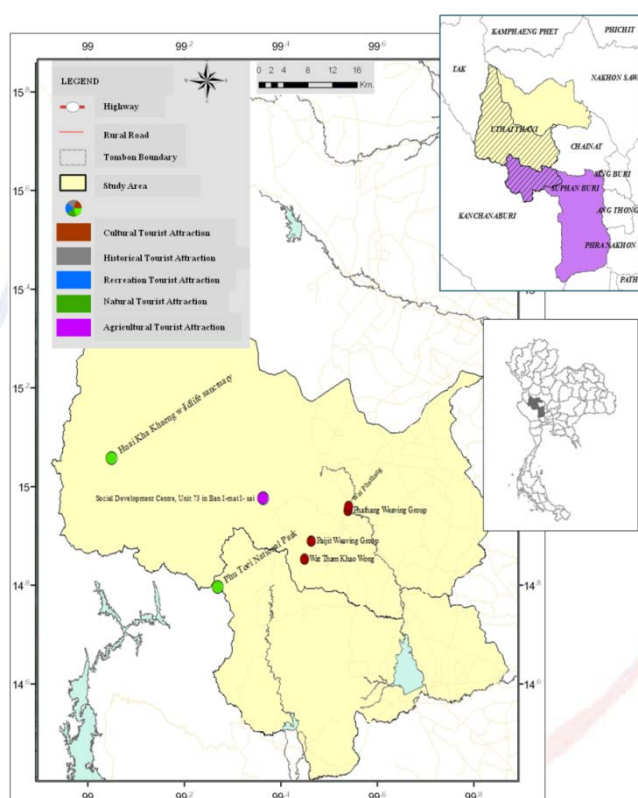


Figure 10. Seven high potentials of Tourist attractions in the study area

In Table 3, the results based on the evaluation of SWOT analysis was outlined. In terms of its *strengths*, it could be concluded that the study area has a wide variety of tourism resources: natural, cultural and agricultural. Diversity of ethnic groups and their unique cultures and products are other strengths. The richness and abundance of forests and wildlife as well as the high topographical areas allow temperate plants to grow in winter. Despite its strengths, the *weaknesses* are that this area is in an early stage of tourism development. TAT does not train local people for tourism management and sustainability. Tourism management is thus rather weak and is operated by inexperienced or untrained local staff. Moreover, there is no clear stakeholder to operate and manage tourist activities. Each province operates tourism management separately. Connection and continuity in managing and promoting tourism activities between the two districts does not occur. This is due to the fact that each district has by different government leadership and uses different tourism

policies. As a result, the connecting area lacks cooperative efforts. In terms of accessibility, the road network linking the two connecting districts - Dan Chang district, Suphan Buri province and Ban Rai district, Uthai Thani province – is inconvenient. In the rainy season, some roads linking the two connecting regions cannot be used. Only a four-wheel drive car can access these roads. *The opportunities* are that this area can be promoted to be a new tourist attraction because it is not far from the new ASEAN hub – the intersection of East-West and North-South (GMS) Economic Corridors⁶ (Figure 10). It is only three hour-drive from Bangkok (Figure 11), hence the access to this area can be set as a one or two-day trip from Bangkok to respond to tourist demands both domestic and international . Moreover, one of the main strategies of the Thai Government Policy on National Tourism Development Plan 2012 – 2016 is to promote tourism at local levels and develop infrastructure to support tourism. It implies that the basic infrastructure in this area will be developed in the near future. *The threats* are that the natural resources, especially wildlife sanctuaries and forests in hills and mountains, are being destroyed continuously by swidden agriculture. Also during the high seasons, in some tourist areas such as Ban I-mat I- sai center, tourists may exceed the limitation of carrying capacity. Further study in sustainable tourism is needed to maintain fragile and valuable resources in the study area.

Table 3. SWOT Analysis of the study area

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> - a wide variety of tourism resources - diversity of ethnic groups and cultural products - temperate plants 	<ul style="list-style-type: none"> - early stage of tourism development - weak tourism organization and management - lack of connection and continuous of tourism activities - lack of linking road between border
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> - close to intersection of East-West and North-South (GMS) Economic Corridors - a possible day-trip from Bangkok - development of domestic tourism by the National Tourism Development Plan 2012-2016 	<ul style="list-style-type: none"> - natural resources degradation by swidden agriculture - exceed the limitation of carrying capacity

⁶ Greater Mekong Sub- Region (GMS) Economic Corridors is the cooperation program which has contributed to the development of infrastructure to enable the development and sharing of resource bases, and promoting the free flow of goods and people in the subregion.

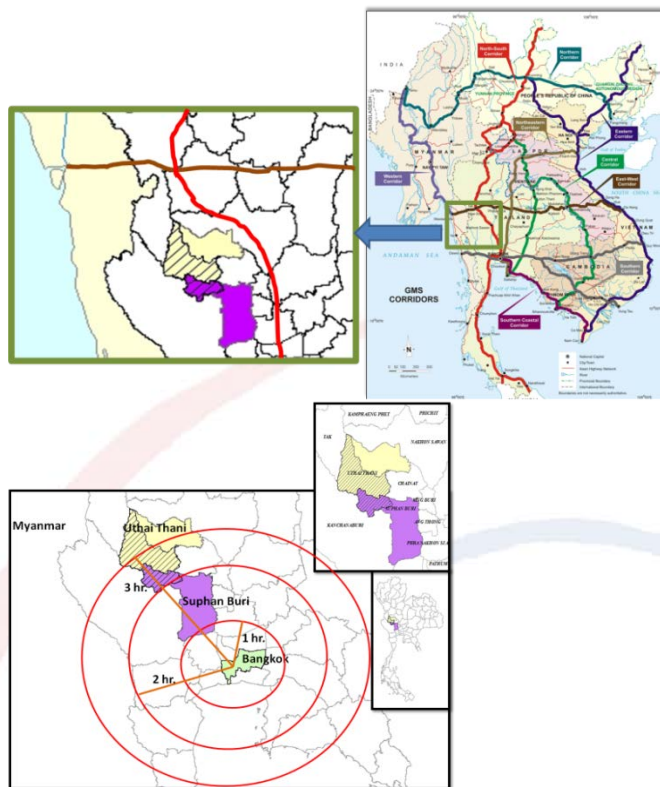


Figure 11. Intersection of East-West and North-South (GMS) Economic Corridors

Figure 12. The areas within radius distance of car-driven: 1 hr., 2 hrs. and 3 hrs. from Bangkok

The result of potential assessment and SWOT analysis suggest that this area has potential to be set as cultural and natural tourism resources. The ethnic diversity leads to a wide variety of cultural traditions. That is unique costumes, handicrafts, hand-woven fabrics as well as demonstration of weaving, e.g. Lao Krung tribe's weaving can become the products for tourism industry in this area. As well, the richness of forestry and wildlife in the area and nearby attracts many tourists. Activities such as bird watching and hiking can be set as a package tour in the future. However, without giving knowledge about sustainable tourism to local people, this area can be at risk for the cultural invasion from newcomers as well as the unplanned conversion of forest and agricultural lands. Setting-up a sustainable program of joint working between private tourism agencies and relevant local authorities in the study area should be initiated. Suggestions based on the results in relation to the level of potential of tourist attractions in this study are as follows:

- For tourist attractions having low and medium potential, there is a need to develop basic tourism facilities, e.g., such as transport links, and support facilities, e.g., as tour operators and restaurants, communications, access to surrounding attractions.
- For tourist attractions having high potential, there is a need - to develop tourism activities, service and marketing to promote the area. Setting quality standards of local products is another important factor that can increase product value. Online advertisement might be another way to promote cultural tourism in the study area and tourists can directly contact local people.

V. Conclusion

Tourism resources in the study area, the connecting area of Amphoe Dan Chang, Suphan Buri and Amphoe Ban Rai, Uthai Thani, have been investigated. This paper presents the first stage of the project entitled “Geographical Techniques for the Study of Cultural Diversity and Tourism Development”, which aims to explore and identify the potential of tourist attractions. Methodology involved making field surveys, development of GIS tourism databases, and implementation of SWOT analysis. Results showed that tourist attractions are based almost entirely on their cultural and natural heritages. Although their strengths in terms of the cultural uniqueness and the richness of forestry and wildlife in the area and nearby, there are major weaknesses regarding the incompleteness of physical transportation and facilities, and the uncooperative attitudes between relevant government agencies. This demonstrates that planning for the study area requires more supporting infrastructure and superstructure, services, local product development and cooperation of relevant provincial authorities. Some specific policy and planning for sustainable tourism approaches are advisable. Further study in the second-year stage, determining tourism potentials of this area from the local community’s perspective, will be carried out.

Appendix:

High potential cultural tourist attractions

Wat Thum Khao Wong (Khao Wong Cave) is a splendid Buddhist temple. It is situated some 12 kilometers from Amphoe Ban Rai. This monastery was established in 1987. It is a beautifully decorated 4-storey Thai-style pavilion made by teakwood having limestone mountain scenery on the back. There are seven or eight caves which are kept as a meditation area for monks. In front of the building there are artificial waterfalls, a fish pond and beautiful garden decorated by stones and flowers creating an atmosphere suited for meditation and contemplation. (Figure 13A).

Wat Phathang (Phathang Temple) is one of the oldest temples in Amphoe Banrai. There is Luang Pho Toh the very exquisite and huge Buddha's statue. Nearby Wat Pahthang, there is a weaving hub, which was awarded as excellent cotton cloth product prize from UNESCO.⁷ (Figure 13B)

Baan Pha Tang Local Weaving Center (Phathang Weaving Group): about two hundred years ago, people from Laos, known as the Lao Krung, settled in the region bringing with them their weaving tradition. This cultural heritage has still been preserved unchanged until this day. Ban Rai Village still actively engages in weaving. It forms a secondary source of income after farming. Most of the weaving is done in cotton, producing items that are customarily used by the people of that area. The superb quality of the weaving products- hand-woven cotton wedding bed sheet, from Ban Rai is confirmed by the fact that they won UNESCO awards both in 2004 and 2005. Most designs follow old patterns which have been passed on for generations. The inspiration for the designs is usually taken from observing normal daily life. Visitors can view every part of the weaving process and get to know what a weaver's life is like. (Figure 13C)

⁷ <http://thebest.uthaithani.go.th/en/home.html>

Paijit Hand Weaving Group is located in Natapho village, Amphoe Ban Rai. It is one of the most well-know Lao Krung hand weaving groups. The Lao Krung use hand-woven cotton fabrics in many ways; for daily life use, for religious use and sell to tourists which is one of the services in our tourism industry. This group used to have homestay service for tourists but now there is none. (Figure 12D)



Figure 13. High potential of cultural tourist attractions in the study area



Figure 14. Phu Toei National Park

High potential of natural tourist attractions

Phu Toei National Park is a 319 square kilometer national park located in Amphoe Dan Chang. It has been a national park since September 30, 1987. On 26 May 1991,

Lauda Air Flight 004 crashed in a site five kilometers north of Phu Toei. One feature of the park is Khao Thevada (Angel Mountain), a 1,123-metre mountain that is the highest in the province. The mountain is on the borders of Kanchanaburi and Uthai Thani provinces. There is a forest (2-needle-leaf pine trees) situated on Phu Toei Hill which is only 736 meters above mean sea level. This is the only and last pine forest in the central part of Thailand.⁸ At the national headquarters office, there are tourism services such as camping grounds, accommodations and tents, but tourists have to make reservations.

Huai Kha Khaeng wildlife sanctuary is a UNESCO World Natural Heritage site. It is located on the west side of Amphoe Ban Rai and it is part of a large area of National Parks and Wildlife Reserves spanning several Western Thai provinces, stretching to the border with Myanmar (Burma). They are home to a very diverse array of animals, including 77% of the large mammals (especially elephants and tigers) and 50% of the large birds can be found in this region.⁹

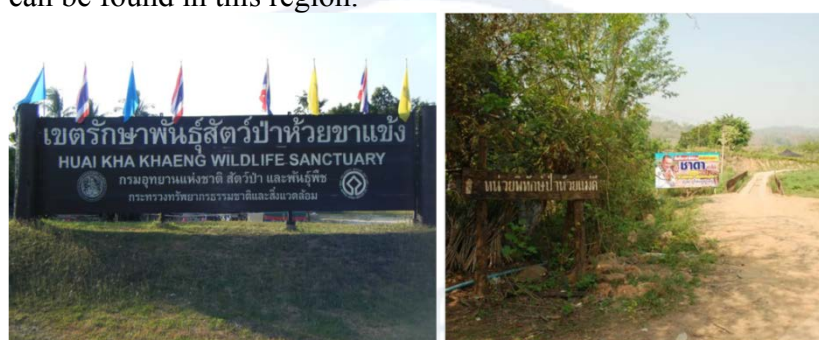


Figure 15. Huai Kha Khaeng wildlife sanctuary

High potential of agricultural tourist attraction *The Social Development Centre, Unit 73 in Ban I-mat I-sai (E-mart, E-sai Cultural Center)* is located in Tambon Kaen Makrut, Amphoe Banrai. It is located on the 600-meter hill above mean sea level which has cool weather all year long. In recent years, this center has become popular among domestic tourists because there is a Demonstration on Agricultural Plantation which was established in 2009 under the cooperation of the Social Development Centre, Department of Agriculture and TAO. The first purpose of this project is to be a self-sufficient agricultural plantation prototype for local communities by initiating the planting of temperate plants and flowers instead of swidden agriculture and now it has become a new agricultural tourist place. The best time to visit this center is during winter. Tourists can join agricultural activities in a pleasant natural ambience, beautiful flowers such as tulips, lilies and strawberries. Moreover, tourists can visit Pwo Karen villages surrounding this area and buy their products such as hand-woven fabrics and agricultural products.

⁸ <http://www.dnp.go.th>.

⁹ <http://www.thaicountrytrails.com/index.php?lay=show&ac=article&Id=145130&Ntype=2>



Figure 16. Temperate plants in E-mart, E-sai Cultural Center

References

- Amphoe Ban Rai, Uthai Thani Province. (2010). *Summary report of Amphoe Ban Rai*. Uthai Thani Province. Thailand. (in Thai)
- Butler, R.W. (1980). *The Concept of a Tourism Area Cycle of Evolution: Implications for Management Resources*. *The Canadian Geographer*, 24(1), 5-16.
- Department of social development and welfare, Ministry of Social Development and Human Security. (2002). *Highland communities within 20 provinces of Thailand*. Bangkok: NETIKUL Printing Company. (in Thai)
- Environmental Research Institute Chulalongkorn University. (2006). *Potential assessment of tourist attractions*. Thailand. (in Thai)
- Gunn, A. Clare. (2002). *Tourism Planning, Basics, Concepts, Cases*. New York.
- Hu, Jian and Podhisita, Chai.(2008). Differential Utilization of Health Care Services among Ethnic Groups on the Thailand-Myanmar Border: A Case Study of Kanchanaburi Province, Thailand. *JOURNAL OF POPULATION AND SOCIAL STUDIES*, Volume 17, Number 1, July, 115-132. [www2.ipsr.mahidol.ac.th/Journal/index.php?]
- Routledge.Leiper, N. (1995). *Tourism management*. Collingwood:Victoria, RMIT Press.
- Priskin, Julianna. (2000). Assessment of natural resources for nature-based tourism: the case of the Central Coast Region of Western Australia. *Tourism Management*, 22, 637–648.
- Second Regional Office of Fine Arts. (2009). *Archaeological excavations in the pre-historic Ban Kao, Kanchanaburi, Central Thailand*. Suphanburi, Thailand. (in Thai)
- Swarbrooke, J. (1999). *Sustainable tourism management*. Oxford: CABI.

Thai Government. (1994). Tambon Council and Tambon Administrative Authority Act 1994.

Bangkok, Thailand: Thai Government.

Tourism Authority of Thailand (TAT). (1989). *A preliminary study for tourism planning in*

Nakhonsawan, Uthaithani, Chainat, and Singburi. Thailand. (in Thai)

Tourism Authority of Thailand (TAT). (1996). *A preliminary study for tourism planning in*

central-west provinces of Thailand: Kanjanaburi, Uthaithani, Ratchaburi, Suphanburi,

Ratchaburi and Prajuabkirikhan. Thailand. (in Thai)

Tourism Authority of Thailand (TAT). (1990). *A preliminary study for tourism planning in*

Suphanburi, Angthong, Lopburi, and Saraburi. Thailand. (in Thai)

Tourism Authority of Thailand (TAT). (2000). *National Tourism Development Plan 2012 –*

2016. Bangkok, Thailand: Tourism Authority of Thailand. (in Thai)

Wight, P. (1995). Sustainable ecotourism: balancing economic, environmental and social

goals within an ethical framework. *Tourism Recreation Research*, 20 (1), 5-13.

World Tourism Organization. (1999). *Global Code of Ethics for Tourism*. World Tourism

Organization. Adopted by resolution A/RES/406(XIII) at the thirteenth WTO General

Assembly (Santiago, Chile, 27 September -1 October ,1999).

Acknowledgements

The authors wish to thank the Faculty of Arts and Chulalongkorn University's Academic Development Plan (CU Centenary) for the financial support that made this study possible. Without their support this study would not have been completed.

*Economic Effects of a Carbon Price on the Australian Economy: A Computable
General Equilibrium Results*

Disna Sajeewani, Mahinda Siriwardana, Judith McNeill

University of Wollongong, Australia

0540

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This paper analyses the macro-economic, sectoral and household effects of a \$A23per tonne carbon price to achieve carbon dioxide (CO₂-e) emissions reduction targets in the Australian economy by employing a static computable general equilibrium (titled as A3E-G) model. The A3E-G model developed for this study is capable of handling endogenous substitution among energy inputs and alternative allocation of resources among energy and capital. The A3E-G model incorporates an explicit tax system that evaluates carbon price impact on the economy under both short-run and long-run closures. The model has been calibrated using an environmentally-extended social accounting matrix (ESAM) which is disaggregated to show detailed picture of carbon emissions by sectors, energy sources, electricity generating sectors, household income groups and various occupations.

Key words: Australia, carbon price, computable general equilibrium model, short-run, long-run.

Introduction

Scientific evidence suggests that greenhouse gases, especially carbon dioxide (CO₂) emissions from anthropogenic activities, have significantly contributed to climate change. These gases have the capacity to trap heat in the atmosphere and the resulting phenomenon is called 'global warming'. During the last 150 years, global surface temperatures have risen by $0.74 \pm 0.18^{\circ}\text{C}$ with 11 of the last 12 years ranked the warmest years of the earth [8]. The consequences predicted as a result of global warming alarmed the national governments around the world. Accordingly, 172 countries participated at the *Earth Summit* in 1992 to establish an environmental treaty called the United Nations Framework Convention on Climate Change (UNFCCC). In order to strengthen the emission reduction commitments set under the UNFCCC, the *Kyoto Protocol* [12] was adopted in December 1997. The Kyoto protocol set countries binding emissions reduction commitments, and, the greenhouse gas emissions - most prevalently CO₂ emissions were identified as a negative externality. As a result, greenhouse gas emissions are viewed as a classical example of a market failure. Thus, the previously ignored external cost (climate change) of greenhouse gas emissions could be internalised into the private decisions of both producers and consumers. In summary, a market mechanism is expected to activate an emissions price (a carbon price) that would ultimately lower the emissions levels.

Pricing carbon has now been on Australia's political agenda over the past decade. In 2006, the Australian states (but not the Federal government) established the states and territories National Emissions Trading Taskforce (NETT). This was one of the significant milestones of Australia's attempt to reduce emissions using price signals. The Taskforce proposed to introduce a national emissions trading scheme. Next, in 2008, the Australian Government announced the Carbon Pollution Reduction Scheme (CPRS) which proposed a cap-and-trade emissions trading scheme as had the NETT Taskforce. Meanwhile, the Australian Treasury in partnership with other leading climate change economic modellers and the Garnaut Climate Change Review undertook comprehensive modelling projects to investigate the potential economic impacts of emissions reduction in Australia. The modelling undertaken by the Treasury is centered on three top-down CGE models namely Global Trade and Environment Model (GTEM), G-Cubed model and the Monash Multi-Regional Forecasting (MMRF) model. This was followed by integrating a series of bottom-up sector specific models for electricity generating, transport, land use change and forestry, and household micro simulation models to obtain projections at sector specific levels and household distributional levels. As it appears, the Treasury modelling is very complex. It has developed modelling scenarios integrating many CGE models as well as sector specific models. This is because the Treasury argues that no single model can adequately capture the global, national, state, industry, and household dimensions of the cost of climate change mitigation policy in Australia.

CGE models require enormous amounts of data. These data are mainly obtained from Input Output (IO) databases. CGE models employed by the Treasury have been calibrated with IO databases with an aggregate household sector representing the consumers in the economy. The micro simulation mode supplements the

disaggregated household level details. However, that model only captures the flows of goods between industries and final consumers and it does not explain income flows between these institutions. An alternative way of obtaining distributional consequences of carbon price policy is to calibrate a CGE model with a Social Accounting Matrix (SAM) database. For instance, a CGE model calibrated with a IO table only captures sectoral interdependence in a detailed production account whereas a SAM based model elaborates and articulates the generation of income by activities of production and the distribution and redistribution of income between social and institutional groups [10]. Towards this end, Pang et al. [9] attempted to construct an aggregate SAM for Australia for the year 1996-97. Because this database is in its aggregate form, the distributional story of the household income and expenditure after a policy shock cannot be projected.

Therefore, two main research questions are addressed in this paper. First, there is a need for a less complex but more descriptive CGE model which is capable of simulating impacts on disaggregated industries and on households under a carbon price policy. Secondly, there is a need for constructing a disaggregated SAM database to calibrate the CGE model in order to measure distributional consequences of a carbon price policy. The rest of the paper is organised as follows. The structure of the A3E-G model is presented in Section 1. Section 2 describes the ESAM database and other necessary data for simulating the model. Section 3 presents macroeconomic, sectoral and household distributional effects of a \$A23carbon price under both short-run and long-run economic environments. Section 5 draws concluding remarks.

1. The A3E-G model

The A3E-G model employed in this study is built based on the ORANI-G model [7], which is an applied general equilibrium model of the Australian economy. However, modifications have been included to incorporate energy industry details, multiple household accounts, and a carbon price mechanism into the model. The model has a theoretical structure that explains the behaviour of producers and consumers in the economy for a given time period. It is a static model which does not have any mechanism for the accumulation of capital. The model is based on the assumption of perfect competition where no individual buyer or seller is able to influence the price. Demand and supply equations for the private sector agents are derived from the solutions to the optimisation problem (cost minimisation, profit maximisation).

The production structure in the model allows each industry to produce several commodities, using intermediate inputs, labour of several types, land, capital and energy inputs. The combination of inputs used in the production process is different from the standard ORANI-G model, as the A3E-G model treats non-energy commodities and energy commodities separately (see similar type modeling structures in [6], [11], [13]). The model then allows price-induced substitution among different energy commodities used in the production process. The nested structure of the production in each sector is displayed in Figure 1. In this nested production structure, inputs are combined at different levels assuming imperfect substitution through a constant elasticity of substitution/transformation (CES/CET) functions or by zero substitution through a Leontief technology of fixed coefficients. Only the commercial

electricity commodity is included in the composite energy group because it is the final form of energy (electricity), which can be utilised by various sectors in the economy. This structure assumes electricity is generated by black coal, brown coal, oil, gas and renewable energy, which supply electricity to the commercial electricity sector. As such, electricity generation is viewed as having normal composite intermediate demand (described by a Leontief function) and commercial electricity sector is treated as having energy demand for other sectors (described by a CES function).

CO₂ emissions are made proportional to the energy inputs (except for commercial electricity) used and/or to the level of economic activity. Carbon emissions are assumed to arise from stationary fuel combustion, industry activity and from household consumption. Emissions intensity - the amount of emission per dollar of inputs - is calculated as a coefficient. These emission intensities are assumed fixed in the model to reflect the unchanged technology and household preferences. Therefore, once the carbon price is introduced, the model re-calculates the market equilibrium based on emissions intensities associated within each sector.

2. The data sources

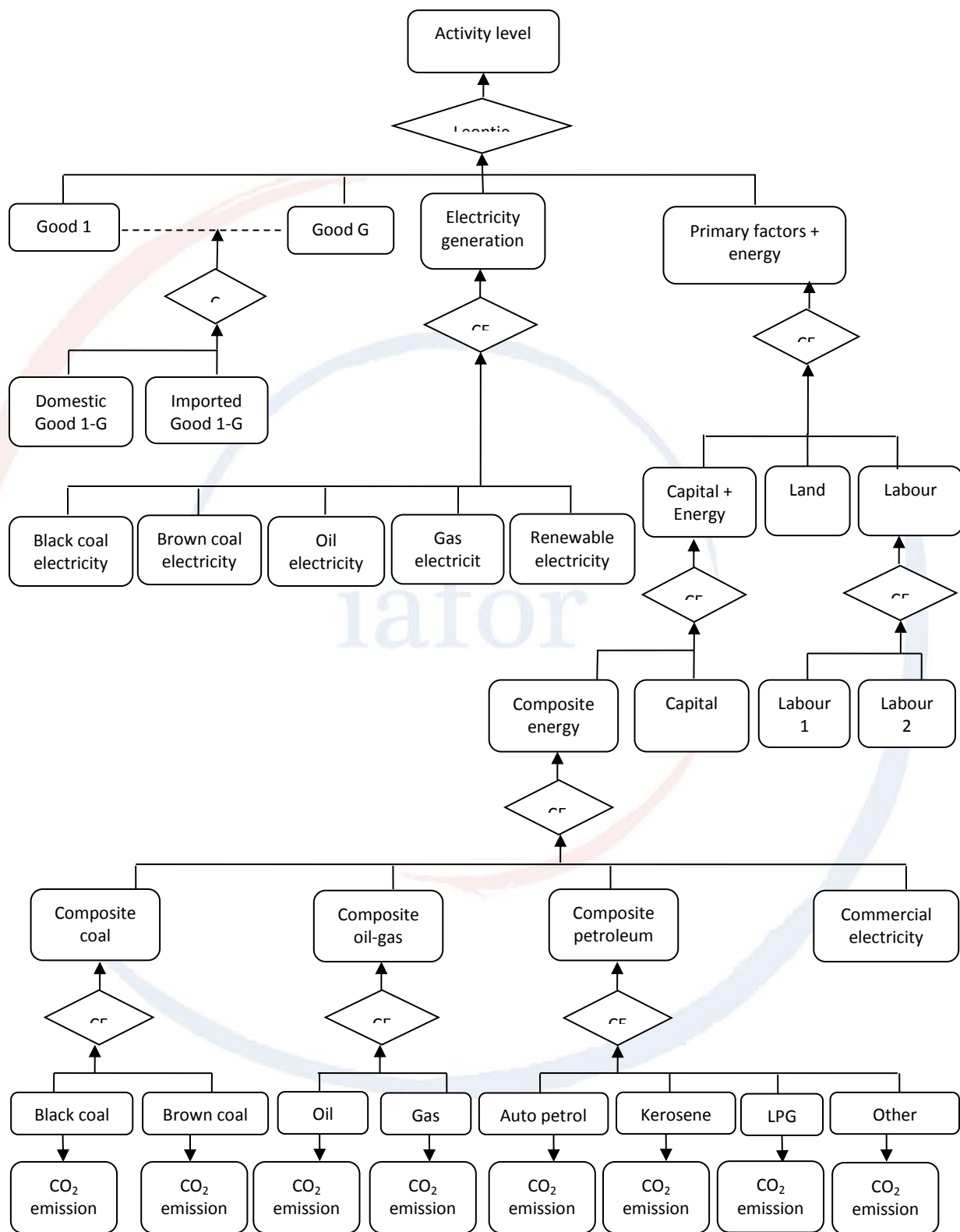
The main data source of the model is derived from the environmentally-extended social accounting matrix (ESAM) developed for Australia. The ESAM was constructed using input-output (IO) table and the system of national accounts (ASNA) published by ABS [1] and [2]. The original 119 sector classification given in the IO table was firstly, disaggregated into several sub-energy sectors and sub-electricity generating sectors and secondly, was aggregated into 35 sectors based on carbon emissions data published by the national greenhouse gas inventory (NGGI) of the Department of climate change and energy efficiency [5]. The ESAM disaggregates household account into 10 income groups and labour account into 9 occupations groups¹.

The carbon emissions resulting from the production and consumption process have been incorporated into the database under three emissions categories, namely input emissions activity emissions and consumption emissions. Input and activity emissions are related to the current production process whereas consumption emissions are related to the household consumption.

The numerous elasticity parameters (Armington elasticities, expenditure elasticities and substitution elasticities for capital-energy, electricity generation types, energy and labour) are extracted from outside sources or used authors' best judgment. The linearised version of the model is solved using GEMPACK [4] software.

¹ Due to limited space the detailed procedure of constructing the ESAM database is not presented, but can be provided on request.

Figure 1: Nested structure of production in each sector



3. Results and Discussion

The Australian government has implemented a carbon tax of \$A23 per tonne of carbon dioxide equivalent to be effective from 1st July 2012 [3] and that price is used to draw simulations under both short-run and long-run economic environments (closures). The major differences between the short-run and long-run economic closures are that short-run assumes fixed capital stocks and real wages whereas long-run assumes fixed rates of returns and aggregate employment. Normally short-run assumes that the time period needed for economic variables to adjust to a new equilibrium after the policy shock is between 1 to 3 years and long-run assumes much longer time periods (more than 3 years) to adjust to a new equilibrium. To be consistent with the government policy, simulation results presented here exclude agricultural and transport sector emissions and household sector emissions. Therefore, a carbon price is directly imposed on input emissions and on output emissions of the rest of the sectors. These impacts are categorised into macroeconomic, industry and household distributional effects to facilitate the analysis.

Macroeconomic effects

The carbon price has reduced the real GDP relative to baseline levels in both short-run and long-run. In the short-run, reduction in GDP is 0.60 percent, whereas in the long-run, reduction in GDP is 0.67 percent. These effects arise due to distortions resulted from the carbon price which is implemented as a form of a tax. This can be seen as a reduction in economic efficiency, thus real GDP is slightly less after the tax. As a result, both the expenditure side and supply side components of GDP are shown to have negatively affected. With respect to supply side components of the GDP, a carbon price increases the cost of variable factors of production, which in turn reduce the incentive for producers to employ these factors in their production processes. For instance, the cost of labour increases in the short-run whereas cost of capital increases in the long-run leading to a reduction in GDP. In the short-run, nominal wages are indexed to the consumer price index. Therefore, increase in the consumer price index by 0.71 percent will lead to proportional increase in nominal wages. This creates a wedge between the price of spending and the average price of output in the economy. This can be observed as a rise in wages relative to the price of output leading to an increase in the real cost of labour. In the long-run, we assume rates of returns are fixed, which creates a wedge between the price of investment and the average price of output. This will result in the rise of capital rent relative to the average price of output, leading to an increase in real rental cost of capital.

As shown in Table 1, real household consumption has reduced by a much higher percentage under the long-run (-0.30 percent) as compared to the short-run outcome (-0.17 percent). This effect can be explained as a result of changes in real incomes available for consumption. For instance, short-run household income is largely affected by the reduction in aggregate demand for employment (-0.87 percent) whereas the long-run household income is largely affected by the reduction in demand for capital stock (-1.59 percent). The loss in household real income from capital (in the long-run) seems to be higher than the loss of real income from labour (in the

short-run). Therefore, real consumption in the long-run has been largely influenced by those who own more capital as compared to labour.

Table1 Percentage change impacts of a \$A23carbon price on macro economic variables

Macro variable	Short-run	Long-run
Real GDP	-0.60	-0.67
Aggregate employment	-0.87	0.00
Real household consumption	-0.17	-0.30
Aggregate capital stock	0.00	-1.59
Export volume index	-2.76	-0.83
Import volume index	0.07	-0.77
Consumer price index	0.71	-0.34
Real devaluation	-0.73	0.48
Real wage rate	0.00	-1.44
Price of exports	0.29	0.11
Terms of trade	0.29	0.11
Emissions reductions (Mt)	70.13	183.13
Emissions reduction (%)	-11.94	-31.19
Carbon revenue (\$ billions)	6.39	3.73

Source: A3E-G model projections.

In the short-run, other than household consumption, the domestic absorption is determined by the balance of trade. In this case, the balance of trade has slightly deteriorated. The overall effect on the trade balance can be further verified by observing the export and import volume indices. Accordingly, export and import volumes have reduced by 2.76 percent and 0.07 percent respectively. Furthermore, the domestic currency has appreciated against the foreign currency by 0.73 percent in real terms, which may have further induced the reduction in exports. As a result, Australia's competitiveness in the international market has been affected by the carbon price. However, the impacts are less severe in the long-run. In this case, the trade balance is determined outside the model, thus, imports tend to move with the level of exports in order to maintain the trade deficit at the 2005 level. Both export and import volumes have declined by 0.83 and 0.77 respectively. In particular, the required change in the real exchange rate to maintain the trade deficit is seen as currency depreciation.

The main intention of introducing a carbon price in the economy is to achieve a required level of emissions abatement. In the short-run, the amount of emissions reduction in the economy is estimated at 11.34 percent (or 70.03 Mt) with a revenue generation of \$6.39 billion. In the long-run more emissions are abated (183.13 Mt), thus, the government would collect less revenue from the remaining emissions in the economy (\$3.73 billion). The high emission abatements are possible in the long-run because the total capital stock and aggregate investment are endogenously determined implying that producers have more capacity to substitute energy with capital.

Industry effects

The detailed analysis of industry effects reveal that the carbon price reduces output in some industries, while it increases output in other industries. Mostly affected industries are high carbon emitting energy related industries. Table 2 gives the percentage change of output and emissions reduction of industries under both the short-run and the long-run. The carbon price generally increases the cost of production of industries producing higher carbon emissions relative to industries producing lower carbon emissions. Accordingly, output changes after a carbon price shock can be explained largely using the percentage reduction of emissions relative to baseline of those industries.

The carbon price increases the prices of directly targeted energy goods such as brown coal, black coal, oil, gas, petroleum products and commercial electricity. On the other hand, a carbon price indirectly affects the prices of goods that utilise energy goods as factors of production. For instance, the commercial electricity price increases with the carbon price (Table 1) mainly as an indirect effect brought about by increases in the cost of production of high carbon bearing fossil energy sources. The increase in prices of commercial electricity exerts further indirect impacts on electricity intensive production sectors. These kinds of combined direct and indirect effects lead to high carbon emissions and energy intensive sectors to contract. As shown in Table 2, significant industry output losses are projected in the brown coal, electricity generating brown coal, electricity generating black coal and commercial electricity sectors. Basically, these sectors (except the commercial electricity sector) have significantly reduced their carbon emissions.

Output contractions in the electricity generating sectors exert a direct impact on the output of the commercial electricity sector. In the short-run, the output reduction in the brown coal and black coal electricity generating sectors contribute to reduce commercial electricity sector's output by 7.49 percent. This is because the contribution to electricity output is much larger with coal powered generating plants as compared to other sources².

Among the other energy sectors, the brown coal sector records the highest output loss. This could be due to two reasons. Firstly, the direct impact (emissions reduction) increases the cost of production of the brown coal sector and, as a result, output contracts. Secondly, indirect impacts (reduced input demand) of the electricity generating brown coal and electricity generating black coal sectors have contracted output in the brown coal sector. This is because the brown coal sector is a major input supplier to coal powered electricity generation in the economy.

The other energy sectors, namely black coal, oil, gas and petroleum outputs have contracted mainly as a response to the direct impacts in the short-run. This is confirmed by looking at emissions reduction in those sectors. However, overall output losses in those sectors have eased slightly due to indirect impacts. In the case of the

² Renewable energy sources contribute 6% whereas coal powered sources contribute 78% to the electricity generating (ABARE, 2005)

oil and gas sectors, the increased input demand from the electricity generating oil and electricity generating gas sectors reduces the negative impacts on the oil and gas sectors. Since major input demanding sectors from the petroleum sector, namely agriculture and road transport sectors have been exempted from the carbon price shock, the petroleum sector experiences only a slight output reduction. Next, the output of the black coal sector decreases slightly as compared to output of the brown coal sector. This could be due mainly to relocating inputs (labour and capital) towards the black coal sector which is less emissions intensive compared to the brown coal sector.

Overall, sectoral outputs of the other remaining sectors have contracted in the short-run. For instance, the output from the iron and steel sector reduces by 4 percent. All other export oriented sectors, namely non metallic products (aluminium) and all other metal products sectors have also reduced their outputs. This could be due to two reasons: one is due to increased electricity prices in the economy; another reason is that emissions associated with these sectors are comparatively high and output related emissions are also priced under the model. In contrast, a slight growth in output is seen in the construction services industry. Because construction services are relatively capital intensive, the improved marginal productivity of capital in the short-run tends to increase the level of output in that sector. Quite by contrast, the sectors exempted from the direct carbon price shock, namely agriculture and road transport services also have reduced outputs in the short-run. This is because these sectors cannot be totally excluded from an external shock due to existence of general equilibrium effects in the economy.

In the long-run, most of the emissions intensive sectors have contracted more than that observed in the short-run. Both electricity generating black coal and electricity generating brown coal contract by 82 percent and 73 percent respectively. Heavy output contraction in electricity generating black coal is mainly due to high emissions reduction of the sector and partly due to contraction in the output of the black coal sector by 10.8 percent. The output of the brown coal sector reduced by 70 percent which is mainly due to its own emissions reduction (71 percent), and partly due to reduced input demand from electricity generating brown coal and black coal sectors. Furthermore, outputs from the electricity generating gas and gas sectors have contracted by 36 percent and 22 percent respectively. A 100 percent expansion can be seen in the electricity generating oil sector. As a result, the corresponding input supplying oil sector has only contracted by 2 percent. The electricity generating renewable energy sector has expanded by 829 percent mainly as a result of substituting lower emissions technologies for higher emissions technologies. The overall impact on the output of the commercial electricity supply sector is -3.3 percent which has significantly improved compared to what was seen in the short-run. This is mainly because of larger expansion observed in the electricity generating renewable energy (829 percent) and electricity generating oil (100 percent) sectors.

Output changes in other sectors show mixed results in the long-run. Similar to the short-run, significant output losses can be seen in the iron and steel sector and all other metal products sector in the long-run. These outputs have declined by 7.6 percent and 6.8 percent respectively. Interestingly, some less emissions intensive

manufacturing sectors show positive expansion in the gross output, especially in the food, beverages and tobacco sector (0.21 percent), textile, clothing and footwear sector (0.51 percent), wood, paper and printing sector (0.24 percent) and all other manufacturing sector (0.58 percent). This is partly because of the comparatively smaller increase in electricity prices in the long-run. Furthermore, when factors are released from emissions intensive sectors they can be absorbed by less emissions intensive sectors. As a result, outputs of the less emission intensive sectors tend to expand. On the positive side, these sectors grow with remarkable reductions in sectoral emissions. Results also show that both the agriculture and road transport services sectors expand by 0.97 percent and 1.1 percent respectively with a slight increase in emissions.

Interestingly, the long-run effects have become favourable for sectors which have relatively fewer emissions as well as sectors that are exempted from the policy. Overall, the carbon price under the long-run has significant effects on reducing emissions associated with high emissions intensive sectors while improving the growth of less emissions intensive sectors in the economy.

Table 2 Industry output and emissions reduction (percentage change)

Industry	Output		Emissions	
	Short-run	Long-run	Short-run	Long-run
1 Agriculture	-0.53	0.97	-0.49	0.93
2 Black coal	-0.56	-10.86	-0.43	-10.96
3 Brown coal	-24.64	-70.20	-19.30	-71.48
4 Oil	-0.11	-1.59	-1.83	-3.29
5 Gas	-0.40	-21.94	-1.91	-23.50
6 Other mining	-0.30	-2.38	-45.18	-48.69
7 Food, beverages and tobacco	-1.03	0.21	-9.75	-13.27
8 Textile, clothing and footwear	-0.97	0.51	-6.07	-11.70
9 Wood, paper and printing	-0.85	0.24	-39.76	-41.94
10 Automotive petrol	-0.53	-1.25	-13.35	-13.75
11 Kerosene	-0.87	-1.74	-25.81	-26.45
12 Liquid gas petroleum	-1.13	-2.67	-25.63	-26.61
13 Other petrol and coal products	0.31	-0.95	-21.25	-26.56
14 All other chemical products	-2.48	-5.59	-10.73	-15.55
15 Non metallic products	-1.46	-0.36	-7.00	-11.97
16 Cement and concrete	-1.23	-1.77	-24.66	-25.78
17 Iron and steel	-3.90	-7.69	-5.68	-11.08
18 All other metal products	-2.37	-6.80	-38.35	-43.50
19 All other manufacturing	-1.12	0.58	2.37	-3.33
20 Electricity generating - black coal	-9.05	-82.10	-30.61	-85.06
21 Electricity generating - brown coal	-17.99	-73.02	-24.48	-80.04
22 Electricity generating - oil	6.88	100.05	0.57	7.96
23 Electricity generating - gas	3.09	-36.33	0.28	-39.57
24 Electricity generating - renewable	11.48	829.47	0.00	0.00
25 Commercial electricity	-7.49	-3.31	0.00	0.00
26 Gas supply	-0.74	1.43	-0.54	1.06

27	Water and sewerage services	-0.49	-0.25	-0.44	-0.40
28	Construction services	0.03	-1.27	-11.46	-13.49
29	Trade services	-0.58	0.41	-2.89	-3.58
30	Accommodation and cafe	-1.43	-0.52	-1.53	-1.14
31	Road transport services	-0.84	1.11	-0.76	1.01
32	Other transport services	-1.19	-1.91	-0.75	-1.93
33	Business services	-0.35	0.00	2.09	-0.76
34	Public services	-0.44	-0.23	-7.55	-11.58
35	Other services	-0.32	-0.13	0.00	0.00

Source: A3E-G model projections.

Household effects

This section presents the carbon price impact at different household income groups. The model is used to capture income and expenditure patterns of ten household groups. The household income is basically determined as changes in wage income (disaggregated into 9 occupational groups), capital rent, land rent, government transfers and other transfers. The wage income is solely received by the households, which determine a major part of household income. Table 4 presents the projection of household employment by nine occupational groups in the economy.

The short-run results indicate the overall reduction in derived demand for occupational labour categories due to slack labour market assumption. This closure assumes capital mobility between sectors. Accordingly, a reduction in output of many sectors in the economy is closely related to reduction in employment. Furthermore, as the labour income is received by the households, the reduction in derived demand for occupational labour will basically have an effect on household income at different degrees.

The long-run situation is quite different. Because full employment and allow capital mobility between sectors are assumed under this closure, results show that employment effects have been favourable for many employment groups except on trade persons and related workers category and intermediate production and transport workers category.

Table 4 Percentage change of household labour employment by occupational categories

Occupational category	Short-run	Long-run
1 Managers and administrators	-0.97	0.13
2 Professionals	-0.71	0.14
3 Associate professionals	-0.81	0.15
4 Trades persons and related workers	-0.89	-0.67
5 Advanced clerical and service workers	-0.79	0.13
6 Intermediate clerical, sales and services workers	-0.85	0.15
7 Intermediate production and transport workers	-1.37	-0.52
8 Elementary clerical, sales and service workers	-0.79	0.43
9 Labourers and related workers	-0.98	0.01

Source: A3E-G model projections

With regard to household consumption, a carbon price alters relative prices of commodities as industries incorporate the carbon price into their production costs. These changes affect the composition of household consumption of goods and services in the economy. For instance, the increased prices of carbon intensive commodities will have a disproportionate impact on those households, which consume more carbon intensive commodities. Accordingly, commodities that are required for subsistence requirements are purchased regardless of their price increase. The remaining consumption - the 'luxury' or 'supernumerary' expenditure - is altered with relative price changes.

Table 5 shows the percentage change in household real consumption under various carbon price scenarios. The real household consumption of each income group is negatively affected under both short-run and long-run with the magnitude of the impact varies between two closures. It is also quite clear that short-run assumption generates proportionate consumption reductions in the income groups of deciles 3 to 10. However, projected household consumption impacts are progressive under the long-run and the degree of change varies from -0.004 (decile 1) to -0.714 percent (decile 10).

Another important issue of a carbon price in the economy is to evaluate how household real income varies between income groups. As shown in Table 5, income distribution effects range from a proportional to mildly progressive tax incidence under the short-run. However, the effects are not significant on deciles 1 and 2. These two groups receive a significant proportion of government transfers which constitute their major source of income³. As a result, introduction of a carbon price may not necessarily reduce their household post tax income. The rest of the income groups share the burden quite proportionately to their relative income, with middle income groups (deciles 5, 6, 7, and 8) fairing the worst. This is because in the short-run, household incomes are mainly affected by the changes in labour supply rather than changes in capital rent. Accordingly, this projection confirms that middle income households receive wage income as a major part of their total income and that wage income is affected by the carbon price policy. The post tax income effect on the last two income deciles (deciles 9 and 10) are relatively less than the average middle income group effect.

In contrast, the long-run impacts of the carbon price policy lead to a progressive tax incidence with the highest income groups (deciles 9 and 10) fairing the worst. The degree of change varies from -0.10 percent to -1.36 percent. This is mainly because the income distribution stems primarily from capital income under the long-run. Capital income constitutes a larger proportion of post-tax income of rich household groups. Moreover, the post-tax income changes of the rest (deciles 1 to 8) are somewhat less burdensome as compared to the short-run.

³ More than 75% of the total incomes constitute government transfers for these two groups combined.

Table 5 Percentage changes in household real consumption and real income

Household deciles	income	Real consumption		Real income	
		Short-run	Long-run	Short-run	Long-run
1 st		-0.002	-0.004	-0.14	-0.10
2 nd		-0.001	-0.010	-0.18	-0.14
3 rd		-0.030	-0.034	-0.62	-0.34
4 th		-0.051	-0.051	-0.55	-0.32
5 th		-0.107	-0.084	-0.76	-0.42
6 th		-0.128	-0.097	-0.73	-0.38
7 th		-0.162	-0.194	-0.75	-0.69
8 th		-0.186	-0.219	-0.72	-0.66
9 th		-0.211	-0.499	-0.64	-1.28
10 th		-0.328	-0.714	-0.68	-1.36

Source: A3E-G model projections, 1st – 10th range poorest to richest.

5. Concluding remarks

The impacts of a carbon price in the Australian economy are evaluated using an A3E-G model calibrated to an ESAM database. The carbon price used for this simulation is entirely based on the Australian government decision to implement a carbon price of \$A23 from July 2012. Both the short-run and long-run economic conditions are considered to estimate impacts of \$A23 carbon price on the macro economy, industries and household groups in Australia. The carbon price is likely to have an increased cost on the economy while generating a considerable revenue and emissions reduction to the economy. The negative impacts on households can be minimised by employing a compensation mechanism to recycle the revenue collected from the carbon price. This will be an area for future research using the model developed in this study.

References

- [1] ABS (Australian Bureau of Statistics). "Australian national accounts: Input output table, 2004-05." Catalogue No, 5209.0. Australian Government Publishing Service, Canberra, 2008a.
- [2] ABS. "Australian system of national accounts, 2005." Catalogue No. 5204.0, Australian Government Publishing Service, Canberra, 2008b.
- [3] Australian Government. "Strong growth, low Pollution: Modelling a carbon price". Commonwealth of Australia, Canberra, 2011.
- [4] Cossi, G. and Pearson, K. "GEMPACK: A General Purpose Software for Applied General Equilibrium and Other Economic Modellers." Computer Science in Economics and Management, Vol.1, 1988, pp.189-20.
- [5] DCCEE (Department of Climate Change and Energy Efficiency). "National greenhouse gas inventory (NGGI)." Australian Government, Canberra, 2005.
- [6] Devarajan, S., Go, D. S., Robinson, S., and Thierfelder, K. "Tax policy to reduce carbon emissions in a distorted economy: Illustrations from a South Africa CGE model." The B.E. Journal of Economic Analysis and Policy, Vol.11, No.1, 2011, pp.1-22.
- [7] Dixon, P. B., Parmenter, B. R., Sutton, J., and Vincent, D. P. "ORANI: A multisectoral model of the Australian economy." Amsterdam, North-Holland, 1997.
- [8] IPCC (Intergovernmental Panel on Climate Change). "Climate change 2007: Impacts, adaptation, and vulnerability.", Ed., M. Parry, O. Canziani, J. Palutikof, Can Der Linden and C. Hanson Cambridge, Cambridge University Press, 2007.
- [9] Pang, F., Meagher, G. A., and Lim, G. C. "An aggregated social accounting matrix for the Australian economy: Data sources and methods". Growth, Distribution and Social Accounting Matrices, Korean National Statistical Office, Daejeon, South Korea, 2007.
- [10] Round, J. "Constructing SAMs for development policy analysis: Lessons learned and challenges ahead." Economic Systems Research, Vol.15 2003, pp.161-183.
- [11] Telli, C., Voyvoda, E., and Yeldan, E. "Economics of environmental policy in Turkey: A general equilibrium investigation of the economic evaluation of sectoral emission reduction policies of climate change." Journal of Policy Modeling, Vol.30 2008, pp.321-340.
- [12] UNFCCC. "Kyoto Protocol to the united nations framework convention on climate change." http://unfccc.int/key_documents/kyoto_protocol/items/6445.php, 1998.
- [13] Yusuf, A. A., and Resosudarmo, B. P. "On the distributional effect of carbon tax in developing countries: The case of Indonesia." Working Paper in Economics and Development Studies, Department of Economics, Padjadjaran Universtiy, 2007.

Enhancing Coral Reef Resilience through Ecological Restoration: Concepts and Challenges

Tai Chong Toh, Chin Soon Lionel Ng, Loke Ming Chou

National University of Singapore, Singapore

0555

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The combination of environmental and anthropogenic stressors has driven the global decline of coral reefs. Changing demographics of the human population and growing dependence on coral reef resources have necessitated mitigation measures to improve the sustainable use of the reef ecosystem. While management measures are useful in slowing the unprecedented loss of coral reefs, active restoration can be pivotal to facilitating the recovery of impacted reefs. With the rapid development of reef restoration techniques in the past decade, there is a need for a review and synthesis of restoration initiatives to identify factors that contribute to its efficacy. We reviewed the variety of reef restoration projects attempted to date and identified the key biological and ecological processes governing the different techniques. An analysis was made to elucidate the effects of biological, management and socio-economic challenges faced by restoration practitioners and used to examine how these factors might synergistically impact the success of future reef restoration efforts. Finally, we recommend the proper management of environmental and anthropogenic stressors before any attempts at active restoration are made, as well as the use of appropriate techniques to address the underlying causes of reef degradation. This study provides a comprehensive understanding of the drivers that contribute to the success of reef restoration as a tool for sustainable coastal development and resource management.

INTRODUCTION

Coral reefs are one of the world's most important environmental and economic assets. The provision of refugia and food by coral reefs makes them an ideal habitat for resident and transient populations of marine organisms. Over one million species, including over 4000 fish species, reside in coral reefs within the Coral Triangle alone (Burke *et al.*, 2011). In addition to the maintenance of key fishery stocks, the ecological processes associated with coral reefs, such as nutrient cycling and coastal protection, provide critical benefits to coastal communities. The total ecosystem goods and services provided by coral reefs globally is estimated to be US\$375 billion annually (Costanza *et al.*, 1997) and they support more than 275 million people residing within 30 km of the reefs (Burke *et al.*, 2011).

However, more than 60% of the world's coral reefs are now under immediate and direct threats from coastal development, pollution, unsustainable and destructive fishing practices (Burke *et al.*, 2011). These anthropogenic pressures have been further intensified by rapid population growth and the increased dependence on coastal resources. At the global scale, changes in climate and ocean chemistry have also severely threatened coral reefs. The combination of effects from both local and global threats has resulted in an unprecedented worldwide decline of coral reefs and an overall depression of coral reef resilience, even in well managed sites such as the Great Barrier Reef (Hughes *et al.*, 2010; De'ath *et al.*, 2012), hence raising concerns of the ecosystem's potential collapse.

Resilience is the ability of an ecosystem to maintain key functions and processes in the presence of recurrent disturbances by either resisting or recovering from the impacts, without switching to alternative stable states (Holling, 1973; Hughes *et al.*, 2005). There is general consensus that the increase in the slow drivers of change such as pollution and climate change have led to a decrease in the capacity of coral reefs to absorb impacts caused by the acute disturbances (Fig. 1). Recent observations suggested the possibility of large-scale phase shifts from the original coral-dominated state to an alternative stable state dominated by macroalgae and other assemblages (Done, 1992; Bellwood *et al.*, 2004). This drastic shift in community dynamics can severely decrease coral cover and productivity, with flow-on effects on other species dependent on coral reefs (Hughes *et al.*, 2010).

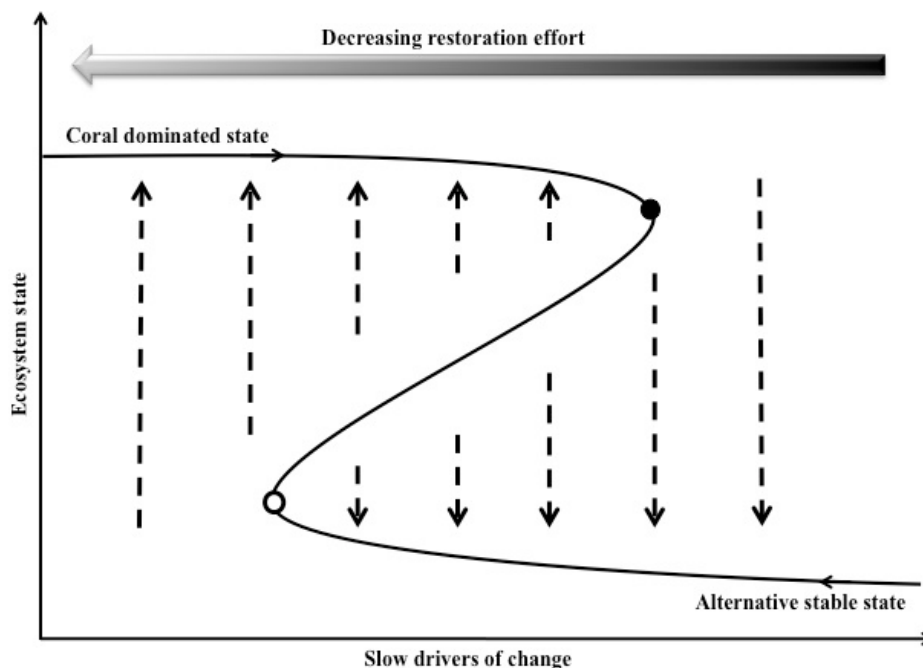


Fig. 1. Non-linear transition of coral reefs to alternative stable states dominated by other assemblages in response to increased slow drivers of change (or stressors) such as overfishing, pollution and climate change. Increasing the intensity of stressors past the threshold level (•) results in the deviation of coral reefs from a coral-dominated state (→) to an alternative stable state. Decreasing stressor intensity can reverse this trajectory (←) with the tipping point at a substantially lower threshold level (o). The occurrence of acute disturbances (such as cyclones and bleaching events) can displace the ecosystem from its equilibrium state, but the ecosystem has the capacity to return to the original state provided that the displacement does not exceed the critical threshold. Resilience, or the capacity of each state to resist change due to acute disturbances (represented by dotted arrows), decreases with elevated stressor intensity for ecosystems in the coral-dominated state, but increases for ecosystems in the alternative stable state. The extent of restoration efforts required (represented by the block arrow) thus decreases with the reduction in slow drivers of change. (Modified from Hughes *et al.*, 2010).

In an attempt to reverse this phenomenon, several strategies have been proposed to restore and rehabilitate coral reefs. The most cost-effective approach is the passive management of coastal zones through legislation and enforcement (Edwards, 2010; Haisfield *et al.*, 2010) to regulate the activities carried out within designated Marine Protected Areas (MPA) or marine reserves. However, for impacted reefs where little or no recovery has taken place even with proper management, active interventions have instead been pivotal in assisting their recovery (Rinkevich, 1995; Edwards, 2010). Over the past few decades, numerous reef restoration approaches have been developed to increase coral cover and enhance the resilience of coral reefs, with techniques designed to address biological and ecological bottlenecks that hinder natural recovery (Edwards, 2010). Active restoration can be broadly classified into physical and biological approaches (Fig. 2) - the former involves substrate modification or stabilization to provide suitable substrata for coral growth and settlement, while the latter requires the direct or indirect transplantation of coral materials onto the reef using source materials derived from asexually or sexually propagated corals. More recently, the incorporation of an intermediate nursery phase has been strongly advocated to augment coral growth rates and survivorship prior to transplantation (Shafir *et al.*, 2006).

As a result of the heightened awareness of the global decline of coral reefs, substantial research has been devoted to improving these techniques, and coral reef restoration has since been increasingly adopted as a key management tool for coastal managers (Rinkevich, 1995). Given the dynamic and complex nature of coral reefs, the identification of the underlying causes of reef degradation is vital to achieving success in reef restoration initiatives. In this review, we examine the key biological and ecological attributes that are of practical relevance to different reef restoration techniques, as well as the challenges that will impact the success of future restoration efforts.

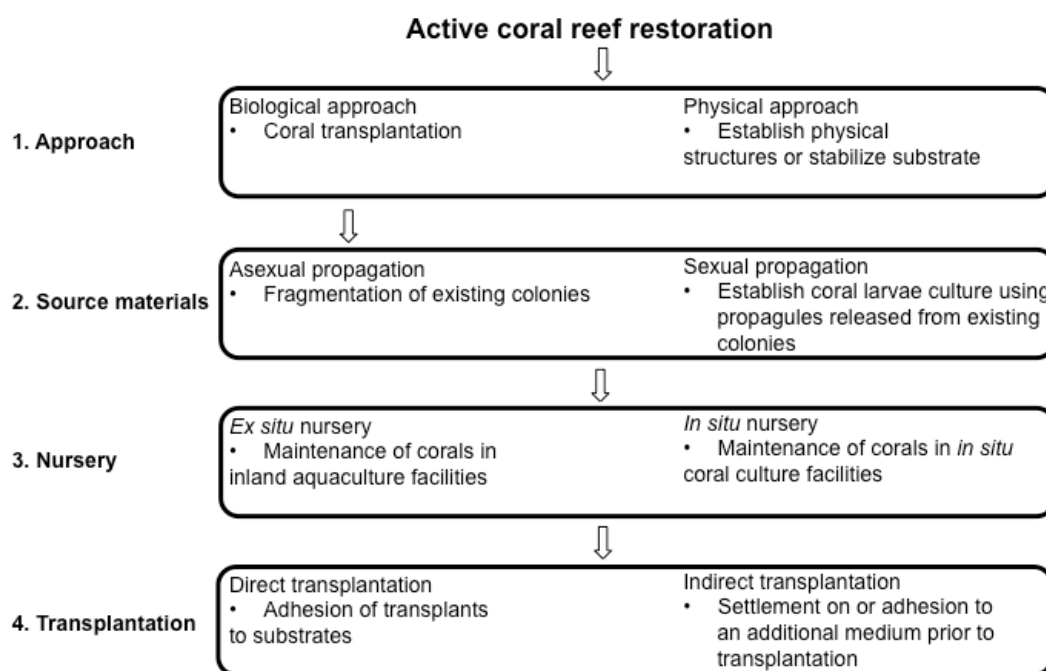


Fig. 2. Overview of active coral reef restoration approaches. A mix of biological and physical approaches can be employed, but the sequence: (1) selection of overall restoration approach, (2) sourcing for coral material, (3) establishment of nursery and (4) transplantation, is generally followed.

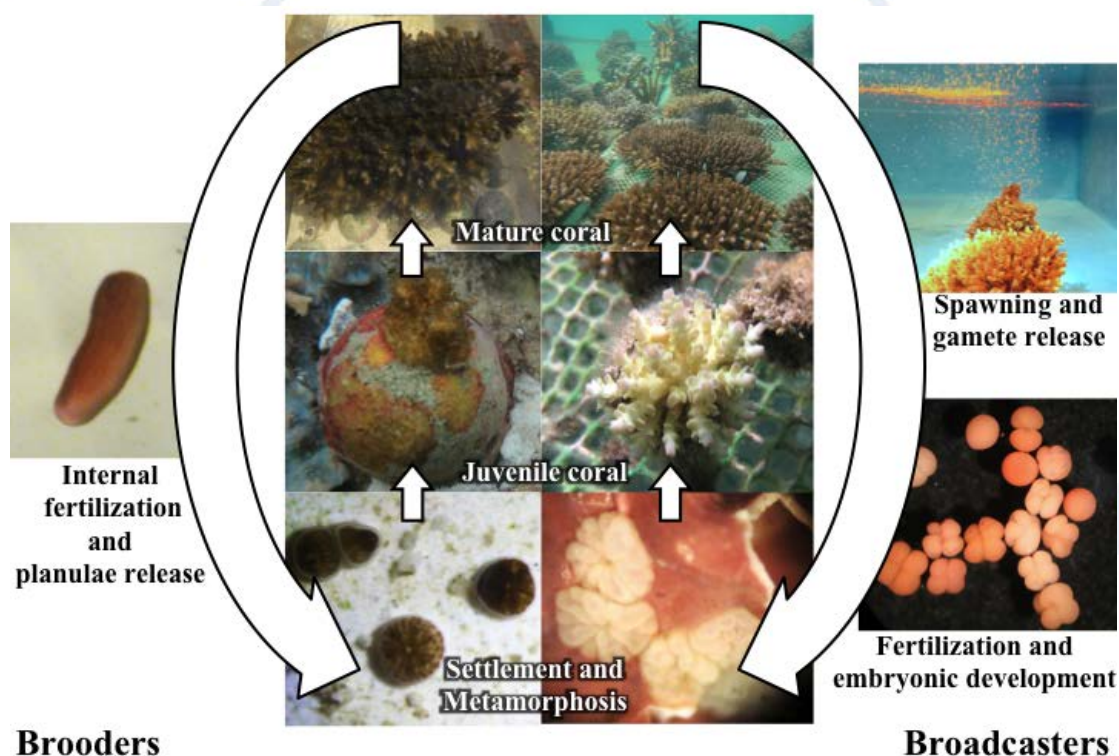
SCLERACTINIAN CORAL BIOLOGY

Coral reproduction and developmental biology

The reproductive biology of scleractinian corals is among the most extensively studied of marine clonal organisms. They reproduce asexually to generate genetically identical clones, predominantly through polyp budding to facilitate growth and wound healing after fragmentation (Sammarco, 1986; Richmond, 1997). However, other unique asexual reproductive modes have also been reported. Brooding corals such as *Pocillopora damicornis* have been shown to release both sexual and asexual coral larvae, and it was hypothesized that asexual larvae developed as a result of parthenogenesis of unfertilized eggs (Stoddart, 1983). Polyp bailout and polyp expulsion, where new coral polyps extend away from the parent colony, and are subsequently released to recolonize other substrata, have also been observed (Sammarco, 1982; Kramarsky-Winter *et al.*, 1997). The ease of generating large amounts of source material rapidly via coral fragmentation makes this one of the most popular coral restoration techniques (Rinkevich 1995; Edwards, 2010). However, species such as *Pectinia lactuca* exhibit much higher mortality rates upon

fragmentation than others such as *Acropora hyacinthus* for which natural fragmentation is a reproduction strategy (Yap *et al.*, 1992; Toh *et al.*, 2012). Coral fragmentation as a restoration tool should thus be exercised with caution to reduce any collateral damage to the parent colonies.

Sexual reproduction in scleractinian corals consists of two sexual systems (Fig. 3). Corals can either be hermaphroditic (both eggs and sperms developing within and attached to the gut of the coral polyps) or gonochoric (single-sex colonies) (Harrison & Wallace, 1990). A mixed sexual system (having both male and female polyps within the same colony) has also been observed in corals, but such occurrences are rare (Baird *et al.*, 2009). The development of coral larvae (planulae) can also be classified into two reproductive modes (Fig. 3). Brooding corals take up sperm released from other colonies to fertilize the eggs internally. Subsequently, the embryos develop within the polyp, which releases coral planulae. Conversely, broadcast spawning corals release their gametes into the water column and fertilization occurs externally. Coral gametogenic cycles can take months to complete (Guest *et al.* 2012), but embryogenesis is usually completed within 18 to 24 hours after fertilization (Toh *et al.* 2012).



Brooders **Broadcasters**
 Fig. 3. Sexual systems and reproductive modes in scleractinian corals. Mature broadcast-spawning corals release gametes into the water column, and fertilization and embryogenesis occur externally. Brooding corals undergo internal fertilization instead and release the coral planulae through their polyps. The motile larvae then settle onto a suitable substrate and undergo metamorphosis to form a primary polyp.

The high fecundity of scleractinian corals and the capacity to produce large numbers of propagules have prompted studies to experiment with the use of sexually propagated corals for reef restoration as a means to enhance genetic diversity (Omori *et al.*, 2008; Guest *et al.*, 2010; Toh *et al.*, 2012). The process of accurately determining the timing for propagule release is achieved by conducting extensive histological and field studies. Coral spawning usually occurs during specific periods

within a year and the timing can vary across geographical locations and among species (Baird *et al.*, 2009). The subsequent larval rearing stage has to be conducted *ex situ* under controlled conditions to minimize physical damage to the developing embryo and reduce bacterial fouling (Toh *et al.*, 2012).

Coral larvae settle and metamorphose in response to biochemical cues derived from a range of sources, including bacterial biofilm, algae and conspecifics (Gleason & Holfmann, 2011; Toh & Chou, 2013). Many of these chemicals have been used, both in the purified and unpurified form, to enhance coral settlement prior to transplantation. The most cost-effective method is to biologically condition the settlement substrates in seawater for biofilm development but isolated compounds can also be coated on the substrates to direct the settlement pattern (Guest *et al.*, 2010). However, in addition to the long culture time and expertise required, the financial costs of culturing sexually propagated corals can increase significantly as coral juveniles are often subjected to a range of post-settlement stressors, such as fouling which can lead to high mortality rates.

The establishment of stable structures such as artificial reefs has also been developed based on the knowledge on coral developmental biology. In areas where the structural integrity of the reef has been compromised due to activities such as blast fishing, coral larval settlement is compromised and post-settlement mortality is increased due to the damaging effects of moving rubble pieces on coral tissue (Fox, 2004). Substrate stabilization techniques would thus be particularly useful in assisting the recovery of degraded sites that are not limited by larval supplies (Fox *et al.*, 2005; Raymundo *et al.*, 2007).

Coral life history traits

Scleractinian coral growth rates are highly variable among species and are non-linear, with rapid growth early in life but declining as the colony ages. Fast-growing corals such as corals from the family Acroporidae can grow up to 4 cm per year (Toh *et al.*, unpublished data), but are prone to mechanical damage and are less resilient to disturbances such as tropical storms and acute *El Niño* warming events. Hence, their populations tend to be more dynamic, with large spatial and temporal variation in sizes (Hughes & Jackson, 1985). Conversely, slow-growing corals are more resistant to stress and populations are more robust (Hughes & Jackson, 1985), but their growth rates can be as low as 0.2 cm per year (Toh *et al.*, unpublished data). In addition, coral growth rates can be augmented by facilitation. Under favorable conditions, such as that provided in a nursery, coral size can be increased by more than 13 times over a span of 4 months (Shafir *et al.*, 2006).

The differences in coral life histories thus affect the choice of species and restoration strategy. Transplantation of fast-growing corals facilitates rapid re-colonization of the denuded site and as their calcium carbonate skeletons are more fragile than those of the slow-growing species, they are easier to fragment for asexual propagation. However, due to their low resilience to stressors, fast-growing corals often exhibit high mortality rates if they are transplanted to areas prone to disturbances or with currents that are too strong. Restoration of these sites can be achieved via the transplantation of the more robust slow-growing corals, although their growth rates are significantly slower. Hence, it is crucial to transplant a variety of both fast- and

slow-growing corals to increase both, heterogeneity and resilience of the restoration site to disturbances.

Coral nutrition

Scleractinian corals are capable of carrying out both autotrophy and heterotrophy (Goreau *et al.*, 1971), enabling them to adapt to different environmental conditions and supplementing their diet with a diverse range of nutrients (Houlbrèque & Ferrier-Pagès, 2009). Autotrophy is the predominant means through which corals fulfill their nutritional needs, and is achieved by the translocation of photosynthates formed by symbiotic zooxanthellae present in coral tissues (Muscatine & Porter, 1977). The availability of solar irradiation is thus an important consideration for reef restoration, especially during the mariculture and transplantation phase. Excess irradiance can lead to the production of toxic by-products (such as hydrogen peroxide) in the zooxanthellae, leading to stress and the expulsion of the zooxanthellae from the coral tissue (Glynn, 1996), making the corals appear white, or 'bleached'. This bleaching response prevents the over-accumulation of toxins. Although corals have the ability to recover upon the re-establishment of the zooxanthellae, they tend to be more susceptible to diseases and exhibit elevated mortality rates (Glynn, 1993; Hughes *et al.*, 2010). Conversely, irradiance-attenuating factors such as sedimentation will reduce photosynthetic rates (Barnes & Chalker, 1990). This results in a nutrient deficit, with the corals undergoing metabolic starvation and eventually death (Houlbrèque & Ferrier-Pagès, 2009). Therefore, the design of coral nurseries should not only include adaptive measures such as shading to prevent excessive irradiation, but also ensure that nurseries in locations experiencing elevated light attenuation rates are sited at shallow depths to ensure sufficient irradiation. The implementation of these adaptive measures, in conjunction with frequent monitoring efforts will facilitate timely responses to changes in environmental conditions and reduce unnecessary coral mortality.

Heterotrophy accounts for 15-35% of the total daily metabolic requirements in scleractinian corals and provides alternative sources of carbon and inorganic nutrients (Houlbrèque & Ferrier-Pagès, 2009). The food sources are diverse, and can include zooplankton, dissolved organic matter and suspended particulate matter (Houlbrèque & Ferrier-Pagès, 2009). Corals are capable of capturing and ingesting zooplankton as early as two days after settlement (Toh *et al.*, 2013) and nutrient enhancement in corals enhances tissue growth, skeleton calcification rate and photosynthesis (Dubinsky *et al.*, 1990; Ferrier-Pagès *et al.*, 2003; Petersen *et al.*, 2008). In addition, heterotrophy compensates for the reduced photosynthetic activity experienced during low light conditions caused by events such as high levels of sedimentation, as well as bleaching episodes (Anthony & Fabricius, 2000; Ferrier-Pagès *et al.*, 2011). Since corals are sessile and rely primarily on their tentacles and mucus for prey capture (Lewis & Price, 1975), physical processes such as hydrodynamic forces constitute the key determinants of prey capture and assimilation rates. Flow rate in particular, increases the prey encounter rate but high flow rates can result in coral polyp deformities and reduce the contact time required for prey ingestion (Sebens *et al.*, 1997; Piniak, 2002). Prey density affects coral ingestion rates, and prolonged increase in prey numbers can facilitate coral growth (Petersen *et al.*, 2008). The literature on the feeding biology of corals to date indicates that nutrient enhancement should be practiced in *ex situ* nurseries to augment coral growth, and that *in situ* coral nurseries should be constructed in relatively sheltered sites with low to moderate flow rates.

Furthermore, since flow rates are one of the key drivers structuring the distribution of corals on the reef (Sebens & Johnson, 1991), transplantation should be conducted in sites where the coral species are known to exist, to ensure that the hydrodynamic conditions are optimal for the species.

ECOLOGY OF CORAL REEFS

Connectivity

The life cycle of scleractinian corals includes a mobile planktonic phase. Physical and biological processes direct the dispersal of coral larvae and influence the genetic linkages between coral reef populations (Roberts *et al.*, 2001; Tay *et al.*, 2011; Toh *et al.*, 2012). Hydrodynamic forces transport larvae among populations and are key determinants of the source and sink sites of genetic material (Lugo-Fernández *et al.*, 2001; Cowen & Sponaugle 2006) Therefore, variations in hydrodynamic patterns due to seasonal changes or coastal developments can influence the larval supplies received by any reef (Fiechter *et al.*, 2008). Biological factors such as coral planulae settlement competency, longevity and vertical migration affect both the dispersal range and the duration that coral larvae remain in the water column (Szmant & Meadows, 2006; Tay *et al.*, 2011).

Establishing the extent of connectivity between populations provides useful estimates for the recovery potential of degraded reefs. A site receiving limited larval supply, for instance, would have a reduced juvenile population, thus the renewal and natural recovery of the reef from disturbances would be extremely slow (Hughes *et al.*, 2010). Additionally, understanding the connectivity between coral populations maximizes the efficacy of restoration projects and facilitates spatial prioritization for restoration and conservation. The establishment of a network of protected sites (Jones *et al.*, 2007) coupled with the strategic restoration of identified source sites (such as via coral transplantation) to create a series of inter-connected 'restoration networks' can generate large amounts of larvae to seed distant or inaccessible sites. The larval supply will be increased several folds if multiple inter-connected source sites have been restored. Moreover, the spillover effects of the restored sites can also benefit adjacent sites not included in the scope of the intended restoration project, and serve to increase larval supply and recruitment rates (Halpern, 2003).

Community interactions

Competition for resources is an essential part of survival. For scleractinian corals, the amount of light and food received by a colony is determined in part by the suitability of the site that the larva has recruited on (Harrison & Wallace, 1990), and competition for these resources inevitably ensues upon settlement. Competition among scleractinian corals can result in a myriad of responses. Some, such as intraspecific fusion produce no apparent negative impacts, but most other interactions produce deleterious effects such as tissue damage, growth retardation and increased mortality rates on one or both of the corals involved. This may arise due to one of the following mechanisms: mesenterial filament extrusion, extension of sweeper tentacles and polyps, overgrowth and histo-incompatibility, with spatial ranges of up to 10 cm (Lang & Chornesky, 1990). Hence, the proximity among which coral colonies are placed in nurseries or transplanted should be considered carefully. The nursery-rearing of fast-growing and aggressive corals would benefit from spacing the colonies

further apart from each other to reduce the risks of overgrowth and tissue damage to other corals.

Fouling organisms such as sponges, algae and barnacles are detrimental to coral health. The scientific literature is replete with studies of fouling organisms impacting coral growth, survival and reproduction through overgrowth, abrasion, shading and allelopathy (Tanner, 1995; McCook *et al.*, 2001). Macroalgae overgrowth in particular, can rapidly reduce coral cover (Tanner, 1995; Hughes *et al.*, 2010). Biological controls can limit the proliferation of fouling communities and are thus vital to the maintenance of coral populations. However, anthropogenic disturbances having altered the dynamics of many biological communities are driving major phase shifts across the globe. For example, nutrient inputs from land developments often lead to algal blooms in coastal areas, while overfishing has drastically reduced the numbers of biological controls to levels below what is required to keep fouling organisms in check (Fig. 4; Hughes *et al.*, 2010). Several strategies have been tested to reduce the effects that fouling communities can have on reef restoration projects. Regular maintenance of coral nurseries and transplant sites including the manual removal of surrounding fouling organisms and the use of anti-fouling paints are common means of reducing the establishment and proliferation of fouling communities (Edwards, 2010). These approaches tended to be more labour- and cost-intensive and may not be sustainable in the long-term. Alternatively, the introduction of biological controls has been demonstrated to be effective in controlling fouling algal communities in *ex situ* nurseries (Ng *et al.*, 2013, Toh *et al.*, in review) although the advantages for *in situ* applications (Villanueva *et al.*, 2010) are limited.

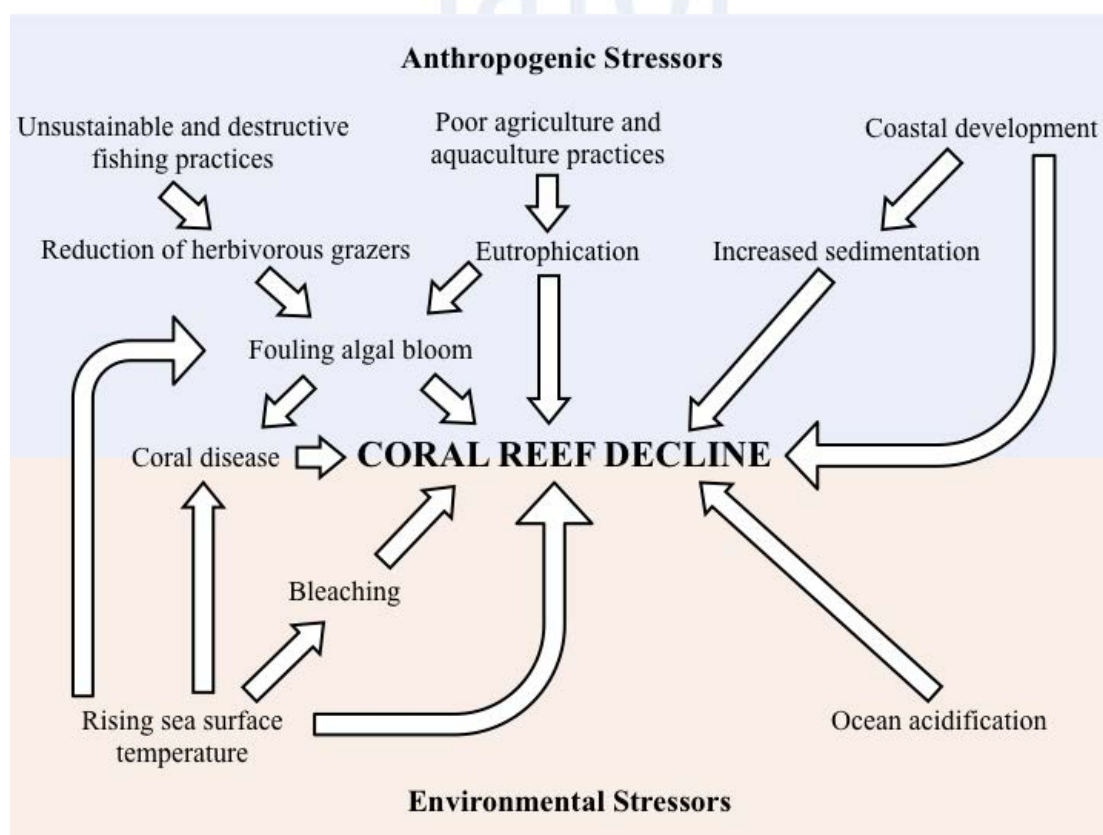


Figure 4. The impacts of environmental and anthropogenic stressors on coral reefs.

REEF RESTORATION: FUTURE CHALLENGES

Changing environmental and social dynamics

The rapidly changing environmental and social dynamics of the world today pose complex challenges to reef restoration. Environmental perturbations have ramifications on coral reefs around the world (Fig. 4), even for those in well-managed sites (De'ath *et al.*, 2012). Climate change has resulted in increased global sea surface temperatures and acute disturbances such as typhoons are projected to be more intense and frequent in the next decade (Easterling *et al.*, 2000). The combined effects of chronic and acute natural disturbances further depress the resilience of coral reefs, and reduce the recovery time between disturbances (Hughes *et al.*, 2010). Rising sea surface temperatures and ocean acidification have been particularly detrimental to the survival of scleractinian corals. Ocean acidification impairs coral skeletal development and severely attenuates growth rates, while the increase in sea surface temperatures have resulted in more frequent episodes of coral bleaching, with associated increases in mortality and disease due to depressed immunity (Glynn, 1996; Brown, 1997). At elevated temperatures, coral larvae are also shown to exhibit decreased longevity, and tend to settle and metamorphose much earlier (Edmunds *et al.*, 2001; Nozawa & Harrison, 2002), thus posing limits on their dispersal range and reducing genetic diversity.

The increasing reliance on resources derived from coral reefs continues to exert pressure on existing reefs (Fig. 4). In contrast to environmental perturbations, anthropogenic stressors are more localized (Burke *et al.*, 2011). However, the effects tend to be more periodic and long-lived. Coastal development presents one of the major challenges in rapidly developing and highly urbanized countries. Countries such as Singapore have lost 60% of its coral reefs since the 1960s due to extensive land reclamation, dredging and coastal development (Chou, 2008; Burke *et al.*, 2011). In addition, surface runoff and eutrophication resulting from agriculture and aquaculture activities have also increased the incidences of harmful algal blooms, intoxicating and asphyxiating coral reef organisms (Anderson *et al.*, 2002). Unsustainable fishing practices represent another major source of anthropogenic pressures, especially in many developing coastal nations (Burke *et al.*, 2011). Even though destructive fishing practices have been banned in several countries, the demand for seafood continues to increase (Burke *et al.*, 2012). To meet these demands, commercial fishing and trawling activities are especially widespread in these developing coastal nations, quickly decimating the vital fish populations required to sustain healthy reefs (Turner *et al.*, 1999).

As coastal development, land reclamation and unsustainable fishing practices persist unabated, and the global climate and ocean chemistry continue to change, the existence and recovery of coral reefs is unequivocally threatened (Fig. 5). The synergistic effects of environmental and anthropogenic pressures will thus hinder the long-term success of restoration activities (Fig. 4). Localized anthropogenic factors generates downstream effects which impacts coral reefs directly by increasing coral mortality rates and habitat loss, or indirectly by changing the community dynamics. The impacts are magnified due to the increased occurrence of acute natural perturbations, which further depresses the resilience of coral reef and hinders the natural recovery of impacted reefs. Hence, it is important to incorporate risk assessments during the planning phase of any reef restoration project, and make provisions for timely and adaptive management during the implementation phase.

Furthermore, as time and resources are limited, effective resource allocation is critical in reef restoration projects. A concerted effort among stakeholders, policy makers and scientific experts should be encouraged to maximize the benefits of restoration projects.

Effective management of stressors and the cost of reef restoration

Active restoration is never an alternative to proper coral reef management. The cost of reef restoration projects is substantially higher than that required to conserve and manage natural habitats (Edwards, 2010). Haisfield *et al.* (2010) demonstrated that utilizing enforcement to protect Indonesian coral reefs was 70 times more cost-effective than active rehabilitation. Furthermore, management of the reefs has the added benefit of preventing further destruction to coral reefs by restricting the type and extent of fishing activities in the area (Haisfield *et al.*, 2010). Embarking on reef restoration without proper management of coral reefs is counter-productive and may cause further damage to the reefs (Edwards, 2010).

Clearly, the management of stressors is crucial when engaging in coral reef restoration, but this may be complicated in most instances. The balance between socio-economic interests and habitat conservation and restoration presents a challenge to many coastal managers. Cultural practices have been a major driving force in many coastal cities where fishing is the primary means of livelihood (Lieber, 1994; Price, 1996). Although the reliance on coastal resources may be reduced by switching to alternative livelihoods such as tourism and industrial activities, these efforts require immense governmental support and commitment (Allison & Ellis, 2001), which are often met with resistance from the coastal communities to abandon their local traditions (Ikiara & Odink, 1999). Additionally, legislation to regulate activities within the marine reserves may exist, but the effectiveness may be hampered by the lack of enforcement and compliance (Qiu *et al.*, 2009). The persistent use of destructive fishing practices near restoration sites for example, will inevitably hinder the success of restoration initiatives (Fig. 5).

Some studies have also attempted to provide a monetary valuation for natural habitats to demonstrate that habitats are worth more preserved than destroyed (e.g. Costanza *et al.*, 1997), but these efforts tend to be ignored largely due to the disparity between short and long-term benefits (Botsford *et al.*, 1997). The scarcity of land has driven both urban and developing coastal nations to reclaim parts of their coastal waters to accommodate their immediate economic aims. Even with measures such as silt screens to reduce excessive sedimentation, the benefits are limited and temporary. Furthermore, proponents of coastal development often argue that lost habitats can be adequately substituted by artificial modifications, but they fail to recognize that coastal modification irreversibly alters natural systems such as hydrodynamic forces and increases terrestrial surface runoff. The ecosystems services subsequently provided by the artificial habitats will not be at the same levels as those provided by the original habitats (Perkol-Finkel & Airoidi, 2010).

The cost of coastal management and restoration can be high, with slow returns on investment (Spurgeon & Lindahl, 2000; Perkol-Finkel & Airoidi, 2010). Most of the associated benefits are intangible and are often perceived as having a lower value compared to immediate monetary benefits. The cost of restoration can range from US\$13,000 to \$100 million per hectare (Spurgeon & Lindahl, 2000) and is hardly

viable on a large scale, especially for developing nations (Edwards & Clark, 1998). However, the use of cost-benefit analysis has been useful in justifying the economic feasibility of restoration projects. The adoption of the total economic value approach to account for the direct and indirect value of coral reefs has shown that the benefits far outweigh the initial costs incurred for reef restoration in the long run (Spurgeon, 2001). To improve the cost-effectiveness of reef restoration, the cost can be substantially lowered through public involvement (such as using volunteers and members of the local community) to reduce labor and operating costs, and improving the effectiveness of existing restoration techniques. Strategic partnerships between projects can further reduce the startup costs and maximize the use of the resources, while the inclusion of community training and education initiatives provide long-term indirect benefits for restoration projects.

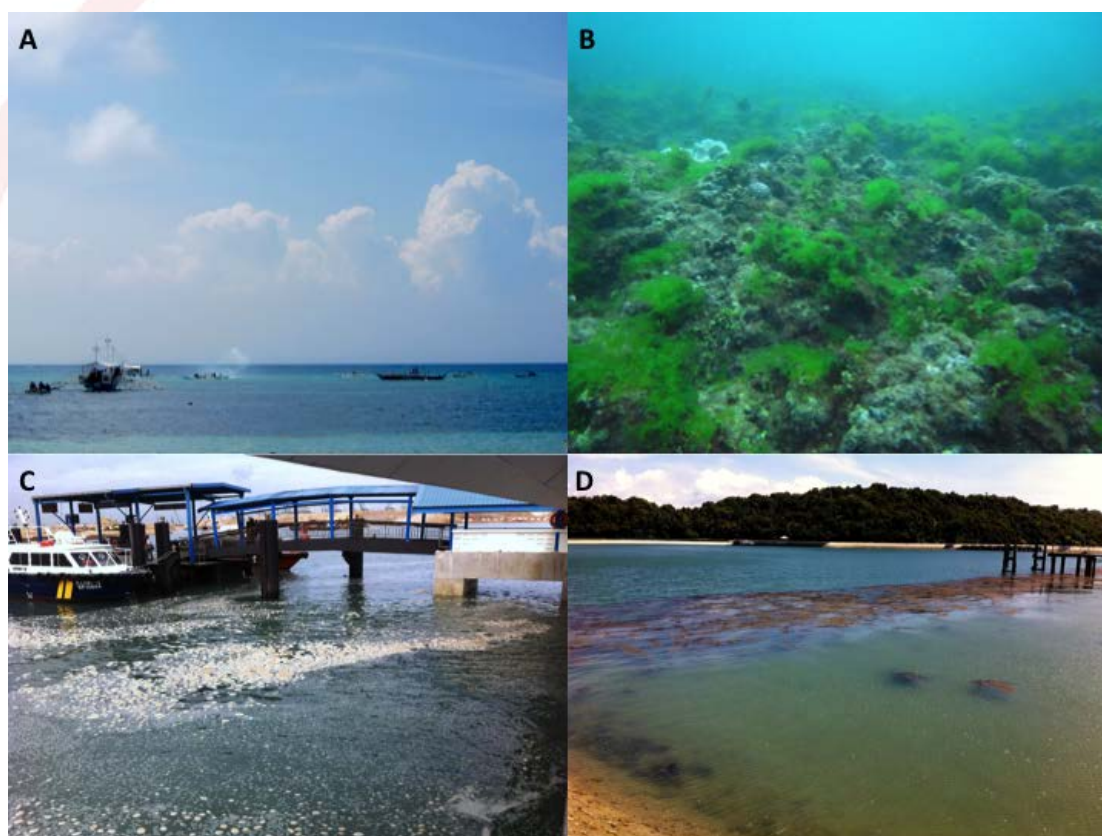


Figure 5. The challenges of effectively managing anthropogenic stressors. (a) Destructive dynamite fishing continues in one of the designated Marine Reserves in Cebu, Philippines due to noncompliance by the local community, (b) the phase shift from a previously coral-dominated to an algae-dominated reef in Bolinao, Philippines raises doubts if the reef will recover even though this site is within a Marine Reserve, (c) Sea foam resulting from a nearby land reclamation project in Singapore in spite of precautionary measures, and (d) excessive surface runoff due to coastal modifications in Singapore.

CONCLUSION

Active coral reef restoration is an important coastal management tool to supplement existing approaches. However, compared to terrestrial restoration, the science underlying coral reef restoration is still in its infancy. Most of these techniques have been based on theories developed for terrestrial restoration and empowering reef restoration practitioners and coastal managers with more knowledge of marine ecology and biology is critical to the success of restoration projects. In this paper, we have highlighted the key biological and ecological concepts essential to reef

restoration and identified the major future challenges which can hinder its effectiveness. More importantly, we recommend that the proper management of environmental and anthropogenic stressors be in place before restoration is attempted. The choice of restoration techniques should address the underlying causes of the degradation. Additionally, the inclusion of risk assessments and adaptive management should be integrated into the planning of any restoration project, to facilitate timely responses to possible changes in the social, political and environmental climate.

ACKNOWLEDGEMENTS

We thank the staff and students of the Reef Ecology Laboratory, National University of Singapore, for their administrative and logistical support. This study was part of Tai Chong Toh's Ph.D. dissertation work and supported by the Wildlife Reserves Singapore Ah Meng Memorial Conservation Fund (grant number R-154-000-507-720) and the Wildlife Reserves Singapore Conservation fund.

REFERENCES

Allison, E.H. & Ellis, F. 2001. The livelihoods approach and management of small-scale fisheries. *Marine policy* 25(5):377-388.

Anderson, D.M., Glibert, P.M., & Burkholder, J.M. 2002. Harmful algal blooms and eutrophication: nutrient sources, composition, and consequences. *Estuaries* 25(4):704-726.

Anthony, K.R.N. & Fabricius, K.E. 2000. Shifting roles of heterotrophy and autotrophy in coral energetic under varying turbidity. *Journal of Experimental Marine Biology and Ecology* 252:221-253.

Baird, A.H., Guest, J.R. & Willis, B.L. 2009. Systematic and biogeographic patterns in the reproductive biology of scleractinian corals. *Annual Review of Ecology, Evolution, and Systematics* 40:551-571.

Barnes, D.J. & Chalker, B.E. 1990. Calcification and photosynthesis in reef-building corals and algae. In: Dubinsky, Z. (ed.), *Coral Reefs Ecosystems of the World* 25. Elsevier, Amsterdam. Pp. 109-131.

Bellwood, D.R., Hughes, T.P., Folke, C. & Nyström, M. 2004. Confronting the coral reef crisis. *Nature* 429:827-833.

Botsford, L.W., Castilla, J.C., & Peterson, C.H. 1997. The management of fisheries and marine ecosystems. *Science* 277(5325):509-515.

Brown, B.E. 1997. Coral bleaching: causes and consequences. *Coral reefs* 16(1):129-138.

Burke, L., Reytas, K., Spalding, M. & Perry, A. 2011. Reef at risk revisited. World Resources Institute, Washington DC, USA. 113 pp.

Chou, L.M. 2008. Nature and the sustainability of the marine environment. In: Wong.

T.C. *et al.* (eds.), Spatial planning for a sustainable Singapore. Springer Science, Singapore. Pp. 169-182.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G. & Sutton, P. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253–260.

Cowen, R.K. & Sponaugle, S. 2009. Larval dispersal and marine population connectivity. *Annual Reviews of Marine Science* 1:443-466.

De'ath, G., Fabricius, K.E., Sweatman H. & Puotinen, M. 2012. The 27-year decline of coral cover on the Great Barrier Reef and its causes. *Proceedings of the National Academy of Sciences* 109(44):17995-17999.

Done, T.J. 1992. Phase shifts in coral reef communities and their ecological significance. *Hydrobiologia* 247:121-132.

Dubinsky, Z., Stambler, N., Ben-Zoin, M., McCloskey, L.R., Muscatine, L. & Falkowski, P.G. 1990. The effect of external nutrient resources on the optical properties and photosynthetic efficiency of *Stylophora pistillata*. *Proceedings of the Royal Society of London Series B* 239:231–246.

Easterling, D.R., Meehl, G.A., Parmesan, C., Changnon, S.A., Karl, T.R., & Mearns, L.O. 2000. Climate extremes: observations, modeling, and impacts. *Science*, 289(5487):2068-2074.

Edmunds, P., Gates, R., & Gleason, D. 2001. The biology of larvae from the reef coral *Porites astreoides*, and their response to temperature disturbances. *Marine Biology* 139(5): 981-989.

Edwards, A.J. & Clark, S. 1998. Coral transplantation: a useful management tool or misguided meddling? *Marine Pollution Bulletin* 37:474-487.

Edwards, A.J. 2010. Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program, St Lucia, Australia ii. 166 pp.

Ferrier-Pagès, C., Hoogenboom, M. & Houlbrèque, F. 2011. The role of plankton in coral trophodynamics. In: Dubinsky, Z. & Stambler, N. (eds.), *Coral Reefs, an Ecosystem in Transition*. Springer, Netherlands. Pp. 215–229.

Ferrier-Pagès, C., Witting, J., Tambutte, E. & Sebens, K.P. 2003. Effect of natural zooplankton feeding on the tissue and skeletal growth of the scleractinian coral *Stylophora pistillata*. *Coral Reefs* 22:229-240.

Fiechter, J., Haus, B.K., Melo, N. & Mooers, C.N.K. 2008. Physical processes impacting passive particle dispersal in the Upper Florida Keys. *Continental Shelf Research* 28:1261-1272.

Fox, H.E. 2004. Coral recruitment in blasted and unblasted sites in Indonesia: assessing rehabilitation potential. *Marine Ecology Progress Series* 269:131-139.

- Fox, H.E., Mous, P.J., Pet, J.S., Muljadi, A.H. & Caldwell, R.L. 2005. Experimental assessment of coral reef rehabilitation following blast fishing. *Conservation Biology*, 19(1):98-107.
- Gleason, D.F. & Hofmann, D.K. 2011. From gametes to recruits. *Journal of Experimental Marine Biology and Ecology* 408:42–57.
- Glynn, P.W. 1993. Coral reef bleaching: ecological perspectives. *Coral Reefs* 12:1-17.
- Glynn, P.W. 1996. Coral reef bleaching: facts, hypotheses and implications. *Global Change Biology* 2:495-509.
- Goreau, T.F., Goreau, N.I., & Yonge, C.M. 1971. Reef corals: autotrophs or heterotrophs? *The Biological Bulletin* 141:247-260.
- Guest, J.R., Heyward, A.J., Omori, M., Iwao, K., Morse, A., Boch, C. & Edwards, A.J. 2010. Rearing coral larvae for reef rehabilitation. In: Edwards, A.J. (ed.), *Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program*, St. Lucia, Australia. Pp. 73-92.
- Haisfield, K.M., Fox, H.E., Yen, S., Mangubhai, S., & Mous, P.J. 2010. An ounce of prevention: cost-effectiveness of coral reef rehabilitation relative to enforcement. *Conservation Letters* 3(4):243-250.
- Halpern, B.S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications* 13(1):117-137.
- Harrison, P.L. & Wallace, C.C. 1990. Reproduction, dispersal and recruitment of scleractinian corals. In: Dubinsky, Z. (ed.), *Coral Reefs Ecosystems of the World* 25. Elsevier, Amsterdam. Pp. 133-207.
- Holling, C.S. 1973. Resilience and stability of ecological systems. *Annual Reviews of Ecology and Systematics* 4:1-23.
- Houlbrèque, F. & Ferrier-Pagès, C. 2009. Heterotrophy in tropical scleractinian corals. *Biological Reviews* 84:1-17.
- Hughes, T.P. & Jackson, J.B.C. 1985. Population Dynamics and Life Histories of Foliose Corals. *Ecological Monographs* 55(2):141-166.
- Hughes, T.P., Bellwood, D.R., Folke, C., Steneck, R.S. & Wilson, J. 2005. New paradigms for supporting the resilience of marine ecosystems. *Trends in Ecology and Evolution* 20:380–386.
- Hughes, T.P., Graham, N.A.J., Jackson, J.B.C, Mumby, P.J. & Steneck, R.S. 2010. Rising to the challenge of sustaining coral reef resilience. *Trends in Ecology and Evolution* 25(11):633-642.

- Ikiara, M.M. & Odink, J.G. 1999. Fishermen resistance to exit fisheries. *Marine Resource Economics* 14(3):199-214.
- Jones, G.P., Srinivasan, M. & Almany, G.R. 2007. Population connectivity and conservation of marine biodiversity. *Oceanography* 20(3):12.
- Kramarsky-Winter, E., Fine, M. & Loya, Y. 1997. Coral polyp expulsion. *Nature* 387:137.
- Lang, J.C. & Chornesky, E.A. 1990. Competition between scleractinian reef recorals. In: Dubinsky, Z. (ed.), *Coral Reefs Ecosystems of the World* 25. Elsevier, Amsterdam. Pp. 209-252.
- Lewis, J.B. & Price, W.S. 1975. Feeding mechanisms and feeding strategies of Atlantic reef corals. *Journal of Zoology: Proceedings of the Zoological Society of London* 176:527-544.
- Lieber, M.D. 1994. *More than a living: fishing and the social order on a Polynesian atoll*. Westview Press Inc, USA. 235 pp.
- Lugo-Fernández, A., Deslarzes, K.J.P., Price, J.M., Boland, G.S. & Morin, M.V. 2001. Inferring probable dispersal of Flower Garden Banks Coral Larvae (Gulf of Mexico) using observed and simulated drifter trajectories. *Continental Shelf Research* 21(1):47-67.
- McCook L.J., Jompa J. & Diaz-Pulido G. 2001. Competition between corals and algae on coral reefs: a review of evidence and mechanisms. *Coral Reefs* 19:400-417.
- Muscatine, L. & Porter, J.W. 1977. Reef corals: mutualistic symbioses adapted to nutrient-poor environments. *Bioscience* 27:454-460.
- Ng C.S.L., Toh, T.C., Toh, K.B., Guest, J. & Chou, L.M. 2013. Dietary habits of grazers influence their suitability as biological controls of fouling macroalgae in *ex situ* mariculture. *Aquaculture Research* DOI: 10.1111/are12128.
- Nozawa, Y. & Harrison, P.L. 2002. Larval settlement patterns, dispersal potential, and the effect of temperature on settlement of larvae of the reef coral, *Platygyra daedalea*, from the Great Barrier Reef. *Proceedings of the 9th International Coral Reef Symposium* 1: 409-415.
- Omori, M., Iwao, K., & Tamura, M. 2008. Growth of transplanted *Acropora tenuis* 2 years after egg culture. *Coral Reefs* 27:165.
- Pandolfi, J.M., Possingham, H.P., Sala, E., Jackson, J.B.C., Baron, N., Bradbury, R.H., Guzman, H.M., Hughes, T.P., Kappel, C.V., Micheli, F. & Ogden, J.C. 2005. Are U.S. Coral reefs on the slippery slope to slime? *Science* 307:1725-1726.
- Perkol-Finkel, S., & Airoidi, L. 2010. Loss and recovery potential of marine habitats: an experimental study of factors maintaining resilience in subtidal algal forests at the Adriatic Sea. *PLoS one* 5(5):e10791.

Petersen, D., Wietheger A. & Laterveer, M. 2008. Influence of different food sources on the initial development of sexual recruits of reef building corals in aquaculture. *Aquaculture* 277: 174-178.

Piniak, G.A. 2002. Effects of symbiotic status, flow speed, and prey type on prey capture by the facultatively symbiotic temperate coral *Oculina arbuscula*. *Marine Biology* 141:449-455.

Price, R. 1966. Caribbean fishing and fishermen: A historical sketch. *American Anthropologist* 68(6):1363-1383.

Qiu, W., Wang, B., Jones, P. J. & Axmacher, J. C. 2009. Challenges in developing China's marine protected area system. *Marine Policy* 33(4):599-605.

Raymundo, L.J., Maypa, A.P., Gomez, E.D. & Cadiz, P. 2007. Can dynamite-blasted reefs recover? A novel, low-tech approach to stimulating natural recovery in fish and coral populations. *Marine Pollution Bulletin* 54:1009-1019.

Richmond, R.H. 1997. Reproduction and recruitment in corals: critical links in the persistence of reefs. In Birkeland, C. (ed.), *Life and death of coral reefs*. Chapman & Hall, New York, USA. Pp. 175-197.

Rinkevich, B., 1995. Restoration strategies for coral reefs damaged by recreational activities - the use of sexual and asexual recruits. *Restoration Ecology* 3(4):241-251.

Roberts, C., Halpern, B., Palumbi, S., Warner, R. 2001. Designing marine reserve networks: Why small, isolated protected areas are not enough. *Conservation* 2(3): 10-17.

Sammarco, P.W. 1982. Polyp bail-out: an escape response to environmental stress and a new means of reproduction in corals. *Marine Ecology Progress Series* 10:57-65.

Sammarco, P.W. 1986. Coral reproduction, dispersal, and survival. *Oceanus* 29(2):28-19.

Sebens, K.P. & Johnson, A.S. 1991. Effects of water movement on prey capture and distribution of reef corals. *Hydrobiologia* 226:91-101.

Sebens, K.P., Witting, J. & Helmuth, B. 1997. Effects of water flow and branch spacing on particle capture by the reef coral *Madracis mirabilis* (Duchassaing and Michelotti). *Journal of Experimental Marine Biology and Ecology* 211:1-28.

Shafir, S., Van Rijn, J. & Rinkevich, B. 2006. Steps in the construction of underwater coral nursery, an essential component in reef restoration acts. *Marine Biology* 149:679-687.

Spurgeon, J.P.G. & Lindahl, U. 2000. Economics of coral reefrestoration. In: Cesar, H.S.J (ed.), *Collected essays on the economics of coral reefs*. CORDIO, Sweden. Pp.125-136.

Spurgeon, J.P.G. 2001. Improving the economic effectiveness of coral reef restoration. *Bulletin of Marine Science* 69(2):1031-1045.

Stoddart, J.A. 1986. Coral genetics: new directions. *Oceanus* 29(2): 41.

Szmant, A.M. & Meadows, M.G. 2006. Developmental changes in coral larval buoyancy and vertical swimming behavior: implications for dispersal and connectivity. *Proceedings of the 10th International Coral Reef Symposium* 1: 431-437.

Tanner, J.E. 1995. Competition between scleractinian corals and macroalgae: An experimental investigation of coral growth, survival and reproduction. *Journal of Experimental Marine Biology and Ecology* 190:151-168.

Tay, Y.C., Guest, J.R., Chou, L.M. & Todd, P.A. 2011. Vertical distribution and settlement competencies in broadcast spawning coral larvae: Implications for dispersal models. *Journal of Experimental Marine Biology and Ecology* 409:324-330.

Toh, T.C., Ng, C.S.L., Guest, J.R. & Chou, L.M. (In review). Grazers improve health of coral juveniles in *ex situ* mariculture.

Toh, T.C., Guest, J.R. & Chou, L.M. 2012. Coral larval rearing in Singapore: Observations on spawning timing, larval development and settlement of two common scleractinian coral species. In: Tan, K.S. (ed.), *Contributions to Marine Science*. National University of Singapore, Republic of Singapore. Pp. 81-87.

Toh, T.C. & Chou, L.M. 2013. Aggregated settlement of *Pocillopora damicornis* planulae facilitates coral wound healing. *Bulletin of Marine Science* 89(2):583-584.

Toh, T.C., Peh, J.W.K & Chou, L.M. 2013. Early onset of zooplanktivory in equatorial reef coral recruits. *Marine Biodiversity* DOI:10.1007/s12526-013-0156-5.

Turner, S.J., Thrush, S.F., Hewitt, J.E., Cummings, V.J., & Funnell, G. 1999. Fishing impacts and the degradation or loss of habitat structure. *Fisheries Management and Ecology* 6(5):401-420.

Villanueva, R.D., Edwards, A.J. & Bell, J.D. 2010. Enhancement of grazing gastropod populations as a coral reef restoration tool: predation effects and related applied implications. *Restoration Ecology* 18(6), 803-809.

Yap, H.T., Alino, P.M. & Gomez, E.D. 1992. Trends in growth and mortality of three coral species (Anthozoa: Scleractinia), including effects of transplantation. *Marine Ecology Progress Series* 83: 91-101.

Current Status of Coral Reef Restoration in Singapore

Chin Soon Lionel Ng, Tai Chong Toh, Loke Ming Chou

National University of Singapore, Singapore

0574

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Since the mid-1960s, Singapore's coral reefs have been impacted by a variety of anthropogenic disturbances such as coastal development, land reclamation and seabed dredging. Up to 60% of reefs have since been lost, and the remaining ones are more compact and shallow due to chronic sedimentation and unstable bottom rubble that is easily moved about by currents. Since the late 1980s, various attempts at restoring and rehabilitating Singapore's reefs were initiated and an appraisal of these efforts is timely. We reviewed these reef restoration experiences and synthesized the lessons that are useful for future restoration strategies. The restoration approaches to date broadly include: mitigation measures, substrate modification, optimising methods for rearing scleractinian larvae, use of fragments and corals of opportunity (i.e. naturally fragmented corals and coral juveniles that have recruited on loose rubble) in *in situ* and *ex situ* coral nurseries, as well as transplantation of nursery-reared coral juveniles and fragments to degraded reefs and seawalls. The *El Niño* event in 2010 elevated sea surface temperatures and caused widespread bleaching of hard corals, which affected reef restoration efforts. However, the episode offered insights into the bleaching susceptibility of certain species as well as their suitability for rearing in nurseries and transplantation to other environments. The results from the various projects underscored the need to incorporate adaptive and flexible management strategies in reef restoration and the experience can be applied to future reef restoration to improve success.

Introduction

Coral reefs are one of the world's richest and most biologically diverse ecosystems. They provide food, shelter and nursery grounds for a wide range of marine organisms – such as over 800 species of scleractinian corals and 4000 species of reef fish – and also supply various resources (e.g. seafood, pharmaceuticals, aquarium trade, tourism) and ecological services (e.g. coastal protection, carbon sequestration) (Moberg & Falke 1999; Burke et al 2011). These ecosystem goods and services have been estimated at a staggering US\$375 billion annually (Costanza et al 1997). Coral reefs are thus critical to 40% of the global population who reside within 100 km of coasts, and even more so for some 275 million people living 30 km from the reefs (Burke et al 2011).

However, coral reefs are in a rapid state of decline as a consequence of anthropogenic activities – 19% have since been lost and up to 75% are imperilled by local and global threats (Wilkinson 2008; Burke et al 2011). Destructive fishing practices, coastal development and watershed pollution comprise the majority of local threats, while global factors such as climate change and ocean acidification are mounting stressors that endanger the future of reefs (Burke et al 2011). While reef restoration is deemed a poor substitute to habitat conservation, the former is increasingly employed as an active intervention method to assist in the rehabilitation of damaged reefs, because leaving the reefs to recover by themselves may be too slow and ineffective. Various techniques have since been attempted, ranging from stabilising the substrate, deploying artificial reef structures, establishing nurseries to rear sexual and asexual coral recruits, and transplanting coral material to target localities (e.g. Clark & Edwards 1995; Rinkevich 2005; Raymundo et al 2007; Edwards 2010).

Singapore's marine environment

Singapore is one of the world's busiest shipping hubs, with 80% of its territorial waters managed as port waters and the remainder utilised by sectors ranging from the military, petrochemical industries, aquaculture, to recreation (Chou 2008). To cater to the various demands arising from rapid development and population growth, extensive coastal development has been carried out since the 1960s. Much of the southern and north-eastern coasts of the mainland, as well as the southern offshore islands, have been reclaimed, and total land area has increased by more than 20% (Chou 2008). Coastal defence infrastructures such as seawalls are also ubiquitous, comprising more than 60% of the country's coastlines (Lai WYS, pers. comms.). Based on projections by the Singapore government, land area is expected to increase from the current 71000 hectares to 76600 hectares by the year 2030 (Ministry of National Development 2013).

As a result of the extensive coastal development, land reclamation and regular dredging of shipping channels over the past 50 years, Singapore's coral reefs, mainly located at the fringes of the southern offshore islands, are severely impacted by habitat loss and degradation. The present reef area at 13.25 km² is much reduced from an estimated 39.85 km² in 1953, with decreases in intertidal and subtidal coral reef areas by over 61% and 89% respectively since 1953 (Tun 2012a). Further decline in reef area is expected due to the proposed reclamation to meet land use demands by the year 2030 (Ministry of National Development 2013). In addition to direct habitat loss, high sediment loads are a major contributor to reef degradation. Sedimentation rates

measured off the southern offshore islands have indicated levels as high as 44.64 mg/cm²/day (Low & Chou 1994), smothering corals and increasing coral mortality. The high sedimentation rates also attenuated light in the water column and resulted in underwater visibilities of 2-3 m in the past decade compared to 10 m in the early 1960s (Fig. 1a; Chou 1996). The drastic reduction of light required for corals to photosynthesise resulted in the reefs compacting to shallower depths (Chou & Tun 2012). Many parts of the reef substrata have also degraded, becoming fragmented and unconsolidated especially on the reef slopes where loose rubble is frequently shifted about by currents (Fig. 1b; Chou & Tun 2012).

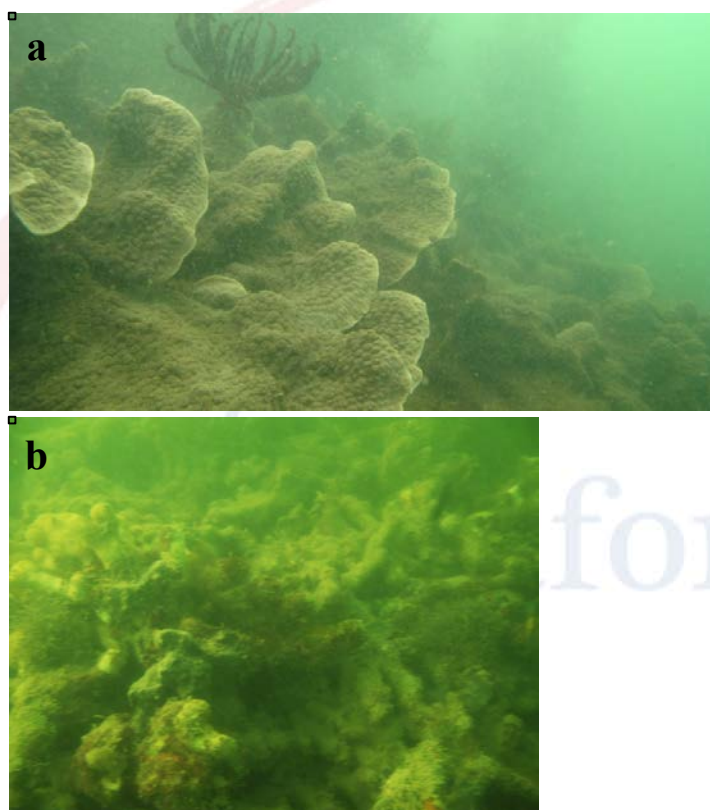


Fig. 1. Coral reef establishment in Singapore is limited by low light due to the high sedimentation (a), and loose, unstable substrate (b). Photo credits: Ng CSL.

Nevertheless, from recent species distribution assessments, Singapore reefs host 255 hard coral species which is approximately one-third of the world scleractinian diversity (Huang et al 2009), in part due to the annual coral mass spawning events that contribute to the seeding of local reefs (Guest et al 2005; Tay et al 2012). Yearly monitoring of the mass spawning events conducted by local researchers also indicated that coral larval sources are not limiting (Tun 2012b). However, coral larvae end up recruiting on loose rubble or unstable substrate, thereby affecting their post-settlement survival rates (Fox 2004).

There is thus a need to explore approaches to circumvent the problems of high sediment loads and unconsolidated substrate, in addition to promoting coral establishment in reef areas that are degraded or destroyed by coastal development.

The plethora of reef restoration projects that has been attempted in Singapore varied in scale and design, and can be broadly categorised as the following: mitigation, substrate modification, coral nurseries, and transplantation. Two decades after the initial reef restoration projects, it is now opportune to examine the effectiveness of these approaches. In this paper, we review the literature on Singapore's reef restoration experiences and synthesise the knowledge acquired. This will help shape future reef restoration strategies and will be relevant to localities with similar environmental conditions.

Mitigation

One of the earliest attempts at reef restoration was mitigation, which involved restitution procedures to compensate for reef habitats facing impending loss or damage (Edwards 2010). Coral colonies or fragments are removed from areas primed for coastal development ('donor sites') and transplanted to secure locations ('recipient sites') where they could establish themselves and continue to grow. This was a management response popularly employed in the coastal waters of the South China Sea by both government and non-government agencies (Chou et al 2009). In Singapore, this entailed the relocation of entire coral colonies away from sites destined for land reclamation. Two such exercises, Reef Rescue 1 and Reef Rescue 2, were conducted by volunteers of the Nature Society Singapore (a local NGO) in 1991 and 1993 (Chou & Tun 1997). As Buran Darat and Pulau Ayer Chawan were to be reclaimed, large coral colonies of various genera and growth forms as well as other reef invertebrates were collected from these areas and placed in large tubs of seawater, then transported to nearby Sentosa Island where they were transferred into containers and brought to the recipient site by divers and snorkelers. However, the recipient site was a shallow area (3-4 m depth at mean spring tides) that was constantly subjected to surge from high-speed vessels and high sedimentation from the nearby reclamation works, and as the coral colonies were merely wedged between boulders without the use of adhesives or ropes, they were easily dislodged by wave action. On subsequent surveys, many colonies were overturned and overgrown with algae. As a result, less than 11% of the transplants survived (Chou et al 2009).

Important lessons which helped shape future coral transplantation efforts were learnt, i.e. recipient sites in Singapore waters are best positioned 3-6 m deep to reduce fouling by macroalga which commonly occurs at shallower depths; transplants should be secured adequately to the recipient sites with adhesives to facilitate growth and survival; and massive and encrusting corals can survive relocation better (Chou & Tun 1997). With the commissioning of more relocation projects in the mid-2000s, scientific groups and environmental consultancies have since learnt from the mistakes of the earlier volunteer-led efforts and improved on their coral relocation strategies.

Substrate modification

An unstable reef substrate leads to current-induced abrasion and the burial of coral recruits, and is thus detrimental to the post-settlement survivorship of corals (Fox 2004). Consequently, substrate stabilization and modification was introduced as a means to facilitate coral establishment. One of the approaches was to provide stable recruitment surfaces in the form of artificial reefs to increase opportunities for coral recruitment. In 1989, precast hollow concrete modules and pyramids assembled from disused rubber tyres were deployed at depths of 15 m on a patch reef near Pulau

Hantu (Fig. 2a, 2b; Tan et al 2010), acting primarily as fish aggregating devices. Fish abundance and diversity increased around the artificial reefs within 1½ years with large fish preferring the concrete modules and small juveniles favouring the tyre-pyramids, as the latter contained crevices suitable for small fish to take refuge in (Chua & Chou 1994). Diversity and abundance of the fish communities reached equilibrium over seven years (Tan et al 2010). Interestingly, the encrusting assemblages growing on the concrete frames were more diverse than those on the tyre-pyramids. Soft corals recruited on the concrete modules, but on the tyres, hydroids and sponges were the dominant colonisers (Han et al 1994). For the purposes of reef restoration, concrete was found to be a more suitable material than rubber, possibly as processed rubber was more toxic and concrete was a more stable substrate (Han et al 1994). The depth of artificial reef installation is also an important consideration, especially since light penetration is reduced and scleractinian coral growth is restricted to the shallows in Singapore waters.

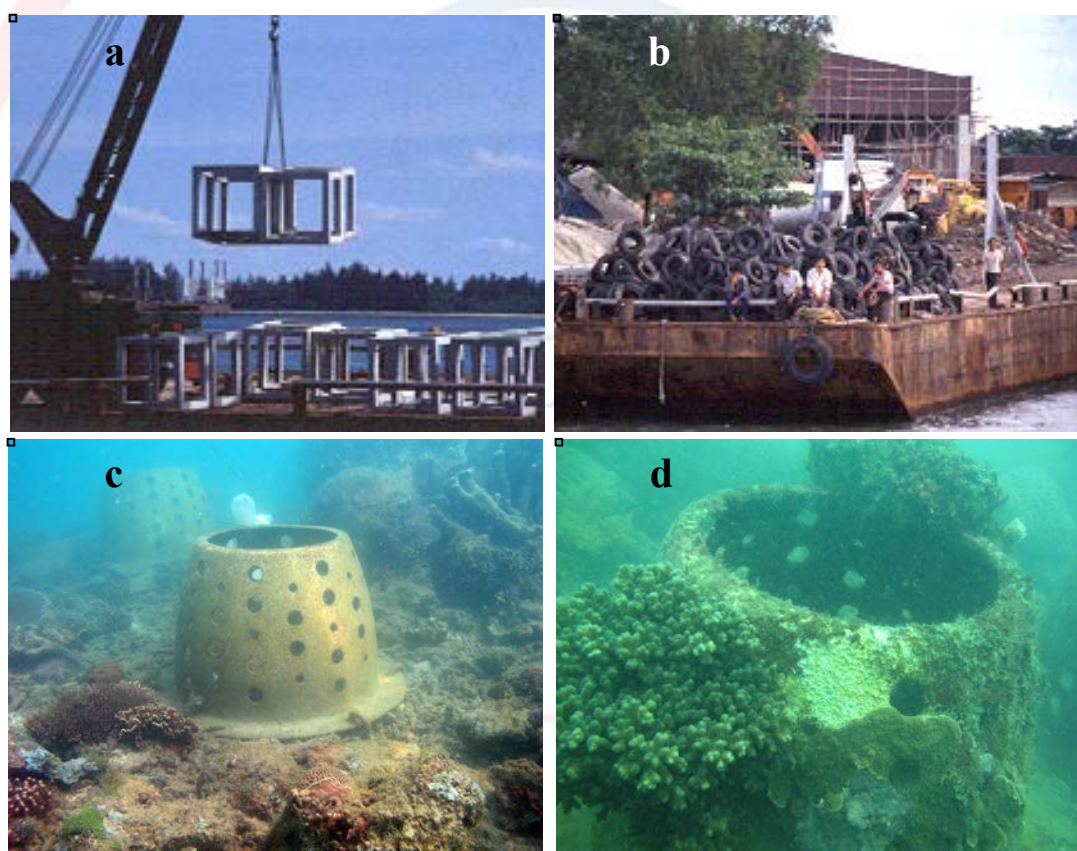


Fig. 2. Artificial reefs in Singapore. Deployment of concrete modules (a) and tyre-pyramids (b) with the use of barges; newly deployed Reef Enhancement Units in 2003 (c); Reef Enhancement Unit in 2013 (d). Photo credits: Reef Ecology Study Team (a, b, c), Ng CSL (d).

A decade after the first artificial reefs were established in Singapore, Loh et al (2006) observed that installing the concrete modules and tyre-pyramids required the use of barges, which were potentially destructive and inefficient if used in shallow areas where artificial reefs are recommended to be sited. Fibreglass modules known as Reef Enhancement Units (REUs) were fabricated and they were light enough to be stabilized at exact locations by SCUBA divers to prevent any unintended damage to other reef organisms (Fig. 2c, 2d). The steep sloping surfaces of the REU precluded

sediment accumulation and the perforated sides facilitated water movement through the structure. The modules were anchored securely by stakes to bare patches on the reefs at St John's Island and Pulau Satumu. Within six months, they were readily colonised by crustose coralline algae, which are able to enhance the settlement and metamorphosis of marine larvae and inhibit the growth of other alga which can be detrimental to corals (Johnson & Mann 1986; Morse et al 1996). Corals which recruited on the REUs exhibited better survival and growth compared to those on adjacent rubble areas and the cavity within the REU also functioned as shelter for reef fish. The study demonstrated that fibreglass was a suitable material for supporting marine life. The relatively lower costs of installing the simple and lightweight REUs (at US\$153 per module including six stakes) compared to deploying barges to do the same for large concrete frames allows for large-scale installation of these units where necessary.

In situ coral nurseries

Coral nurseries play important roles by acting as reserves, or 'genetic repositories' that preserve the diversity of reefs that are facing impending obliteration (Schopmeyer et al 2012). Comprising *in situ* and *ex situ* versions, nurseries serve to protect coral propagules in a sheltered environment until they reach a suitable size, so that their chances of surviving are increased before they are eventually used to supplement transplantation on degraded reefs (Epstein et al 2003; Rinkevich 2005). To date, scientists in Singapore have experimented with the use of both *in situ* and *ex situ* coral nurseries to augment the amount of coral material that can be used for transplantation.

In 2004, researchers from Singapore and Italy collaborated as part of a European Commission project to explore reef restoration techniques that would be applicable across the region (Chou 2011). The researchers built two *in situ* coral nurseries comprising tables made of PVC pipes and angle bars on the reef slopes of St John's and Lazarus Islands. Over 2900 small fragments (known as nubbins) from 13 hard coral species were adhered to plastic pins and reared on trays made from PVC pipes and plastic mesh (Bongiorni et al 2011). Initial mortality rates were high (66%) due to detachment, smothering by sediment and heavy fouling. However, the nubbins that survived had overall high growth rates and coral species which fared the best in the nursery were *Acropora millepora*, *Porites sillimani* and *P. lutea*. The results indicated that this *in situ* 'gardening' approach was viable in environments chronically impacted by high sediment loads.

Corals of opportunity ('COP') are naturally occurring fragments or corals which have recruited on loose rubble – these are common on Singapore's reefs and would otherwise have a low chance of survival in an environment of high sedimentation and low substrate consolidation. Combining scientific expertise from researchers at the National University of Singapore, funding from the private sector (Keppel Corporation) and support from government bodies (the National Parks Board and the National Environment Agency), an *in situ* nursery was established in 2007 at Pulau Semakau using COP as the source material (Chou 2009) (Fig. 3a). Over 600 fragments and juvenile COP from 36 genera were collected from various reefs and secured on elevated mesh frames which were designed to facilitate sediment falling through. Volunteer divers from the public were trained by the researchers and helped with maintenance and monitoring work at the nursery. Appreciable survivorship and growth of the COP were recorded over the course of the project, e.g. survivorship of

juvenile COP of *Pectinia paeonia* and *Pachyseris speciosa* were 93% and 69.6% respectively. The results showed that COP could function as a suitable source of coral material for stocking nurseries, and demonstrated the feasibility of such an intervention method to improve the fate of the COP (Chou 2009; Ng & Chou 2013, in review).

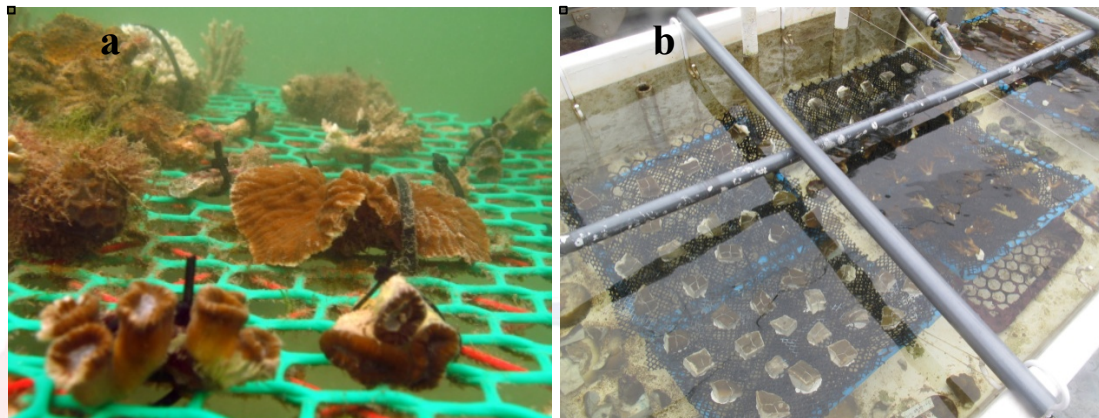


Fig. 3. ‘Corals of opportunity’ fragments secured on an *in situ* coral nursery frame with cable ties (a), and coral fragments reared in tanks at a mariculture facility which served as an *ex situ* nursery (b). Photo credits: Seow LA (a), Ng CSL (b).

Ex situ coral nurseries

Ex situ coral nurseries are sited on land and are considered short-term alternatives before the coral material is relocated to *in situ* nurseries or transplanted to reefs (Epstein et al 2003). While they are more expensive to run than *in situ* nurseries and are thus only operated on a small scale, they are nevertheless useful for preserving genotypes from reefs that face uncertain fates or where there are constraints in coral material (Epstein et al 2001). The Tropical Marine Science Institute’s mariculture facility on St John’s Island that supplied flow-through, sand-filtered seawater functioned as an effective *ex situ* nursery for the rearing of coral fragments, and facilitated the measurement of parameters indicative of coral health (Fig. 3b). After 12 weeks, *Porites lutea* and *Psammocora digitifera* fragments survived better than those of *Acropora digitifera* (100% and 98.9% versus 5.7%, respectively) (Ng et al 2012a). Additionally, fragments of 19 common hard coral species required between four to 12 weeks of *ex situ* rearing before they grew over the cement substrates and were thus less likely to detach if they were to be transplanted (Ng et al 2012a). Such information will be useful in estimating *ex situ* rearing times of fragments in future restoration efforts.

The St John’s Island mariculture facility also provided a relatively controlled environment which minimised the effects of stressors such as chronic sedimentation in Singapore’s waters. This was critical to facilitating the rearing of coral larvae and juveniles which required an extremely clean *ex situ* environment to enhance post-settlement survivorship. Early work on coral sexual propagation was initiated by marine biologists in the Philippines, from which Singaporean researchers learnt the relevant techniques and incorporated them to larval rearing efforts at the St John’s Island mariculture facility to supplement restoration projects. The emphasis to date

has been on basic coral larval biology. Researchers have elucidated developmental patterns of the common coral species (Toh et al 2012a; Toh & Chou 2013; Toh et al 2013a), enabling them to focus on improving the survivorship of newly recruited corals in an *ex situ* setting. Additionally, Tay et al (2011; 2012) modelled the dispersal patterns of coral larvae and demonstrated the close connectedness of reefs in the region.

Additionally, as with *in situ* nurseries, algal fouling often compromised the health of the reared corals. Researchers experimented with the use of herbivorous sea urchins and top-shell snails as biological controls and proposed less cost- and labour-intensive solutions to effectively manage the problem of fouling (Ng et al 2013b). Toh et al (2013b; in review) were also able to improve the *ex situ* rearing of juvenile corals by co-rearing them with the sea urchins and snails. In the presence of the biological controls, the juvenile corals had larger colony sizes, faster growth rates and deeper colouration.

Transplantation

Along with improvements in the scale and techniques of rearing corals in nurseries, researchers have focused on transplanting both asexually- and sexually-propagated coral material to rehabilitate Singapore's marine environment in recent years. With seawalls currently lining more than 60% of the country's shores (Lai WYS, pers. comms.), one project explored the feasibility of introducing marine life onto these coastal defence structures (Gunasingham 2009; Ng 2011). Hard coral, soft coral and sponge fragments were reared at the *ex situ* nursery at St John's Island and transplanted onto seawalls at Pulau Tekong and St John's Island using marine epoxy (Fig. 4a). As the seawalls were constantly exposed to strong wave forces and impacts from floating debris, transplants that were able to encrust quickly and hence self-attach securely over the granite rock substrates fared better in terms of growth and survivorship (Ng et al, in prep).

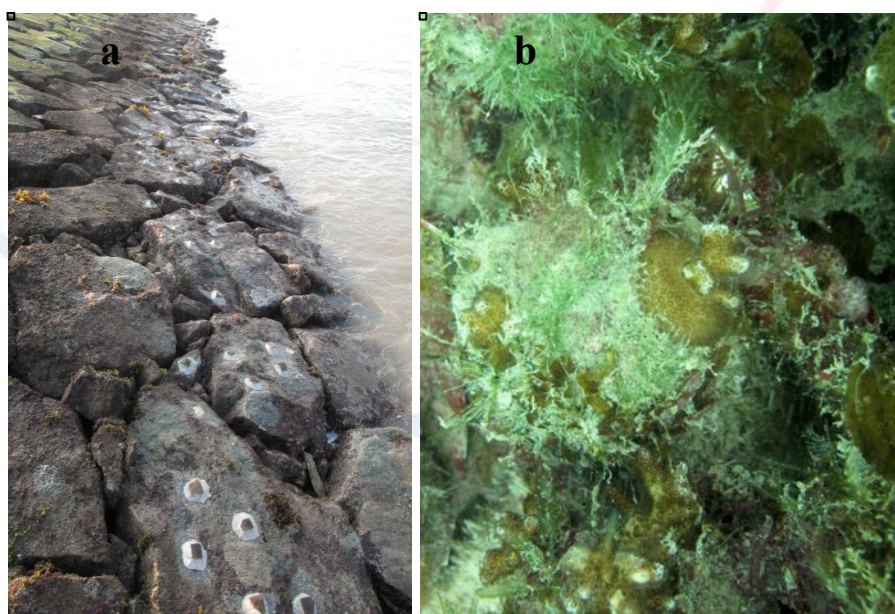


Fig. 4. Coral fragments newly transplanted onto a seawall using marine epoxy (a), and sexually propagated juvenile coral transplanted onto a reef (b) in Singapore. Photo credits: Ng CSL

Corals were also attached to intermediate substrates to facilitate transplantation to impacted reefs. A “plug-in”, consisting of a wall plug embedded in a cement mortar hemisphere, was designed to allow coral larvae to settle and grow. After a period of *ex situ* rearing, the juvenile corals were then transplanted by inserting the plug-ins into holes drilled into the reef substrate (Fig. 4b). Marine epoxy was used to further secure the plugin and prevent it from detaching. The use of the plugin minimised direct contact with the juvenile corals, which are especially vulnerable to mechanical stress, and was thus a practical way of rearing and handling sexually propagated corals. Detachment rates of the juvenile corals in sites of high wave energy have since significantly reduced to 2% with the employment of the plugins. Survivorship of the corals three months after transplantation has also been maintained at approximately 80% (Toh et al, in prep).

Effects of mass bleaching event on reef restoration efforts in Singapore

In 1998, sea surface temperatures (SSTs) rose up to 2°C above the average monthly readings for up to three months, causing unprecedented widespread bleaching on Singapore’s coral reefs (Toh et al 2012b). Over 90% of corals bleached – 20% of which did not recover as conditions normalised (Chou et al 2012). A large-scale bleaching event occurred again in 2010 in response to a rise in SSTs (Guest et al 2012). Up to 10% of scleractinian corals died, but 80% of the bleached hard corals recovered in four months, followed by close to full recovery in six months (Chou & Tun 2012). There was an apparent reversal in bleaching susceptibility patterns, as coral genera which were severely impacted in 1998, were not as affected in 2010, and vice versa (Guest et al 2012).

The consequences of the 2010 mass bleaching were more acutely felt with the initiation of more reef restoration projects at the turn of the century. At the mariculture facility at St John’s Island where the *ex situ* rearing of coral fragments was underway, temperatures in the tanks were as high as 31°C in May 2010, similar to that recorded on the reefs (Ng CSL, unpublished data). Adaptive measures to reduce the thermal stresses imposed on the corals included increasing the water flow in the tanks to prevent overheating and providing shade nets to reduce excessive solar irradiation. Monitoring frequencies were increased and a range of responses was observed across the coral genera: those that rapidly succumbed and died from the thermal stress (e.g. *Pocillopora* sp.), those that bleached but showed full recovery in six months (e.g. *Psammocora* sp. and members of the family Faviidae), and those that exhibited little or no bleaching (e.g. *Acropora* sp. and *Goniopora* sp.). The settlement patterns of coral larvae in the *ex situ* nursery varied as well, with greater settlement percentages recorded for larvae derived in April 2010 (~80%) compared to April 2011 (~30%) for one of Singapore’s commonest species, *Pectinia lactuca* (Toh TC, unpublished data).

At the *in situ* coral nursery in Pulau Semakau, coral bleaching trends were similar to those reported for the natural reefs (see Guest et al 2012). Fifty percent of COP bleached, but 60% of these recovered; in addition, unlike fragments of other species, those of *Acropora* sp. – a group of corals considered highly vulnerable to stressors – did not bleach (Tong HYC, pers. comms.). Coral fragments transplanted on the seawall at Pulau Tekong started bleaching in May 2010, accompanied by a decrease in live coral tissue. All *Pocillopora damicornis* and *Hydnophora exesa* fragments bleached and died by July 2010, but nearly half of *Porites lobata* fragments survived

the bleaching event and proceeded to grow over the granite rock substrate in the months that followed (Ng CSL, unpublished data).

With reference to the nursery-reared corals and transplants, it is clear that the effects of global stressors such as the 2010 mass bleaching episode can be wide-ranging. In light of increasing climatic variability, the importance of close monitoring and adaptive management measures to safeguard the coral material intended for reef restoration is further underscored. This will allow actions to be taken to remediate any potential damages that may occur.

Conclusions

The various approaches and techniques that have been tested have provided useful lessons to reef restoration practitioners and these experiences will help define upcoming restoration efforts. The results thus far have indicated that restoration is feasible in a marine environment as challenging as Singapore's, and that the methods used will be applicable to locations that experience similar conditions of high sediment load and unconsolidated rubble. There remains an urgent need to explore ways of reducing degradation and enhancing coral establishment on Singapore's reefs. For example, coral larval dispersion modeling and reef connectivity studies such as those by Tay et al (2011; 2012) will help in prioritizing sites for restoration.

It is, however, encouraging that the public and the government agencies appear to be more conscious of the natural environment. This is apparent from observations that environmental impact assessments (EIAs) are more common before the commencement of major developmental work, even though EIAs are not mandatory by law (Chou 2008). Mitigation procedures (e.g. coral relocation exercises) are also increasingly conducted before development projects begin. It is increasingly important to continue to explore various avenues of educating the local community and the authorities to facilitate coral reef conservation efforts. As demonstrated by the *in situ* coral nursery project at Pulau Semakau, articles published in the local media (e.g. Kesava 2007) are a useful way of raising awareness.

Acknowledgements

We would like to thank past and present members of the Reef Ecology Study Team (National University of Singapore) as well as staff of the NUS Tropical Marine Science Institute St John's Island Marine Laboratory for their generous assistance with the reef restoration projects undertaken to date. This study was supported by grant number R-154-000-557-490 from the National Parks Board, Singapore,

References

- Bongiorni L, D Giovanelli, B Rinkevich, A Pusceddu, LM Chou & R Danovaro. 2011. First step in the restoration of a highly degraded coral reef (Singapore) by *in situ* coral intensive farming. *Aquaculture*, 322–323: 191–200.
- Burke L, K Reytar, M Spalding & A Perry. 2011. *Reefs at Risk Revisited*. World Resources Institute, Washington DC. 114pp.
- Chou LM & K Tun. 2012. Status and challenges of coral reef monitoring in East Asia: Singapore. 8th ICRI East Asia Regional Workshop, 3-5th September 2012, Jeju, Republic of Korea.

Chou LM & KPP Tun. 1997. Coral transplantation as a reef conservation tool – the Singapore experience. PACON 97 Proceedings. PACON International, Hawaii. 12pp.

Chou LM, KB Toh, YC Tay & VXH Phang. 2012. Coral reefs in Singapore: past, present and future. The Asian Conference on Sustainability, Energy and the Environment Official Conference Proceedings 2012, p.431-436.

Chou LM, T Yeemin, BGY Abdul Rahim, ST Vo, P Alino & Suharsono. 2009. Coral reef restoration in the South China Sea. *Galaxea, Journal of Coral Reef Studies* 11: 67-74.

Chou LM. 1996. Response of Singapore reefs to land reclamation. *Galaxea, Journal of Coral Reef Studies* 13: 85–92.

Chou LM. 2008. Nature and sustainability of the marine environment. In: Wong TC, BKP Yuen & C Goldblum (eds.), *Spatial Planning for a Sustainable Singapore*, Springer, Netherlands, p169-182.

Chou LM. 2011. Southeast Asia's coral reef biodiversity: can restoration reverse the loss? *Innovation* 10(1): 36-39.

Chua CYY & LM Chou. 1994. The use of artificial reefs in enhancing fish communities in Singapore. *Hydrobiologia* 285: 177-187.

Clark S & AJ Edwards. 1995. Coral transplantation as an aid to reef rehabilitation: evaluation of a case study in the Maldiv Islands. *Coral Reefs* 14: 201-213.

Costanza R, R d'Arge, R de Groot, S Farber, M Grasso, B Hannon, K Limburg, S Naeem, RV O'Neill, J Paruelo, RG Raskin, P Sutton & M van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253-260.

Edwards A. 2010. Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program, St. Lucia. 166pp.

Epstein N, RPM Bak & B Rinkevich. 2001. Strategies for gardening denuded coral reef areas: the applicability of using different types of coral material for reef restoration. *Restoration Ecology* 9(4): 432-442.

Epstein N, RPM Bak & B Rinkevich. 2003. Applying forest restoration principles to coral reef rehabilitation. *Aquatic Conservation: Marine and Freshwater Ecosystems* 13: 387-395.

Fox HE. 2004. Coral recruitment in blasted and unblasted sites in Indonesia: assessing rehabilitation potential. *Marine Ecology Progress Series* 269:131-139.

Guest JR, AH Baird, BPL Goh & LM Chou, 2005. Reproductive seasonality in an equatorial assemblage of scleractinian corals. *Coral Reefs* 24: 112-116

Guest JR, AH Baird, JA Maynard, E Muttaqin, AJ Edwards, SJ Campbell, K Yewdall, YA Affendi & LM Chou. 2012. Contrasting patterns of coral bleaching susceptibility in 2010 suggest an adaptive response to thermal stress. *Plos One* 7(3) e33353.

Gunasingham A. 2009. Towards a marine paradise. *The Straits Times* (4 July 2009).

Han EJS, JKL Low & LM Chou. 1994. Recruitment of scleractinian coral juveniles and other sessile organisms on artificial substrata. Proceedings, Science Research Congress 1994, Singapore, p229-234.

Huang D, KPP Tun, LM Chou & PA Todd. 2009. An inventory of zooxanthellate scleractinian corals in Singapore, including 33 new records. The Raffles Bulletin of Zoology, Supplement No. 22: 69-80.

Johnson CR & KH Mann. 1986. The crustose coralline alga, *Phymatolithon Foslie*, inhibits the overgrowth of seaweeds without relying on herbivores. Journal of Experimental Marine Biology and Ecology 96, 127–146.

Kesava S. 2007. Coral nursery for garbage island. The Straits Times (31 July 2007).

Loh, T–L, JTI Tanzil & LM Chou, 2006. Preliminary study of community development and scleractinian recruitment on fibreglass artificial reef units in the sedimented waters of Singapore. Aquatic Conservation: Marine and Freshwater Ecosystems, 16: 61-76.

Low JKY & LM Chou. 1994. Sedimentation rates in Singapore waters. In: Sudara S, CR Wilkinson & LM Chou (eds.). Proceedings, Third ASEAN-Australia Symposium on Living Coastal Resources, Vol. 2: Research Papers. Chulalongkorn University, Bangkok, Thailand, p697-701.

Ministry of National Development 2013. Our Land Use Plan. <<http://www.mnd.gov.sg/landuseplan/>>

Moberg F & C Falke. 1999. Ecological goods and services of coral reef ecosystems. Ecological Economics 29: 215-233.

Morse ANC, K Iwao, M Baba, K Shimoike, T Hayashibara & M Omori. 1996 An ancient chemosensory mechanism brings new life to coral reefs. The Biological Bulletin 191: 149–154.

Ng CSL & LM Chou. 2013. Rearing juvenile corals of opportunity in *in situ* nurseries – a reef rehabilitation approach for sediment-impacted environments. Marine Biology Research (in review).

Ng CSL, SZ Ng & LM Chou. 2012a. Does an *ex situ* coral nursery facilitate reef restoration in Singapore's waters? In: Tan KS (ed.), Tropical Marine Science Institute St John's Island 10th Anniversary Commemorative Volume: Contributions to Marine Science, p.95-100.

Ng CSL, TC Toh, KB Toh, J Guest & LM Chou. 2013b. Dietary habits of grazers influence their suitability as biological controls of fouling macroalgae in *ex situ* mariculture. Aquaculture Research doi:10.1111/are.12128

Ng PKL. 2011. Modern biodiversity research. In: Ng PKL, RT Corlett & HTW Tan (eds.) Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development. Didier Millet, Csi. p.134-147.

Raymundo LJ, AP Maypa, ED Gomez & PL Cadiz. 2007. Can dynamite-blasted reefs recover? A novel, low-tech approach to stimulating natural recovery in fish and coral populations. Marine Pollution Bulletin 54: 1009-1019.

Rinkevich B. 2005. Conservation of coral reefs through active restoration measures: recent approaches and last decade progress. *Environmental Science & Technology* 39: 4333-4342.

Schopmeyer SA, D Lirman, E Bartels, J Byrne, DS Gilliam, J Hunt, ME Johnson, EA Larson, K Maxwell, K Nedimyer & C Walter. 2012. In situ coral nurseries serve as genetic repositories for coral reef restoration after an extreme cold-water event. *Restoration Ecology* 20(6): 696-703.

Tan HTW, LM Chou, DCJ Yeo & PKL Ng. 2010. *The Natural Heritage of Singapore* 3rd edition. Prentice Hall-Pearson Education South Asia Pte Ltd, Singapore. 323 pp.

Tay YC, JR Guest, LM Chou, & PA Todd. 2011. Vertical distribution and settlement competencies in broadcast spawning coral larvae: Implications for dispersal models. *Journal of Experimental Marine Biology and Ecology* 409: 324-330.

Tay YC, PA Todd, PS Rosshaug & LM Chou. 2012. Simulating the transport of broadcast coral larvae among the Southern Islands of Singapore. *Aquatic Biology* 15: 283-297.

Toh KB, LM Chou, YC Tay & VXH Phang. 2012b. The impacts of climatic extremes on coastal and marine biodiversity in Singapore and management challenges. *The Asian Conference on Sustainability, Energy and the Environment Official Conference Proceedings 2012*, p.423-430.

Toh TC & LM Chou. 2013. Aggregated settlement of *Pocillopora damicornis* planulae on injury sites may facilitate coral wound healing. *Bulletin of Marine Science* 89(2): 583-584.

Toh TC, CSL Ng, J Guest & LM Chou. 2013b. Grazers improve health of coral juveniles in *ex situ* mariculture. *Aquaculture* (in review).

Toh TC, J Guest & LM Chou. 2012a. Coral larval rearing in Singapore: observations on spawning timing, larval development and settlement of two common scleractinian coral species. In: Tan KS (ed.), *Tropical Marine Science Institute St John's Island 10th Anniversary Commemorative Volume: Contributions to Marine Science*, p.81-87.

Toh TC, JWK Peh & LM Chou. 2013a. Early onset of zooplanktivory in equatorial reef coral recruits. *Marine Biodiversity* doi 10.1007/s12526-013-0156-5

Tun K. 2012b. An annual sea show. *The ALUMNUS Issue* 90, July-September 2012, p.6

Tun PPK. 2012a. *Optimisation of Reef Survey Methods and Application of Reef Metrics and Biocriteria for the Monitoring of Sediment-impacted Reefs*. PhD thesis, Department of Biological Sciences, National University of Singapore. 208 pp.

Wilkinson C. 2008. *Status of coral reefs of the world: 2008*. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia. 296pp.

*Drylands Agriculture and Prevention Strategy of Environmental Agroecosystem
Damage in Kabupaten Musi Rawas, South Sumatra*

Agustina Bidarti

Sriwijaya University, Indonesia

0579

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Until now, the use of drylands as agricultural mode is severely lack in Indonesia. Agriculture, Paddy farming in this sense, is done more in wetlands. In fact, the drylands area occupies the largest area of Indonesia. Besides that, the future of drylands has a strategic position in the agricultural development in Indonesia. Therefore, the use of drylands is an important tool in the equality of development. Interestingly, drylands focus only to producers of agricultural commodity plantations, housing, medicine, and foreign exchange. When drylands of Musi Rawas, South Sumatra is used for agricultural purposes, it requires integrated management across sectors. In order to preserve the environment, it is necessary to follow the rules of proper management of the environment. Drylands management is one way to optimize the use of the land and the preservation of land and the environment. Improper land management can reduce the productivity of land and agricultural product will also reduce the quality of the surrounding environment. The purpose of writing this paper is to describe the impact of agricultural activities on drylands agro-ecosystem and strategies in addressing the environmental damage it causes.

Keywords : Agriculture, drylands agro ecosystem, pollution, environment

1. INTRODUCTION

The emergence of ambiguous issues, on the one hand there is the demand to provide resources in meeting food consumption due to the emergence of the other side of the advances in science and technology and population growth. Therefore, to realize the creation of a balance is necessary prudent action that did not result in changes to the environment. Agroecosystem formed as a result of interaction between social systems with natural systems, in the form of human activity that takes place to meet the needs of daily life (livelihood). Priority activities carried out by the farmers are cultivating rice (paddy).

Dry land is part of the terrestrial ecosystem relatively greater extent compared with wetlands (Odum, 1971). Furthermore, according to Hidayat et al (2000) Dry land is a stretch of land that was never flooded or inundated by water at some time during the year. Overall dry land has an area of approximately 70%. At this time the use of land for agricultural purposes either dry crops and perennial crops such as oil are highly developed.

Relief soil will determine whether land management easier and dry. According Subagio et al (2000) relief of land is determined by the slope and elevation differences. Judging from the shape, fertility and other physical properties, management of dryland relatively heavier compared to wetlands (rice paddies). Until now the attention of various parties to the sustainable management of dryland relatively low compared with lowland wetland management (Irawan and Pranadji, 2002).

Utilization of dry land in hilly and mountainous regions for seasonal agriculture produces food in common and do people who live in rural areas, one in Musi Rawas, South Sumatra Province. But sometimes, the use of dry land in the mountains and hills on a continuous basis without regard to principles of conservation will cause erosion and fertility decline in weight.

In recent years environmental degradation has become a national and international issues, including in Indonesia. One of the underlying case is global warming, clearing of forests for agriculture is a contributor to global warming. Changes in forest into dry land agro-ecosystem for agricultural purposes and settled temporarily in order to make ends meet has been going on for a long time. This has resulted in the degradation of soil fertility decline. Utilization of dry land in the hills or slopes continuously either for agricultural purposes or agricultural season crops can lead to land erosion and fertility decline in weight. To maintain the sustainability of the land required proper management efforts. Therefore, in this study there are some problems to be studied. First, is the opening for dryland farming in Musi Rawas, South Sumatra has an impact on soil fertility? Secondly, what about the existing environment agroecosystem with the opening of dryland agriculture in the region? Third, is opening in dryland farming is done with the proper management of the land so that sustainability can be maintained?

Furthermore, the purpose of this paper is to describe the impact of agricultural activities on dry land agro-ecosystem, including pollution and environmental damage they cause, and how management and mitigation solutions.

2. LITERATURE REVIEW

Since the end of the 19th century the development of dryland agriculture in particular on the island of Java has been very fast and so far has spread beyond the island of Java. Between the years 1875-1925 (50 years) increases were more than 350% (Lombart, 2000). This happens due to the availability of low-lying wetlands for most farmers who use it as farmland food decreases. Some shrinkage of wetlands in the lowlands due to conversion of land to non-agricultural land that is not under control. Agroecosystem mostly used by the state or the civilized agrarian society. Agriculture or agro word shows the activity or intervention communities against natural or agricultural ecosystems. The term can be given a meaning as an agricultural community activities that take advantage of natural or land for food, energy and other materials that can be used for survival (Pranaji, 2006). In this benefit the community can take directly from nature, or the first processing or modification. So an agroecosystem already contains public intervention or alter the natural balance of the ecosystem to produce something useful.

According to Hidayat (2000) that the dry land agro divided into several categories based on climate, altitude above sea level and the type of soil that is based Climate divided into two, namely (1) Dry land wet climate (LKIB) ie regions with rainfall above 2500 mm / year, (2) dry land dry climate (LKIK) ie regions with rainfall below 2000 mm / year. According to Hidayat (2000) that the dry land agro divided into several categories based on climate, altitude above sea level and the type of soil that is based Climate divided into two, namely (1) Dry land wet climate (LKIB) ie regions with rainfall above 2500 mm / year, (2) dry land dry climate (LKIK) ie regions with rainfall below 2000 mm / year.

Meanwhile, when divided by altitude where dry land divided into: (1) Upland plateau (LKDT) which is the area located at an altitude above 700 meters above sea level and (2) lowland dry land (LKDR) which is the area located at an altitude of 0 - 700 meters above sea level. Based on the type of soil on dry land can be divided into:

1. Oxisol, a land that has been progressing very advanced, cross the land, textured clay to heavy clay, porosity is high, power hold little water and clay minerals dominated by kaolinite, iron oxide and aluminum. Land is relatively resistant to erosion.
2. Inceptisol, land is still fairly young and soil properties vary, depending on the parent material (fine texture of argillaceous silt, very acidic to neutral). Included into the main types of dry land agriculture.
3. Ultisol, Soil has a base saturation less than 35% at a depth of 125 cm. This land has undergone weathering occurs tranlokasi further and clay in the parent material which generally consists of aluminum-silica-rich material with a wet climate.
4. Andisol, Land andisol andik has attributes with the parent material such as volcanic ash-rich volcanic glasses and minerals easily weathered. Properties - properties such as light weight content, rich in organic matter, rich in volcanic glass containing amorphous minerals (alofan), has no nature behind the drought, power withstand very high water and resistant to erosion. Soil texture varies from coarse argillaceous berliat up. The reaction is generally slightly acidic soil.

Farm management in particular dryland sustainable and sustained require a professional and follow the rules of the environment. According Goenadi (2002)

sustainable agricultural land management has five pillars, namely productivity, security, protection, viability and acceptability.

Disruption in the environment due to human greed, lack of concern for ecology and due to the use of agricultural technologies that do not refer to the development of environmentally sound (Ambo Ala, 1997). In addition, not terakomodirnya use / application of fertilizer is unable to prevent environmental damage (Nuhfil, et al., 2003). Furthermore Reintjes, et al. (1999), says that when the fertilizer used in the region is low, the output will be far behind compared with the growth of population. This phenomenon is common among farmers who manage marginal lands.

Management of dryland agrokosistem seen as part of the ecosystem management of natural resources by the farmers who occupy the areas where they settled. According Soerianegara (1977) dryland agro-ecosystem management is part of the interaction or cooperation with natural resource agroecosystems.

On sloping land with a slope of more than 15% when the soil is not managed well when planted, it is very susceptible to erosion in the rain. This happens because the land is not able to absorb the rain water into the soil, resulting in surface flow (run off) the washed granules into the soil so that the soil is not fertile anymore. According Sutono et al (2007), due to erosion during the rainy season not only washed away the soil grains but also washed manure and compost are also awarded to the ground so that the soil washed into thin, so erosion should be prevented as early as possible. The impact of this erosion is in the bottom of the siltation in the watershed (DAS) which resulted in the disruption of local water ecosystem balance.

3. METHOD

The method of research using quantitative methods that use mathematical calculations. Further quantitative analysis with qualitative analysis described systematically and identified in accordance with the conditions on the farm agroecosystem in Musi Rawas, South Sumatra with a case study on dryland agriculture. In addition to sharpening the qualitative analysis carried out also by the method of observation and interviews, especially interviews. Based on that, the qualitative analysis is then placed in a descriptive tabulation.

4. RESULTS

Sustainable agricultural development in dry land agro-ecosystem management can be seen as an effort to repair and regenerate the natural resources that can be recovered (renewable resources) in the region. In the utilization of arid land resources for sustainable agriculture and environmental approaches require follow environmental rules. There are several methods to control the negative impact of the exploitation of the use of dry land. Based on the data though, there are some strategies adopted by farmers in dryland areas in Musi Rawas, South Sumatra.

4. 1. Conservation of Dryland Agriculture in Musi Rawas, South Sumatra

One of the efforts to address land degradation caused by exploration conducted by farmers in dryland areas Musi Rawas South Sumatra is to implement the alley cropping systems in the development of dryland farming systems, because these

systems provide many advantages such as may suppress erosion. Theoretically, the model is in line with the opinion Sudharto et al., (1996) that increases the productivity of the soil due to the addition of organic matter through the results of hedge clipping, can increase plant growth and production, and to create microclimate conditions (temperature) in the hallway plant . Provision of forage materials, by farmers in dryland areas Musi Rawas, South Sumatra, as mulch derived from legume crop plants are trimmed at the age of 1.5 to 2 months can increase levels of soil organic matter and water availability, improve soil physical properties and increase production. According Adiningsih and Sudjadi (1989), alley farming systems can prevent erosion double that with mulch clipping yield and reduction of surface flow.

Application of tunnel farming systems by farmers in dryland areas Musi Rawas South Sumatra shows that with the march of erosion buffer plants grass king (king grass) planted parallel to the contour lines can effectively reduce the rate of erosion. Furthermore, from the results of king grass clipping are held every month can produce 0.5 tons of forage that can be given to cattle for 20 days. From the plot area of 1 hectare will produce 1 tonne of forage that can be used to feed cattle. In the next assessment year (second year) terrace already formed as a result of planting vegetative grass plant terrace king. With the formation of the terraces on sloping land is established representative farm land for different types of plants both food crops and tree crops suitable to local conditions and suppress the occurrence of erosion at a time when it rains. With the formation of terraces gradually to become permanent, in addition to preserving the land also cause land productivity will be better.

4. 2. Strategy setting Farmers Dryland Cropping Patterns Musi Rawas in South Sumatra

Dry land purely rely on the availability of water from rainfall in the agricultural production process, where the cropping system settings arranged in the form of intercropping using plants with different harvest and the growth is not much need for water and is an alternative to solve the problem of limited water. Dry land is generally prone to erosion both by water and by wind. One alternative technologies to address the erosion of using cropping systems hallway. Other functions of the alley cropping is to create a microclimate in dry land dry climate and the plants used are adapted to crops commonly grown farmers and thus has a market share. The results Vishnu et al (2005) states by combining several crop cassava, corn, peanuts, soybeans and green beans are arranged in a crop intercropping may provide advantages and can provide fairly good stability in the face of limited rainfall.

4. 3. Strategy Embung Dryland farmers in Musi Rawas, South Sumatra

Ponds or water tank is a reservoir of micro-sized farms (small farm reservoir) was built to accommodate the excess rain water and use it at a time when the rainy season if needed crops during the dry season. Appropriate use of such techniques for rainfed ecosystem that has the intensity and distribution of rainfall is uncertain (Syamsiah and Fagi, 2004).

Making ponds and its application in dryland farmers have a lot to do, especially in eastern Indonesia bagiagian which has a dry climate with limited water. In dry climates the use of ponds has become a habit for most farmers. Dryland farmers in Musi Rawas in South Sumatra have ponds at the moment is 1458 pieces with a total

area of 755.58 ha of inundation and 3083 ha of irrigation, average land holding per farmer ponds in dryland farmers Musi Rawas South Sumatra is 0 , 51 ha.

In the dry season showed that with the application and use of ponds as a source of water mixed with the fertilizer (ngecor) then it becomes more efficient use of water and labor costs can be reduced due to watering and fertilizing done simultaneously.

4. 4. Use of Organic Fertilizer to Farmers Dryland Musi Rawas in South Sumatra

Processing of agricultural land for continuously will cause the land to be thin so that for the next farming need a lot of inputs to restore soil nutrient that has been absorbed by plants. The use of inorganic fertilizers are unbalanced continuously to the production process can damage the land and in the long run become ineffective land for agriculture. One alternative to save the sustainable use of land is to reduce the input that comes from chemicals and switch to organic fertilizer derived from organic material or waste crop residues. In general, the current problems faced by dryland farmers Musi Rawas, South Sumatra, Indonesia in particular and generally is difficulty getting an inorganic fertilizer needs tends to increase. This difficulty is partly due to the availability of inadequate or improper distribution system and other factors. As an illustration, in 2008 the national production of about 6 million tons while the needs of up to 9 million tons. These constraints affect kapada decreased land productivity and production of various agricultural commodities nationwide.

One of the efforts undertaken by upland farmers in Musi Rawas, South Sumatra to overcome shortages of fertilizer and reduce dependence on inorganic fertilizers is to optimize the use of natural resources available locally. Utilization of agricultural waste which is still a concern as the basic material of organic fertilizer is expected to reduce dependence on inorganic fertilizers. On the utilization of agricultural waste to create efficient use of the limited land availability and to maintain environmental. Agricultural waste or residual part of agricultural production that can not be used directly. This waste has undergone a process of decomposition when it contains many nutrients needed for plant growth. When the plants die, the decomposition process occurs later due to the activities of microorganisms with the end result in the form of humus (Sutanto, 2002).

Nutrient content of each different crop residues. The dryland farmers in South Sumatra Musi Rawas using organic fertilizer derived from neem seed residue. Diola neem seed dregs of the ginger plant with some inorganic fertilizer treatments. The use of organic fertilizer (compost) derived from neem seed residue by dry land farmers in Musi Rawas South Sumatra, suggesting that the growth of rice plants better and higher crop production and use of organic fertilizers. Thus, there are several advantages to the use of organic fertilizers is the efficiency of the cost because the price of fertilizer is cheaper, higher production and maintain soil fertility and sustainability.

5. CONCLUSION

Based on this study, that the impact of agricultural activities on dry land agroekosistem the Musi Rawas, South Sumatra, it can be minimized. One of the efforts to address land degradation due to exploration is to convert the technology package for the development of dryland farming systems. Cropping arrangement is

an attempt to suppress the occurrence of erosion, improve soil productivity with the addition of organic matter through the results of crop plants, can increase plant growth and production. By building ponds or water tank or reservoir of micro-sized farms can hold excess rain water during the rainy season and use it if necessary crop during the dry season. Utilization of the ecological chain can create an inexpensive and natural fertilizer, while maintaining soil fertility and sustainability. By doing dry land management alternatives are expected agroekosiste in drylands is sustainable with minimal environmental impact.

6. RECOGNITION

In this study, the authors would like to thank the informants as well as all those who help implement the study. Both government agencies that exist in Musi Rawas, as well as government agencies in the city of Palembang, particularly the Department of Agriculture. Then the farmer groups, as well as dry land farmers in Musi Rawas, South Sumatra, either as a primary informant mapun secondary. As well as those who have given advice and input to build in refining this research paper.

7. REFERENCES

- (1) Ala A, 1997. "Pertanian Organik sebagai Suatu Alternatif Pertanian Berwawasan Lingkungan" in *Journal of Flora and Fauna*, UNHAS – Indonesia, Volume 5 Nomor 1.
- (2) Hidayat, A., Hikmatullah, dan D. Santoso. 2000. *Potensi dan Pengelolaan Lahan Kering Dataran Rendah*. Pusat Penelitian Tanah dan Agroklimat, Badan Penelitian Dan Pengembangan Pertanian. Bogor.
- (3) Irawan, B dan T. Pranaji. 2002. *Kebijakan Pemberdayaan Lahan Kering Untuk mendukung Pengembangan Agribisnis dan Peetanian Berkelanjutan*. Pusat Penelitian dan Pengembangan Sosial Ekonomi Pertanian. Bogor.
- (4) Nuhfil H. A.R.. 2003. *Strategi Pembangunan Pertanian: Sebuah Pemikiran Baru*. LAPPERA Pustaka Utama, Yogyakarta.
- (5) Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Saunder Company. Philadelphia.
- (6) Sudharto, T., N. Efram, E. Sunarto, Suriatinah, A. Hartono, dan R.L. Watung, 1996, "Sistem Usahatani Budidaya Lorong untuk Mendukung Tanaman Pangan dan Buah-buahan di Lahan Kering di Wilayah Gunung Mas, Kalimantan Tengah", in *Prosiding Lokakarya Evaluasi Hasil Penelitian Usahatani Lahan Kering*, Palangkaraya, 16 Desember 1996. Pusat Penelitian Tanah dan Agroklimat.
- (7) Sutanto, R. 2002. *Penerapan Pertanian Organik*. Penerbit Kanisius. Yogyakarta.
- (8) Syamsiah, I. dan A.M Fagi. 1997. *Teknologi Embung. Sumberdaya Air dan Iklim dalam mewujudkan Pertanian Efisien*. Kerjasama Departemen Pertanian dengan Perhimpunan Meteorologi Pertanian Indonesia (PERHIMPI).
- (9) Wisnu, I.M.W, I. Basuki dan Johanes. 2005, "Alternatif Sistem Usahatani dan Pengelolaan sumberdaya air dalam pengembangan lahan kering di NTB", in *Prosiding Seminar Nasional Inovasi Teknologi Pertanian Mendukung Pembangunan Pertanian Lahan Kering*. Kerjasama. PSE dan UNIB. Hlm. 1-33.

Introduction of Renewable Energy into City-Chino in Nagano.

Tetsuya Takano*¹, Hiroshi Kawamura*²

*¹City office of Chino, Japan, *²Suwa Tokyo University of Science, Japan

0608

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org

1. Introduction

City-Chino is located almost at the center of Prefecture Nagano, which is also nearly at the center of Japan. Area of Chino covers altitude ranging from 750 to 2899m, while inhabiting area is mainly 750 to 1,200 m. Population is about 55,000, while roughly three million people visit Tateshina highland and other resort spots for relaxation and recreation. Average temperature over a year is 10.8 deg C (cf. 16.2 deg C in Tokyo), and annual precipitation is 1,200 mm (cf. 1,800 mm in Tokyo), which offers comfortable inhabitant environment. The sunshine hours are long, the land is rich of water, and about 75 % of the area is covered by forest. These are all advantageous conditions for the introduction of the renewable energy.

Introduction of the renewable energy is now highly promoted in Japan because of the global warming and the disastrous experience of the Tohoku earthquake and tsunami. FiT (Feed-in Tariff) has been started from 2012 in Japan. City Chino started a new section, Natural Energy Section, in the Department of Industry and Economy to accelerate the introduction of the renewable energy and thus to promote local industry and economy. The first author is now with the Natural Energy Section and is engaged in promoting the utilization of the renewable energy in the administration of the local government.

2. Activity of introducing renewable energy in City Chino

2.1 Activities by private sector

(1) Natususawa mineral spa

A mountain lodge is operated by private sector to serve hikers and climbers of mountain Yatsugatake (Fig. 1). Since it is located remotely from the city area, no commercial transmission line is connected. Thus, the renewable energy is intensively utilized. The energy is 100 % supplied with the renewable energies such as small hydro, solar, wind and biomass power. Especially, a small hydroturbine of the cross flow type (Fig. 2) is installed and connected to a water pipe with water head of about 30 m since 2001. The electricity of 6 kW max is generated constantly for all year around including the winter time. Now almost all the electricity is supplied by this hydro system. City office is now going to promote this activity with use of the website and through new souvenir products.

(2) Onsite test of a small hydroturbine of washbasin type

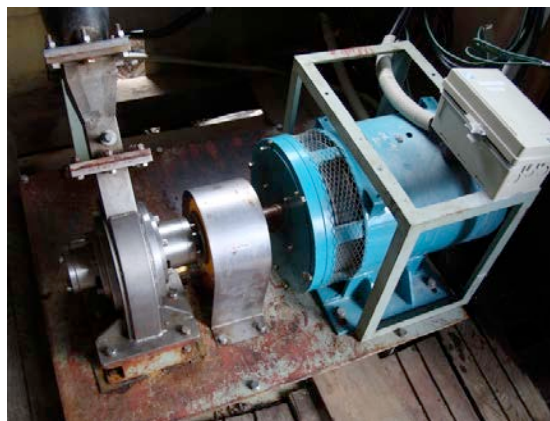


Fig. 2 Hydroturbine (cross flow type) and generator (6 kW max.)



Fig. 1 Natususawa mountain lodge at 2,000m. Solar panels and small wind turbines are seen.

An onsite test is now being made using an agricultural water channel in Chino. As seen in Fig. 3, water is eccentrically introduced into a basin and the water vortex is generated, which rotates an impeller. This type is suitable for a small head difference and easy to be installed without large civil work. Another feature is that the leaves and debris flow easily through the basin and no filters nor screens are needed in front of the intake. This test is operated by a company AEC Co, Ltd. in Chino. This is the first onsite test of this type in Japan. It is planned to run for three months and its commercial supply is expected after the test.

(3) Hydropower station by a private company

A hydro power station of 250 kW is now being operated by Mibugawa Power Company Co, Ltd. This type of small power station is usually installed by utilizing a level difference of U-turning agricultural water channel. Chino is located in the slope of Mount Yatsugatake; there are not few spots suitable to this type of installation. Other two stations are going to start operation in 2013.

(4) Small solarpower station by private person

Since the start of FiT in 2012, a private person is now able to install a solar power station and sell the electricity to power company. Capacity is typically 50 to 150 kW in this area. Now two sites are operating and other three are in preparation. Figure 4 shows an example of such a solar power station with 50 kW. From the aspect of the land use, the agricultural land must be converted to miscellaneous usage, which must be admitted by the local government. The land tax increases, but it can usually be compensated by the income. So-called Mega-Solar power station usually requires a large land and big civil work, but a small solar power station needs no such large investment at the beginning. So, the city government is now promoting this type of small solar power stations.



Fig. 3 On site test of a washbasin type hydropower generation (200 W max.)

2.2 Activities by local government Chino

(1) Promotion of renewable energy by subsidy
Smaller solar power facilities, installed on the roof of private houses, are promoted by subsidy. City Chino offers 200,000 yen (max.) for the solar power facility less than 10 kW since 2003. To facilitate the biomass utilization, 100,000 yen (max.) is offered for a pellet stove. More than 200 applications are made for the solar power and 10 for the pellet stove. The planned budget is consumed in a short period every year. This indicates citizens have large interest in the renewable energy.



Fig. 4 Privately operated solar power station. The electricity is sold to the utility company.

(2) Research committee on Future Eco City Chino

As mentioned before, the City office Chino started Natural Energy Section in the department of Industry and Economy and also organizes Research committee on Future Eco City Chino in collaboration with private companies, NPO's, and a university, Suwa Tokyo University of Science. Interested and active citizens are also included. Four sub-committees are running.

1) Solar power sub-committee

Since the start of the FiT, Mega Solar business is now widely being developed in the whole country by large enterprises. In these cases, most of earned profit often flows outside of the local area and only a small portion such as the rent of ground and cost of maintenance work remains there. The sub-committee studies a framework in which earned money remains in the local region and is recirculated to further promote local industry and employment. A local company is now established to realize this scheme. A solar power station with about 2 MW is now going to be constructed on a field of Yatsugatake Agricultural Vocational School. In this neighboring area, there exist several water supply facilities, suitable for small hydro power generation, and a compost center, usable for biomass energy production. Accordingly, this area is now going to be developed in combination as Chino Eco-Energy Park. Figure 5 indicates this area.

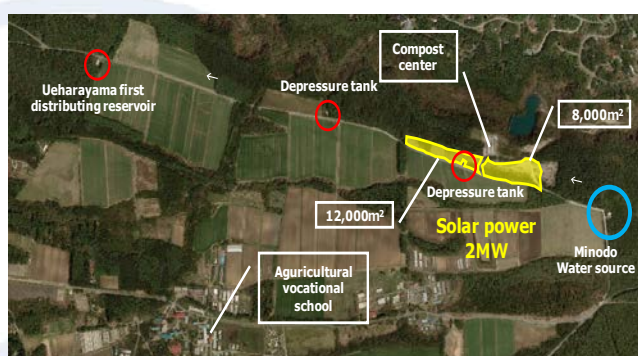


Fig. 5 Area of Chino Eco-Energy Park including solar, small-hydro and biomass energy generations

A low-cost solar-powered street light has been developed by collaboration of small companies and citizens in Chino. It can be produced now with a less than half of normal market price, because design and assembling are made by themselves. Now 13 units have been installed in primary and middle schools in Chino and 26 are planned to be constructed in future. This is expected to help the eco-education of children.

2) Small hydropower sub-committee

Special feature of the city water supply of Chino is that all the water sources are underground fountains and no river water intake is utilized. Accordingly the water supply is stable independently of season. On the other hand, the water flow from individual source is rather small but experiences a large elevation difference before delivered to the final consumer. Now, installation of a small hydropower generator in this water supply system is studied by the sub-committee. Technical feature of this flow is a relatively small flowrate compared to a large elevation difference. Fairly intensive search was made, but no hydroturbine suitable for these conditions has been found with a reasonable price. Accordingly, a pump reverse turbine is now being developed in collaboration with a pump manufacturing company, Komatsu Pump Works Co, Ltd., in a neighboring town. After a model test with an equivalent specific speed, suitable type and size will be selected and be installed at one of the depressurize tanks shown in Fig. 5.

The area of city Chino spreads over the foot of Mount. Yatsugatake. A network of agricultural water channel is well developed even since 250 years ago. There are also many branches of Tenryu River system. These water channels and rivers are all regulated by the river law and their stake holders. Since the regulations on the 1st and 2nd class rivers are strict, normal class rivers are now investigated. Those whose cost can balance with income will better be operated by private sectors, while those cannot will be promoted by the city government if beneficial with aspects of education or industry promotion.



Fig. 6 An agricultural water channel (top) and a water fall (bottom), at which a small hydropower station is planned.

3) Utilization of unused energy sub-committee

Since the 75 % of the city area is covered with the forest, thinning of the forest and the utilization of the resultant timber are of great importance both from the preservation of the forest and also from the promotion of the renewable energy. The city office supports the pellet stove as mentioned earlier. A private sector develops a wood stove suitable for a kind of wood common in this region. The developed stove becomes fairly popular in this area. The sub-committee gives advices in the occasions of construction or renovation of public facilities to introduce renewable energies.

3. Laboratory test of a microhydroturbine

Although large scale hydroturbines are well developed and their technical characteristics are studied in detail, those of microturbines are not known well. Thus, a laboratory scale performance test of a microhydroturbine is being carried out. It is a turgo type impulse turbine made by a Canadian company Energy Systems & Design [1]. The inlet water passes through one or two small nozzle(s), where the pressure head is converted velocity. The water then impinges to the turbine runner, which converts the momentum energy of the water into shaft power and spins the generator. In the generator, magnets are imbedded in the rotor that moves past coils of wire, where the electricity is generated. This electric power is first the alternating current (AC), and then is

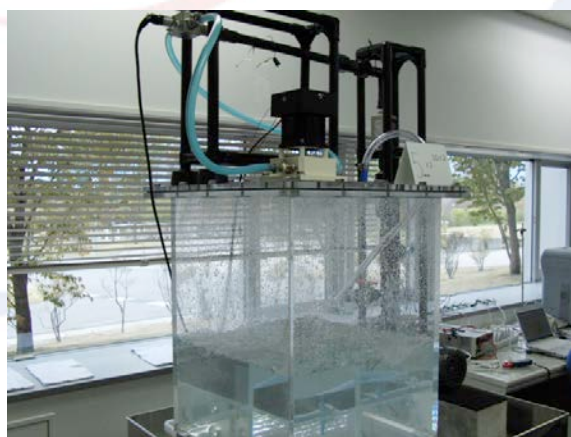


Fig. 7 Outlook of the test loop. The microhydroturbine is seen at top center, the pump bottom right, pressure gauge top left.

inverted into the direct current (DC) with a rectifier. The generator was directly coupled to the turbine (see Fig. 7).

A small water loop was constructed to circulate water. The water is circulated by a small pump. The flow rate and the water head was measured and fed to the water turbine. A photograph of the circulation loop is shown in Fig. 8. The hydroturbine is installed on the top of a reservoir tank. After driving the turbine, the water was poured into the tank and recirculated by the pump. Diagram of the test loop and the arrangement of apparatus are shown in Fig. 9. Both the flow rate and the pump head changed following the performance curve of the circulation pump and the opening of the regulation valve.

The tested turgo impeller of 75mm in diameter is shown in Fig. 10. Two water nozzles are seen in the photo. The nozzle head is replaceable for diameters from $d=3$ to 7 mm depending on the flow condition. In the present test, one and two nozzles were examined. The water head and the flow rate were adjusted by a flow regulation valve. The rotation speed n of the turbine was measured with use of a non-contact tachometer.

To measure the generated electric power, ohmic resistance was connected to the output terminals. The voltage V and the current I were measured to obtain the generated power. In the measurement, the electric load was changed by adding the ohmic resistance in parallel, that is, by increasing the conductance ($1/\Omega$).

Typical results are shown in Fig. 10, where the generated power and the rotation speed are given for single and two nozzles with $d=7$ mm. With the increasing

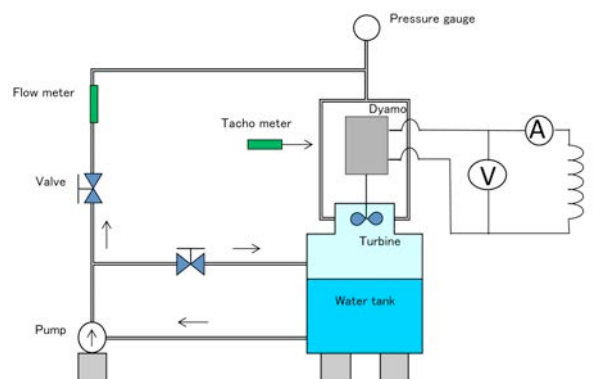


Fig. 8 Diagram of the test loop and measurement devices.

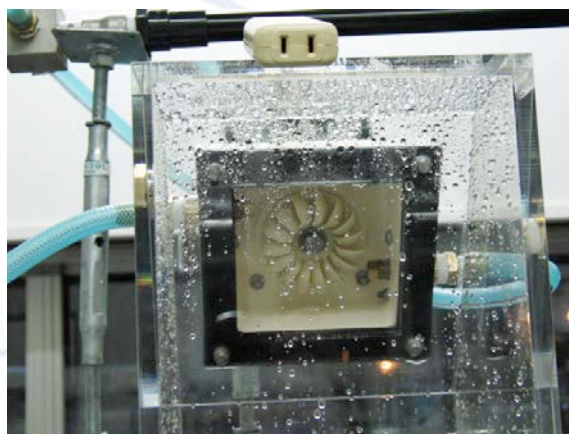


Fig. 9 Impeller and nozzles

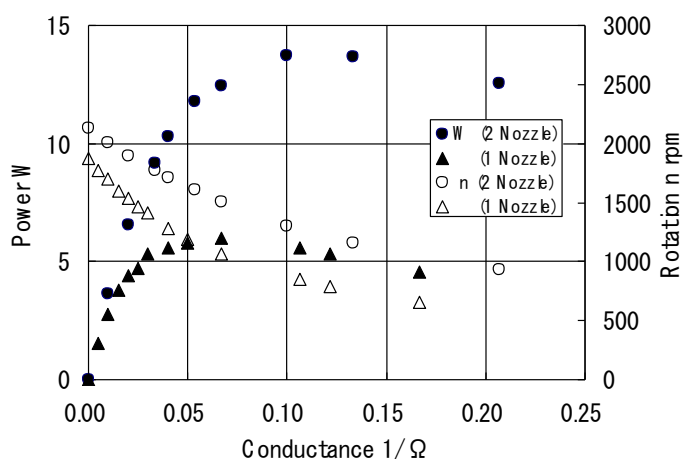


Fig. 10 Generated power P (W) and the rotation speed n (rpm) for one and two nozzles with $d=7$ mm. Pump head was mostly constant as 90- 104 kPa.

conductance, that is, the decreasing ohmic resistance, the power increases and the rotation speed decreases. A maximum power appears at a conductance depending on the flow and nozzle conditions. The maximum power is of course larger in the two nozzle system than in the single one and is more than doubled.

To compare these two cases, the efficiency is plotted as a function of the conductance in Fig. 11. The measured power in the present method was not exactly equal to the power generated by the turbine, because the power loss inside the generator was not included in the measured value. To account the loss due to the internal resistance of the generator, the open circuit voltage (V_0) was measured prior to the experiment as a function of the rotation speed n . The obtained voltage was used instead of the one between output terminals to calculate the generated power including the loss due to the internal resistance. The difference was small and within several percents. Thus, the output power P is defined as $P=V_0I$. However, since there still exist core and mechanical losses, the net generated power and the efficiency are higher than those obtained by the present methods.

The theoretical hydrodynamic power P_{th} at the exit of the nozzle(s) is the product of the momentum energy and the flow rate Q ; that is, $P_{th} = (1/2)\rho v^2 Q$, where ρ is the density of the water, and v the velocity at the nozzle outlet. The velocity can be obtained as $v=Q/\pi(d/2)^2$, where Q is the flow rate at each nozzle. Then the efficiency η is defined as $\eta =P/P_{th}$. Figure 11 gives the efficiency obtained for one and two nozzles with $d=7$ mm. The efficiency is almost equal for one and two nozzles when the conductance is small, while that of two nozzles extends up to a larger value with the increasing conductance.

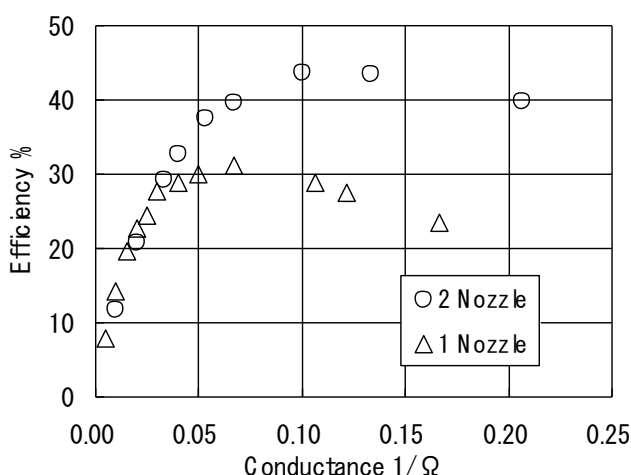


Fig. 11 Efficiency for one and two nozzles with $d=7$ mm. Pump head was mostly constant as 90-104 kPa.

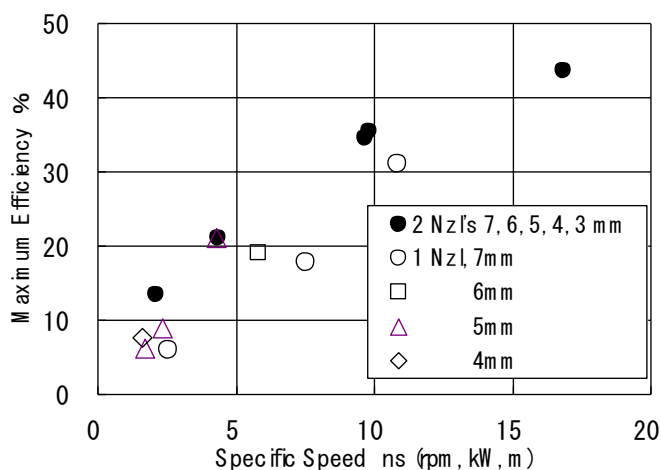


Fig. 12 Maximum efficiency for one and two nozzles versus the specific speed.

Figure 12 shows the maximum efficiency against the specific speed n_s of the hydroturbine for one and two nozzles with various nozzle diameters. The specific speed n_s is defined as $n_s=nP^{1/2}/H^{5/4}$, where H is the equivalent water head in meter calculated from the water velocity at the nozzle exit. The maximum efficiency increases with the increasing specific

speed and is higher for the two nozzles than for the single one. The maximum efficiency reaches up to 45 %, which is fairly high for such a small system.

4. Concluding remarks

The City Chino is a town rich in various renewable energies such as the solar, hydro and biomass. However, their utilization is still at the beginning stage. On the other hand, the interest in the renewable energy is increasing very rapidly among industries and citizens. The city government of Chino intends to enhance their utilization in order to preserve environment and also to promote social and industry activities.

A series of performance test was made for a microhydroturbine. A simple test method was established to measure the generated power and the efficiency with a reasonable accuracy. A microhydroturbine with one and two nozzles were tested and compared for various nozzle diameters. A fairly high efficiency was obtained for such a small hydroturbine.

5. Reference

- [1] The Watter Buddy, Owner's manual, Energy Systems and Design, Sussex, Canada. (2012).

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is partially enclosed by a large, light blue circular arc that starts from the bottom left and curves towards the right. There are also some faint, overlapping red and blue curved lines in the background.

Conception of a New Water Collection System Using LiBr Solution for Dry Area

Lu Zhou, Cyril Cassisa, Xungang Diao

Beihang University, China

0616

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Nowadays the problem of water shortage and water pollution is very serious all over the world. Moreover, these limited water resources are faced with a very serious industrial and domestic pollution particularly in developing country like China. To solve the problem of water shortage, many methods have been proposed and studied. we designed a new water condensation system inspired by the principle of dehumidifier which can collect liquid water from humid air based on the water absorption nature of the concentrated lithium bromide solution (LiBr) coupled with the method of vacuum distillation. To verify the conception, we have built a small prototype of the system. Experiments with the prototype show that with a 2L (Liter) LiBr solution of 57% concentration, we can get 0.23g/s liquid water. The energy needed to get 1L liquid water is 7500 kJ which is relatively large. However, as most of the energy is used to heat the solution (4000kJ), we could easily applied solar energy into our system and energy efficiency optimization to reduce the consumption of energy. The proposed water collection system can work in a dryer and colder condition than traditional water condensation system. Preliminary results show the feasibility of this kind of system and open the water condensation technique to a larger scope of weather conditions. This proposed technical solution is a new alternative to climate change adaptation for dry land areas in particular. Improvement of the system is currently under investigation.

Keywords: water collection, LiBr solution, vaccum distillation, solar energy

Introduction

Water shortage is, now and even more in a near future, one of the most serious problem on which the humanity faces all over the world. In the total amount of water available in the world, seawater accounts for about 97%, the freshwater accounts for only 2.5%, and the water in lakes, rivers, and surface water which can be used by human accounts for only 1.3% of the total global freshwater [1]. Moreover, these limited water resources are faced with a very serious industrial and domestic pollution. Nowadays, more than 100 countries around the world have different degrees of water shortage, and 28 countries are classified as water-scarce countries or serious water-scarce countries.

To solve the problem of water shortage, many methods have been proposed and studied. Generally, there are 3 kinds of solutions.

➤ **Seawater desalination:**

The traditional process of seawater desalination is vacuum distillation which consumes a lot of energy and which is not very effective. An alternative way is to use reverse osmosis technology or electrodialysis, which are usually too expensive for widespread use. Moreover, this solution can only be used in coastal areas as desalting seawater requires a consistent and reliable source of feed water to operate and produce potable water effectively and efficiently [2].

➤ **Water purification:**

Water purification aims at reduce the concentration of particulate matter like suspended particles, parasites, bacteria and a range of dissolved and particulate material in the water. In general the methods used include physical processes such as filtration and sedimentation [3], biological processes such as slow sand filters or activated sludge [4], chemical processes such as flocculation and chlorination[5]. In most cases, all these processes are combined to form a whole water purification system. Water purification helps to recycle waste water to provide water for industrial or domestic uses. However, during the process of treatment, essentially during the chemical processes, the water can be polluted again by the chemicals and cause corrosion or toxicosis. Moreover, the process of distillation removes all minerals from water, which makes the water not ideal for drinking.

➤ **Condensation:**

For high humidity areas such as places close to the sea, water can be condensed from the air. This method also applies well in places which has a large day-night temperature difference. A relatively new method to cool warm air and condensate its contents of moisture is to use thermoelectric (TE) devices [6]. Nowadays, atmospheric water condensing products are available for residential and industrial uses. They mainly use sustainable energy such as solar, to achieve the purpose of energy control. However, all the existing products can only work in humid areas but not in a dry and cold condition. For example, in the Chinese city of Dulin, the traditional way of condensation can only function during 4 months (6,7,8,9) when the average vapor pressure is above 4.58mm/Hg as showed in table 1 (0 °C, the saturation vapor pressure is 4.58mm/Hg) [7].

In order to solve this problem of humidity limitation for water condensation systems, we designed a new water condensation system inspired by the principle of dehumidifier, [8] which can absorb the moisture in the air but cannot obtain liquid water.

Table 1: Average vapor pressure of Dulan, China

Station	Dulan, China
Month	Average vapor pressure (mm/Hg)
1	1.1
2	1.3
3	1.8
4	2.5
5	4
6	5.9
7	7.4
8	6.9
9	4.9
10	2.8
11	1.5
12	1.1

In this paper, we propose a water condensation system that can collect liquid water from humid air based on the water absorption nature of the concentrated lithium bromide solution with the method of vacuum distillation. Tests and validations have been made on a simple prototype of the system. The paper is organized as follow. The second section describes in detail the conception of the system and the process of water condensation. The third section presents the tests and results of the experiments. We discuss the performance of the system and present the water quality check in the fourth section and in the last section we give the conclusions.

1. Principle of the LiBr condensation system

We design the water collection system based on the water absorption nature of the concentrated lithium bromide (LiBr) solution coupled with the method of vacuum distillation. LiBr solution is colorless liquid with salty taste and it is non-poisonous. The concentrated LiBr solution has a great ability of hygroscopicity as its water vapor partial pressure is very low. The Pressure-Temperature-Concentration curve of LiBr solution is showed in Fig.1. Another important nature of LiBr solution is that it has a great corrosion to ferrous metals and red copper, which make us have to pay attention to the choice of materials of the equipment used in the experiments.

The machine consists of seven parts (Fig.2): aerator (1), LiBr absorber (2), heat exchanger (3), solar heating panels (4), reaction vessel (5), collection device (6) and vacuum pump (7).

We suppose that the temperature of the environment is $T = 30^{\circ}\text{C}$, the humidity relative is $HR = 15\%$, and in this condition the concentration of the saturated lithium bromide solution in the LiBr absorber is 56% which means that the solution contains a

lot of water. It is the concentration of saturated LiBr at 30°C. Firstly, we use the vacuum pump to make the pressure in the reaction vessel to 0.1bar, and the pressure difference between the reaction vessel and the LiBr absorber will push the solution into reaction vessel. Then the solution will be heated to 110°C by the solar heating panels around the reaction. This is the process vacuum distillation. The water will turn to vapor and will be taken out of the reaction vessel by the vacuum pump. Next the vapor is cooled down in the copper tube of the condenser and then we can collect the liquid water in the collection device.

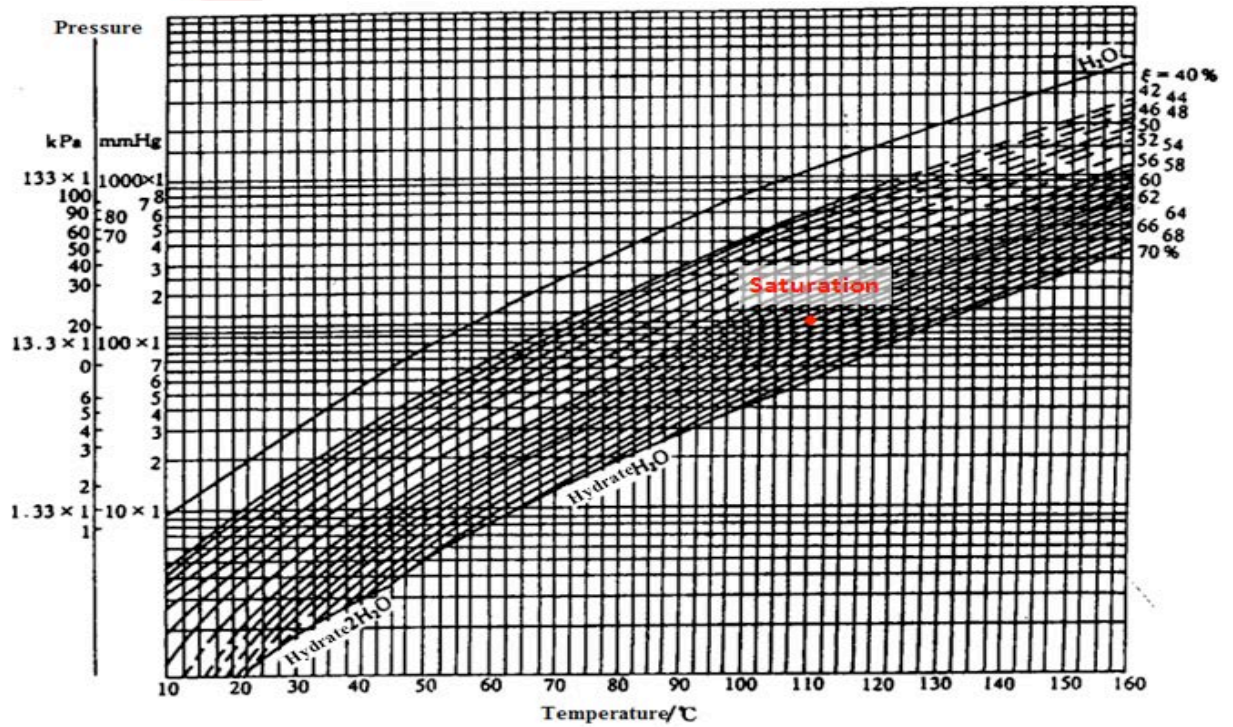


Fig.1: Saturated vapor pressure-Temperature-Concentration curve of LiBr solution [9]

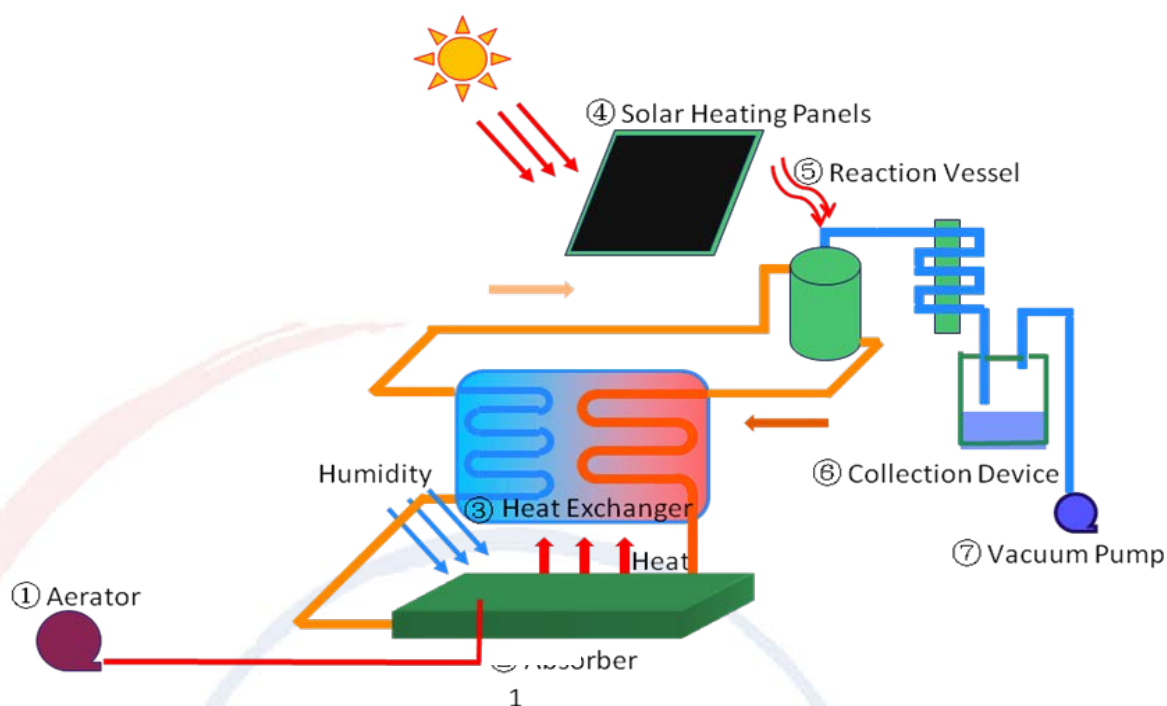


Fig.2: Sketch of the water collection system

When the solution in the reaction vessel reaches $T = 110^{\circ}\text{C}$, we stop heating and in this condition the concentration of the LiBr solution is 64% (Fig.1 red point). There is less water inside the solution. Next, we shut down the passage of the vapor and open another opening on the vessel to balance the pressure between the reaction vessel and the environment. The gravity will make the solution flow out of the vessel and into the heat exchanger, cool down, and flow back to the LiBr absorber. After the solution of 64% mix with the solution in the absorber, it will absorb the humidity in the air. To accelerate the absorption needed time, we use an aerator. The concentration of the solution in the absorber will become 56% after a certain time and then the next cycle begins. The whole cycle of the system is showed in Fig.3.

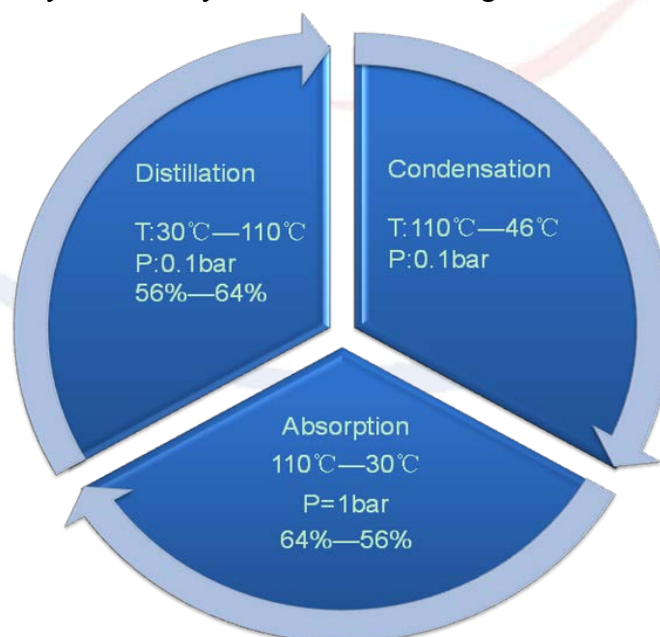


Fig.3: Cycle of the water collection system

2. Experimental verification of the proposed principle

To verify the conception, we have built a small prototype of the system. And we designed and conducted many experiments with the prototype to verify the conception of each section of the system and to evaluate the overall performance of the system.

A. Absorption section

The condition of the experiment is $T = 20^{\circ}\text{C}$, $\text{RH} = 40\%$. Equipment setup is showed in Fig.4.

We use densimeters to measure the density of the LiBr solution every 30 minutes with an air pump which blows maximum 300L air per minute into the absorption cell.

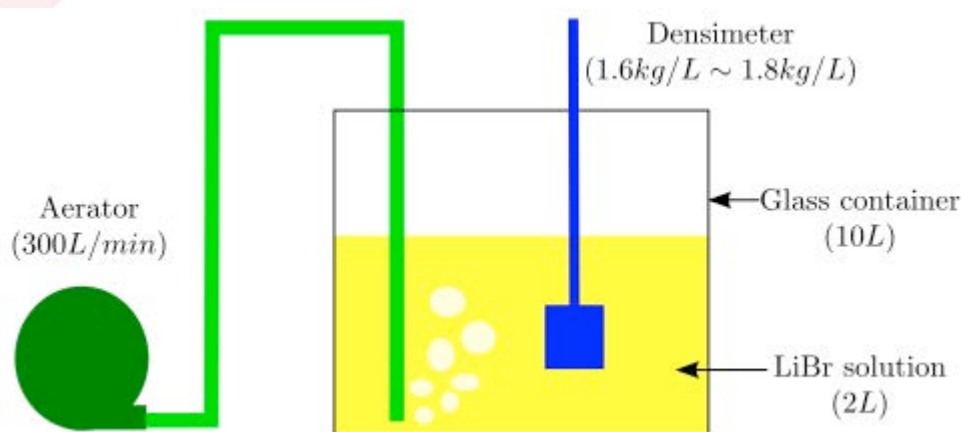


Fig.4: Equipment setup of experiments of absorption section

We can get the concentration of the LiBr solution in the absorption cell with the measured density based on the Condensation-Density table of LiBr solution [10] and the concentration-time curve is showed in the Fig.5. We can see that the concentration of the LiBr solution declines as it absorbs the humidity in the air. We can also notice that the absorption rate varies with the concentration and we would also like to observe the change of the absorption rate. First we calculate the initial mass of the solution m_0 given the initial volume V_0 , initial density ρ_0 and the initial concentration of the solution w_0 by using the Eq.1.

$$m_0 = \rho_0 * V_0 \quad (1)$$

The mass of the solution contains the masse of water plus the mass of LiBr. The mass of LiBr keep unchanged during the experiment. We can then get the mass of LiBr m_{LiBr} using Eq.2.

$$m_{\text{LiBr}} = m_0 * w_0 \quad (2)$$

Then we can calculate the mass of the solution at any time t during the experiment with the concentration of the time t given by Eq.3.

$$m(t) = m_{LiBr} / w(t) = \rho_0 * V_0 * w_0 / w(t) \quad (3)$$

At last we can get the average absorption rate of time t by Eq.4.

$$\bar{v}(t) = (m(t) - m_0) / t \quad (4)$$

The average absorption rate-time curve is showed in the Fig.6. We can see that the average absorption rate declines quickly while the concentration declines. We can also see that 3 hours is a critical time after what the concentration is below 57 % and the average absorption rate becomes smaller than 0.01 kg/ h. In practice, we will consider that the LiBr solution riches saturation at 57% instead of 56% which needs a too long time of absorption for a little gain in amount of water from 57% to 56% concentration.

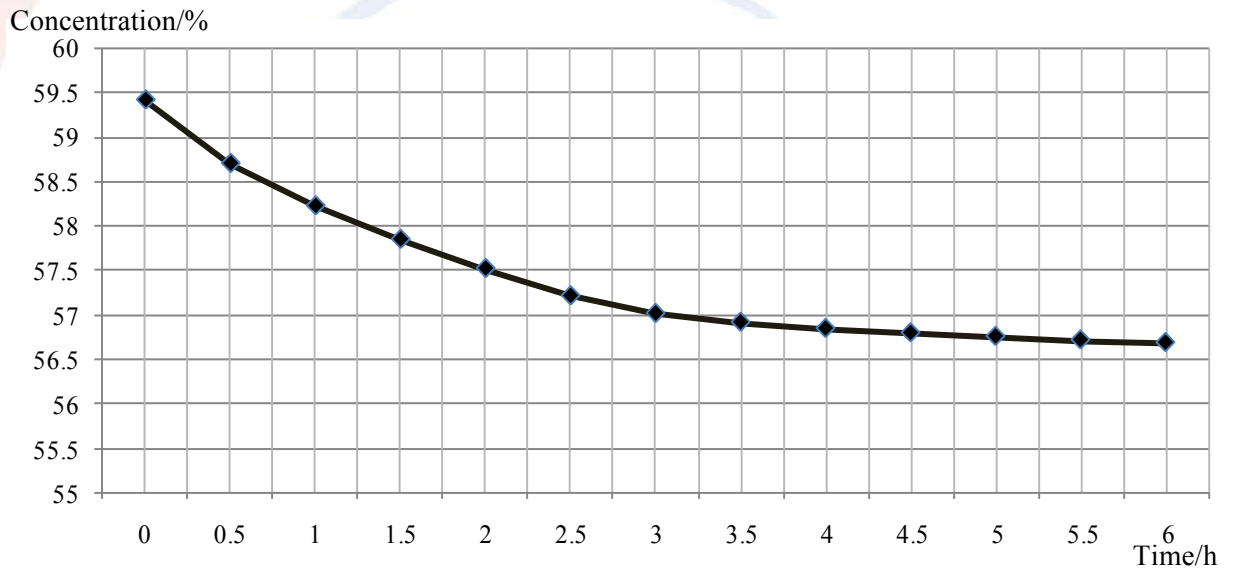


Fig.5: The concentration-time curve of LiBr solution in the Absorption cell

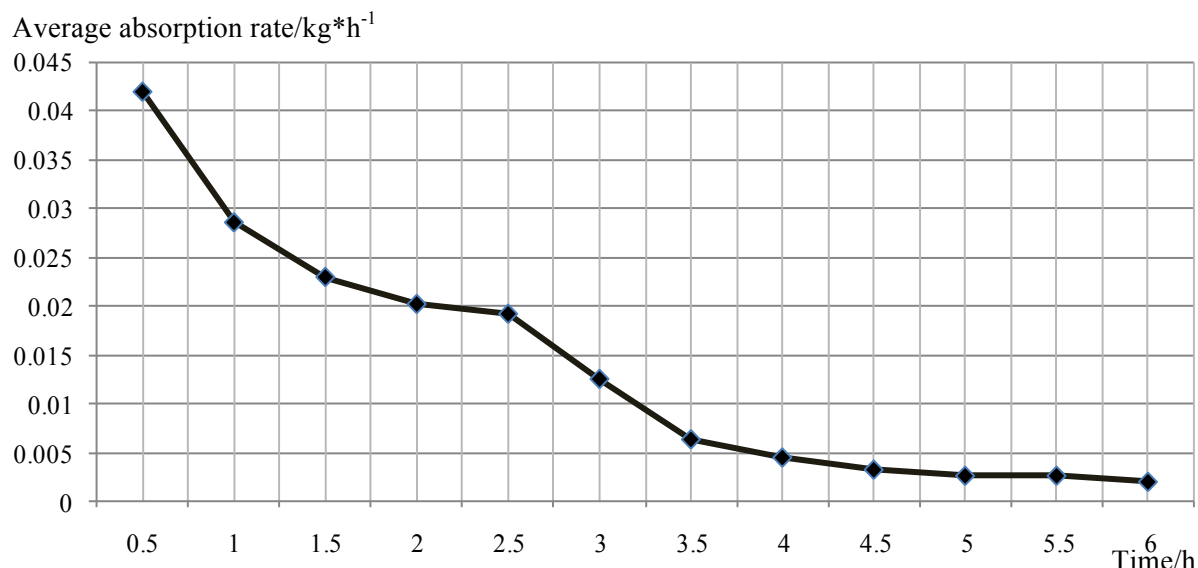


Fig.6: The absorption rate-time curve of LiBr solution in the Absorption cell

B. Distillation and condensation sections

To verify the conception of the distillation section and evaluate the performance of the system, we designed the experiments to calculate the energy needed and the quantity of water obtained theoretically in one cycle.

The experiment of the distillation section and the condensation section is unalienable. So we present the result of the experiments together in this part. The equipment setup is showed in Fig.7. In this preliminary work, we did not have solar energy equipment as we planned in the system design. So we used the electric heater instead. The effect of these two heaters is the same. The condition of the experiment is also $T = 20^{\circ}\text{C}$, $\text{RH} = 40\%$.

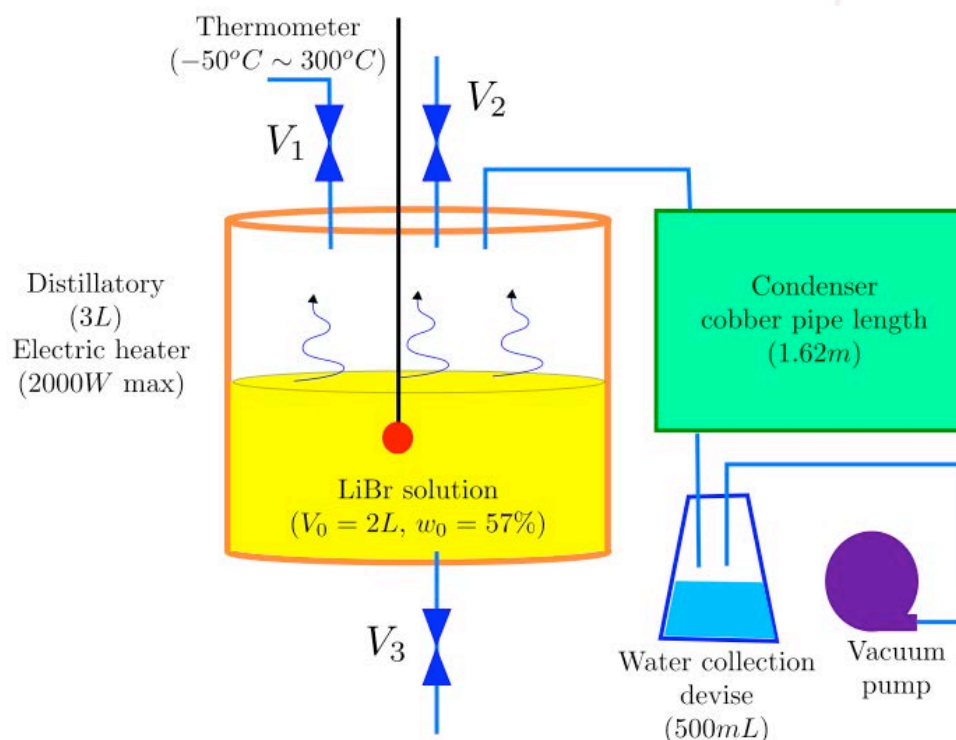


Fig.7: Equipment setup of experiments of distillation and condensation section

The main reaction vessel is made of glass and has a thickness of 3mm. It is cylindrical with an outer diameter of 130mm. When 2L solution is contained, the liquid level is about 165mm in the cylindrical reaction vessel. The reaction vessel is wrapped by electric heater of 2000W which automatically stops working when the temperature reaches at 300°C.

After a period of heating, the system reaches equilibrium. At the beginning of boiling, we switch the temperature controller to auto on/off mode and found that the heater works approximately 50% of working time, so the actual power of electrical heating can be regarded as $p = 1000W$.

The procedure of this experiment is complex as there is a change of the pressure and temperature. The whole steps are showed below:

1. Use the vacuum pump to make the pressure in the distillatory section to 0.1 bar.
2. Close the valves V2 V3, open V1. The LiBr solution then enter the distillatory section from V1. Close the valves V1. Heat the solution with the electric heater up to 110 and then stop heating. During this process, we measure the temperature of the solution every 1 minute after boiling. The vapor flows out of the distillatory and into the condenser where it is condensed and then is collected in the collection device.
3. Shut down the vacuum pump and open V2 to balance the pressure between environment and inside of the distillatory section.
4. Turn on V3 to make the solution flow out of the distillatory section.
5. Measure the density of the solution flow out.

The density of the solution after the process of distillation equals a concentration of 64% and the temperature-time curve obtained is showed in Fig.8.

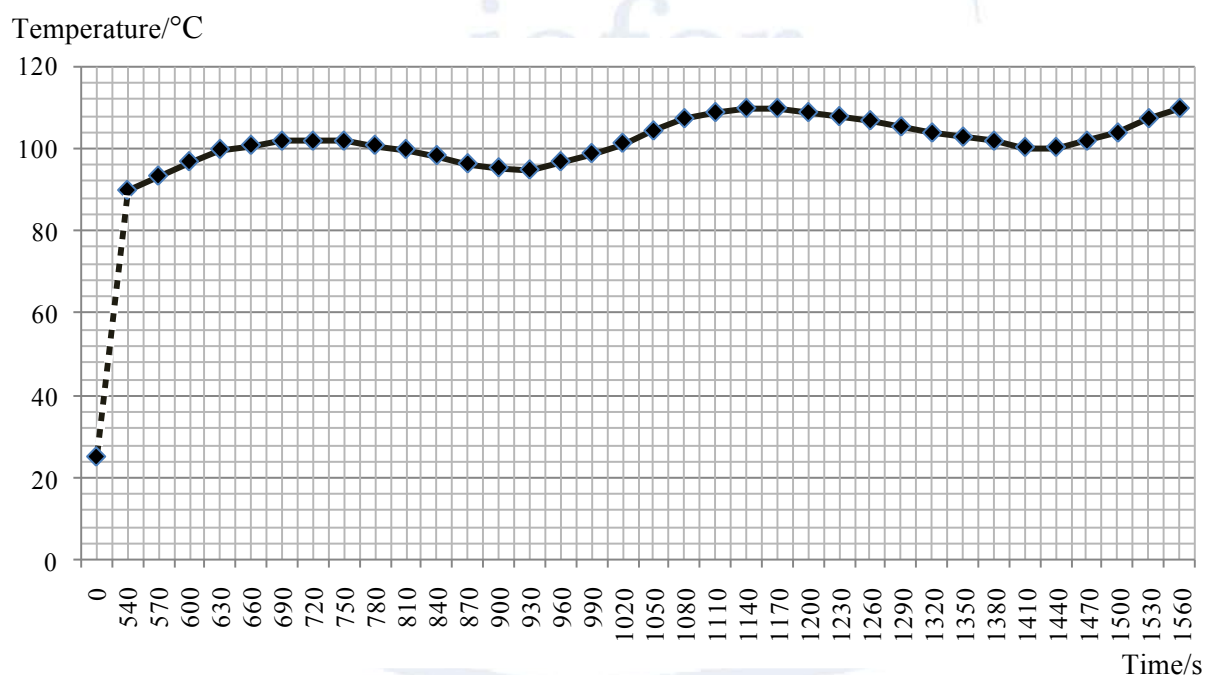


Fig.8: Temperature-Time curve of the LiBr solution in the experiment of distillation

The solution started to boil at 540s when the temperature reaches 90°C. Because of the low pressure (0.1 bar), the boiling point of the solution is lower than at the atmospheric pressure [11]. We stop the heating when the temperature reaches 110°C because if the temperature becomes higher than 110°C, the LiBr may crystallize in the distillatory. Now we can get the quantity of water collected during the experiment by Eq. 5.

$$\Delta m_{\text{water}} = m_0 - m_t = m_{\text{LiBr}} \left(\frac{1}{w_0} - \frac{1}{w_t} \right).$$

(5)

We can get the mass of LiBr in the solution by the Eq. 2 and then we can calculate the quantity of water obtained per second by Eq. 6.

$$q_e = \Delta m_{\text{water}} / \Delta t.$$

(6)

Given that $w_0 = 57\%$, $w_t = 64\%$, $V_0 = 2L$ and $\Delta t = 1560s$, we get that:

$$q_e = 364.58g / 1560s \approx 0.234g / s.$$

The energy needed for heating to get 1L of water can be calculated by the Eq. 7.

$$W_{\text{heater}} = (1000 / q_e) * p = 4273kJ.$$

(7)

The other energy needed is the energy used by the aerator and the vacuum pump. The vacuum pump works during the process of distillation.

$$W_{\text{vacuum}} = (1000 / q_e) * 180 = 770kJ \quad (8)$$

The aerator works during the process of absorption and the time to absorb 1L water from air is calculated by the Eq. 9.

$$T_{\text{aerator}} = 1000 / (\rho_0 * v_0 * w_0 * (1 / w_{3h} - 1 / w_0)) * 3 * 3600 = 73973s$$

(9)

Then we can calculate the energy used by the aerator by the Eq. 10.

$$W_{\text{aerator}} = T_{\text{aerator}} * 35 = 2589kJ$$

(10)

And we can get the total energy needed to get 1L of water is:

$$W = W_{\text{heater}} + W_{\text{aerator}} + W_{\text{vacuum}} = 7632kJ \quad (11)$$

Our system is quite energy consuming but it is reasonable as many improvement can be done on the energy efficiency of this preliminary experimental setup. With this setup, we can get nearly 0.234g water per second and it consumes 7632kJ energy to get 1L water.

3. Discussion

The new water collection system is based on the ability of hygroscopicity of the LiBr solution. So it depends little on the environment temperature. We compare our conception with the product "Dolphin1" from Air2Water Company [12]. The Dolphin 1 can only work when the temperature of the environment is about 30°C and the humidity is above 40%. While our system can work even when the temperature is about 0°C and the variation of temperature influence little our system. As long as the LiBr solution is in state of liquid, the system can function. The system demands that the water partial pressure of LiBr solution is smaller than the one of the air, so the LiBr solution can absorb the humidity in the air. The crystallization is also not preferred in the distillatory. So our system needs to work in the condition where the relative humidity is above

15%. When the humidity is below 15 %, the absorption rate becomes too small and a cycle may take a lot of time.

Meanwhile, our system consumes relatively a lot of energy compared to the Dolphin 1, which consumes 1565 kJ to get 1L water. However, as most of the energy is used to heat the solution (4273kJ), we could easily applied solar energy into our system to reduce the consumption of electrical energy. The main value of our system comes from the fact that we propose, in this work, a new water collection system which can work in a colder and drier condition than existing condensation system. Our system is more suitable for dry areas which have a lot of sunshine but a lack of water.

We have also examined the quality of water we had obtained to prove that there is no pollution of lithium bromide. We use the Silver nitrate solution to test lithium bromide because silver ions and bromide ions will produce silver bromide which is light yellow precipitate. We compare the water we obtained with the tap water and 5% lithium bromide solution. There is no visible precipitate in the water we obtained, proved that the concentration of bromide ion is lower than 7.43×10^{-7} mol/L, which is very low and harmless to human.

4. Conclusion

In this paper, we proposed a new water collection system based on the ability of hygroscopicity of LiBr solution coupled with the method of vacuum distillation. The new system can work in a drier and colder condition than the traditional water condensation system. The prototype we built verifies the feasibility of the system. It can collect about 0.23g water per second and consumes 7632kJ energy to get 1L of water. Water quality check confirms that the water we collected is not polluted by the LiBr. The bottleneck of the system is the absorption rate of the lithium bromide solution which reduces when the concentration of solution in the absorber is close to the saturation. The slow absorption rate prolonged the time of each cycle and thus reduces the efficiency. In order to improve our system, we are currently working on adding solar energy to the system to heat the solution and to provide the needed energy for the air blower and the vacuum pump. We are also working on a bigger absorption container maximizing the air/solution contact surface and on a better air blower to accelerate the humidity absorption rate of the LiBr solution. We would also like to set an automation system to control the valves based on the data obtained by sensors installed in the system. In this way the all cycle process will be autonomous.

5. Acknowledgements

We strongly thank the other students from the group who actively participated to the conception of the entire experiment. We would like to express our thankfulness to the laboratory of the Chemistry and Environment School of Beihang University who provide the laboratory to do the water quality check. We would also like to thank Greenwater project from Shin Development Association and Center of Condensed Matter and Materials Physics of Beihang University who supervise us and provide us the fund to do the research.

References

- [1] Information on http://en.wikipedia.org/wiki/Water_resources.
- [2] Jones, A.T. , Campbell, R.L. (2005) Seawater Desalination: A Generalized Model for Feedwater Intakes, OCEANS, Proceedings of MTS/IEEE, Vol. 3, p. 2647 – 2651.
- [3] Hou Yukun , Kang Ya, Li Tao, Meng Yanbin. (2009) Treatment of polluted surface water from Yellow River (China) with high-density sedimentation tank and ultra-filtration: Pilot scale studies, 3rd International Conference on Bioinformatics and Biomedical Engineering, p. 1 – 4.
- [4] Shaoming Lu, Yongfei Yang, Changhao Hu, Jincui Liu, Shaowen L, Jianyong Guo. (2011) Engineering Demonstration of Micro-polluted Water Pretreatment with High-rate Up-flow Biological Aerated Filter, International Conference on Multimedia Technology, p. 4408 – 4413.
- [5] Rongli Yu, Lina Sun, Tieheng Sun. (2009) Research and application of microbial flocculants in sewage treatment and sludge dewatering, 3rd International Conference on Bioinformatics and Biomedical Engineering , p. 1-4.
- [6] Raghied M. Atta, (2011) Solar Water Condensation Using Thermoelectric Coolers, International Journal of Water Resources and Arid Environments 1(2): p. 142-145.
- [7] Information from: China Meteorological Data Sharing System.
- [8] Yang Hua, Zhang Kang, Qi Chengying, Ren Yan, Wang Huajun. (2010) Experimental Investigation of Operation Characteristics of a Thermoelectric Dehumidifier, 3rd International Conference on Knowledge Discovery and Data Mining, p. 163-166.
- [9] Dai Yongqing. Practical handbook of LiBr absorption refrigeration technology, Published by China Machine Press, Beijing.
- [10] ZHANG Hong-yan, Dong Suxia, Zhangsong Wei, Fan wide. Application of Dilling curve in the lithium bromide absorption chiller. Refrigeration technology, 2001. vol 2, p. 19~ 23.
- [11] Xin-Gang. Modern distillation technology. Beijing: Chemical Industry Press.
- [12] Information on <http://www.alibaba.com/product-gs/525425153/Air2Water.html>

Assessment of Productive and Environmental Efficiencies of Japanese Industries

Mika Goto*¹, Akihiro Otsuka*¹, Toshiyuki Sueyoshi*²

*¹Central Research Institute of Electric Power Industry, Japan, *²New Mexico
Institute of Mining & Technology, USA

0621

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The global warming and climate change becomes a major policy issue in the world. To partly deal with the climate change issue from economics and business concerns, this study proposes a use of Data Envelopment Analysis (DEA) as a methodology for unified (operational and environmental) assessments. The proposed DEA approach has been long serving as an important methodology to evaluate the performance of various organizations. Recently, many researchers have applied DEA to various environmental issues. A contribution of the previous DEA studies was that they found the importance of an output separation into desirable (good) outputs and undesirable (bad) outputs (e.g., CO₂ emission and air pollution substances from production activities). Acknowledging a contribution of these previous studies on DEA environmental assessment, this study classifies efficiency measures into the two categories according to the treatment of undesirable outputs: (a) productive efficiency and (b) unified efficiency under natural disposability. The first efficiency does not incorporate undesirable outputs in the performance evaluation, while the second measure incorporates them to the environmental assessment. Using a data set regarding the manufacturing industries of 47 prefectures in Japan, this study examines their productive and environmental efficiencies to obtain policy implications. The important empirical finding suggests that Japanese regional industries need to make their further efforts to reduce air pollution substances and increase energy efficiency.

Key Words: Environmental Assessment, Disposability, Energy Efficiency

1. Introduction

After the two oil crises in the 1970s, Japan diversified its energy sources through an increased use of nuclear energy, natural gas and coal to reduce the dependency on oil. Manufacturing industries, representing a majority of energy consumption in Japan, have worked on progressing energy conservation and improving energy efficiency. It is known that Japan has few energy resources, so depending on import for 96% of its primary energy supply. Even the nuclear generation is considered as domestic energy, the energy import dependency is still at 82%. Despite the efforts for energy conservation and increasing energy efficiency, oil still accounts for about 40% of Japan's primary energy supply and most of them come from the politically unstable Middle East region. As a result, the Japanese energy supply structure is vulnerable. See Energy White Paper [1].

Since the Great East Japan Earthquake in 2011, such efforts have become more important than before because all nuclear units stop their operations with an exception of only two units in 2013. Approximately 90% of electricity consumption in Japan is produced by fossil fuel power plants. Such conditions resulted in a tight relationship between demand and supply on electricity and increased import of fossil fuels from abroad. Currently Japan faces a major policy change on the energy that is directed towards more renewable resources and less dependency on nuclear power generation. The Japanese government has begun a new policy discussion on Basic Energy Plan regarding a future desirable energy mix.

Along with a shift to the new energy mix after the earthquake in 2011, Japan needs to pay attention to the climate change and global warming in the world. Since the Kyoto Protocol came into effect in 2005, Japanese government promoted environmental policy to reduce GHG (Greenhouse Gas) emissions from a use of fossil fuels. The manufacturing industries are important contributors to the growth of Japanese economy and they have been major contributors for Japanese regional economy. Meanwhile, they are major producers of GHG emissions such as CO₂. In 2011, industry sector as a whole accounts for approximately 34% of CO₂ emission. That is the largest among all sectors for the amount of CO₂ emission, although its share gradually decreases over time. The introduction of CO₂ emission trading scheme had been discussed, but that is not yet determined in Japan.

However, there is a voluntary institution within Japanese industries that continues to promote environmental protection. To achieve the environmental protection goals through global competition, the industries need to improve their productive efficiency and to satisfy environmental requirements in such a manner that they can balance between them for the development of a sustainable society. Under such a business condition, technology innovation in production is essential for Japanese industries. The technology innovation, arising from environmental constraints, is usually associated with an environment-friendly, energy-efficient production system, as discussed by Porter and van der Linde [2]. They stated that corporate efforts for improving the productivity of an entire manufacturing process under environmental regulations resulted in both improving productivity and environmental protection. The assertion is

often referred to as “Porter Hypothesis” in corporate strategy.

The purpose of this study is to examine the productive and environmental performance of manufacturing industries in 47 prefectures (local government units in Japan which correspond to states in the United States). The examination reveals the importance of improved energy efficiency and environmental protection for the manufacturing industries in Japan to attain higher performance. In this study, the achievement of Japanese industries is measured by their unified (operational and environmental) efficiencies. For the research purpose, this study proposes a new use of DEA (Data Envelopment Analysis) environmental assessment, in which desirable and undesirable outputs are combined together under a disposability concept related to environmental strategy. See, for example, recent studies [3,4] for innovative uses of DEA in the area of energy policy and economics.

The reminder of this paper is organized as follows. Section 2 describes DEA environmental assessment as a managerial methodology for enhancing the productive and environmental performance of industries. Section 3 exhibits a data set regarding the manufacturing industries in the 47 prefectures. Section 4 summarizes our empirical results and discusses related policy implications. Section 5 concludes this study along with future research extensions.

2. Methodology

2.1 Previous Efforts on DEA Environmental Assessment

To combat the climate change, many previous studies proposes DEA as a methodology for environmental assessment. See, for example, [5-15] and many other articles published in the past decade. As discussed in the previous efforts, DEA was originally developed as a managerial methodology to evaluate the performance of various organizations in public and private sectors. A contribution of the previous studies in environmental assessment was that they separated outputs into desirable and undesirable ones. An important issue to be considered is how to unify these different outputs to assess the performance of organizations from their production and environmental concerns. See [15] that summarized more than 100 articles in environment and energy studies. As a result of their contributions, DEA environmental assessment can serve as an empirical methodology for planning and developing a sustainable society where economic prosperity can coexist with environmental protection. This study will fully utilize the research wisdom explored in the previous studies.

2.2 Natural Disposability

To discuss DEA environmental assessment, this study needs to describe a strategic concept related to environmental protection [16-18], which is referred to as “natural disposability”, indicating that an organization decreases the directional vector of inputs to decrease the directional vector of undesirable outputs. Given the reduced vector of

inputs, the organization increases the directional vector of desirable outputs as much as possible. This study considers the natural disposability as a negative adaptation to a change on environmental regulation because it does not invest for technology innovation but decreases inputs to cope with government regulation on undesirable outputs.

Figure 1 visually describes the relationship between desirable and undesirable outputs under natural disposability. The functional form (f) is expressed by $g = f(b)$ where g and b stands for desirable (good) and undesirable (bad) outputs. The figure depicts the natural disposability to respond to a regulation change on an undesirable output. As in Figure 1, an organization reduces the amount of an input to decrease the amount of an undesirable output (from b_n to b_r) until it satisfies the level of an undesirable output that is required by governmental regulation. Under the condition, the organization tries to maximize the desirable output as much as possible (from g_n to g_r) under natural disposability to enhance its productive and environmental unified efficiency.

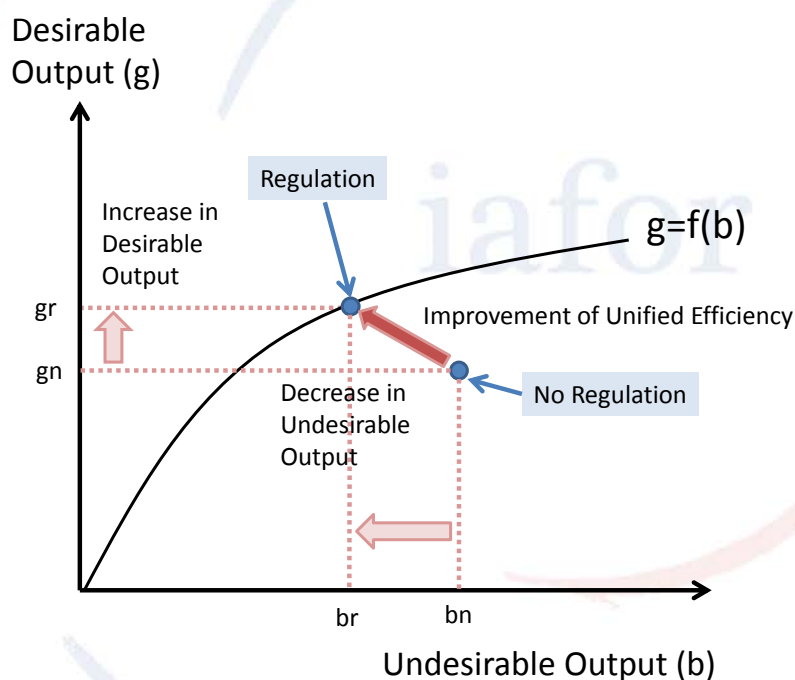


Figure 1: Natural Disposability

As discussed above, the concept on natural disposability originates from corporate strategy to adapt a regulation change on undesirable outputs. The natural disposability responds negatively to the regulation change because it does not invest in the production system for introducing technology innovation. This study is fully aware of an existence of other strategic alternatives in which firms respond positively to the regulation change by considering it as a new business opportunity, or they shift production facilities to a region and a country with less environmental regulation. However, this study excludes such strategic alternatives and focuses on the negative adaptation to the regulation change.

Finally, using an axiomatic expression, production technology to express natural disposability is formulated by the following two types of output vectors and an input vector, respectively [17, 18]:

$$P^n(X) = \left\{ (G, B) : G \leq \sum_{j=1}^n G_j \lambda_j, B \geq \sum_{j=1}^n B_j \lambda_j, X \geq \sum_{j=1}^n X_j \lambda_j, \sum_{j=1}^n \lambda_j = 1, \lambda_j \geq 0 \right\}.$$

In the axiomatic expression, this study considers n DMUs (Decision Making Unit, e.g., corresponding to an organization in private and public sectors). $X \in R_+^m$ is an input vector, $G \in R_+^S$ is a desirable output vector and $B \in R_+^h$ is an undesirable output vector of each DMU. The subscript (j) stands for the j -th DMU and λ_j indicates the j -th intensity variable ($j = 1, \dots, n$) that connects data points to construct a convex hull (part of an efficiency frontier) in a data domain.

2.3 Productive Efficiency

This study starts with describing a non-radial model to measure productive efficiency, or *PE* of the k -th DMU. Since this study employs the non-radial measurement, the level of inefficiency is determined by slacks. The operational efficiency does not consider an influence of undesirable outputs in the efficiency measurement, which is thus based on the fundamental framework of conventional production economics. The *PE* measure regarding the k -th DMU is obtained by the following non-radial model [19]:

$$\begin{aligned} & \text{Maximize} && \sum_{i=1}^m R_i^x d_i^x + \sum_{r=1}^s R_r^g d_r^g \\ & \text{s.t.} && \sum_{j=1}^n x_{ij} \lambda_j + d_i^x = x_{ik} && (i = 1, \dots, m), \\ & && \sum_{j=1}^n g_{rj} \lambda_j - d_r^g = g_{rk} && (r = 1, \dots, s), \\ & && \sum_{j=1}^n \lambda_j = 1, \\ & && \lambda_j \geq 0 \quad (j = 1, \dots, n), \quad d_i^x \geq 0 \quad (i = 1, \dots, m), \\ & && \text{and } d_r^g \geq 0 \quad (r = 1, \dots, s). \end{aligned} \tag{1}$$

The two production factors are expressed by $X_j = (x_{1j}, x_{2j}, \dots, x_{mj})^T$ and $G_j = (g_{1j}, g_{2j}, \dots, g_{sj})^T$. The superscript “ T ” indicates a vector transpose. It is assumed that $x_j > 0$ and $G_j > 0$ for all $j = 1, \dots, n$, where the inequality is applicable to all components of the two vectors.

Slacks regarding inputs and desirable outputs are specified by $d_i^x (i = 1, \dots, m)$ and $d_r^g (r = 1, \dots, s)$, respectively in Model (1). A column vector of intensity variables are expressed by $\lambda = (\lambda_1, \dots, \lambda_n)^T$. They are used for connecting the input and output vectors by a convex combination. Since the sum of structural variables is restricted to be unity in Model (1), the production possibility set is structured under variable RTS (Returns to Scale).

The data ranges (R) in Model (1) are determined by the upper and lower bounds of the two production factors. They are specified as follows:

$$R_i^x = (m + s)^{-1} \left(\max \{x_{ij} \mid j = 1, \dots, n\} - \min \{x_{ij} \mid j = 1, \dots, n\} \right)^{-1} \text{ and}$$

$$R_r^g = (m + s)^{-1} \left(\max \{g_{rj} \mid j = 1, \dots, n\} - \min \{g_{rj} \mid j = 1, \dots, n\} \right)^{-1}.$$

After solving Model (1), the level of OE is determined by

$$\theta^* = 1 - \left(\sum_{i=1}^m R_i^x d_i^{x*} + \sum_{r=1}^s R_r^g d_r^{g*} \right). \quad (2)$$

Here, slacks within the parentheses are obtained from optimality of Model (1).

2.4 Unified Efficiency under Natural Disposability

The research of [17, 18] has proposed the following model to measure the unified efficiency (UEN) of the k -th DMU under natural disposability after incorporating a vector of undesirable outputs or $B_j > 0$ where $B_j = (b_{1j}, b_{2j}, \dots, b_{hj})^T$:

$$\begin{aligned} & \text{Maximize} && \sum_{i=1}^m R_i^x d_i^x + \sum_{r=1}^s R_r^g d_r^g + \sum_{f=1}^h R_f^b d_f^b \\ \text{s.t.} &&& \sum_{j=1}^n x_{ij} \lambda_j + d_i^x = x_{ik} && (i = 1, \dots, m), \\ &&& \sum_{j=1}^n g_{rj} \lambda_j - d_r^g = g_{rk} && (r = 1, \dots, s), \\ &&& \sum_{j=1}^n b_{fj} \lambda_j + d_f^b = b_{fk} && (f = 1, \dots, h), \\ &&& \sum_{j=1}^n \lambda_j = 1, \\ &&& \lambda_j \geq 0 \quad (j = 1, \dots, n), \quad d_i^x \geq 0 \quad (i = 1, \dots, m), \\ &&& d_r^g \geq 0 \quad (r = 1, \dots, s), \quad \text{and} \quad d_f^b \geq 0 \quad (f = 1, \dots, h). \end{aligned} \quad (3)$$

Since Model (3) measures unified (productive and environmental) efficiency, undesirable outputs are incorporated into the model. Slacks regarding undesirable outputs are specified by d_f^b ($f = 1, \dots, h$). Using the upper and lower bounds of inputs, desirable outputs and undesirable outputs, their data ranges are specified as follows:

$$R_i^x = (m + s + h)^{-1} \left(\max \{x_{ij} \mid j = 1, \dots, n\} - \min \{x_{ij} \mid j = 1, \dots, n\} \right)^{-1},$$

$$R_r^g = (m + s + h)^{-1} \left(\max \{g_{rj} \mid j = 1, \dots, n\} - \min \{g_{rj} \mid j = 1, \dots, n\} \right)^{-1} \text{ and}$$

$$R_f^b = (m + s + h)^{-1} \left(\max \{b_{fj} \mid j = 1, \dots, n\} - \min \{b_{fj} \mid j = 1, \dots, n\} \right)^{-1}.$$

Model (3) considers only negative deviations d_i^x ($i = 1, \dots, m$) to attain the natural disposability where all inputs decrease to improve the productive efficiency of the k -th DMU, while satisfying the regulation requirement on undesirable outputs. A unified efficiency score (θ^*) of the k -th DMU under natural disposability is measured by slightly modifying Equation (2), so becoming

$$\theta^* = 1 - \left(\sum_{i=1}^m R_i^x d_i^{x*} + \sum_{r=1}^s R_r^g d_r^{g*} + \sum_{f=1}^h R_f^b d_f^{b*} \right), \quad (4)$$

where the inefficiency score and all slack variables are determined on optimality of Model (3). The equation within the parenthesis, obtained from the optimality of Model (3), indicates the level of unified inefficiency under natural disposability. The unified efficiency is obtained by subtracting the level of inefficiency from unity.

3. Data

Table 1 summarizes descriptive statistics of Japanese manufacturing industries. This study considers three inputs to produce both a desirable output and four undesirable outputs. The three inputs are the amount of labor, capital, and energy. The labor, as an input, is determined by the number of employees multiplied by the index of working hours, which is standardized by year 2000 (unit: index). The amount of capital, as another input, is a capital stock of private-sector firms multiplied by the rate of operation regarding capital assets, standardized by year 2000 (unit: index). The amount of energy is the final energy consumption (unit: 1,000 Terajoule).

A desirable output is the real GPP (Gross Prefecture Product, unit: 100 billion yen). Four undesirable outputs are the amount of carbon emissions (unit: 10,000 ton Carbon), SO_x emissions (unit: 100 kNm³), NO_x emissions (unit: 100 kNm³) and dust emissions (unit: 10 ton per annual).

All data sets constitute for each 47 Japanese prefecture for the year 2002, 2005 and 2008, each of which is related to manufacturing industries and non-manufacturing industries.

The data sources are as follows. The number of employees and the capital stock of private-sector firms are from the regional database of CRIEPI (Central Research Institute of Electric Power Industry). The index of working hours is obtained from the survey on a work force by Ministry of Internal Affairs and Communications and the monthly survey on labor statistics by Ministry of Health, Labor and Welfare. The index of rate of operation on manufacturing industries is obtained from statistics of rate of operation regarding capital for mining and manufacturing industries, prepared by Ministry of Economy, Trade and Industry. The data source concerning the amount of final energy consumption is the energy consumption statistics for each prefecture, prepared by Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry.

Table 1: Descriptive Statistics of Manufacturing Industries

Outputs and Inputs		Desirable Output	Undesirable Outputs				Inputs		
Variables		Real Gross Prefecture Product	Carbon Emissions	SOx Emissions	NOx Emissions	Dust Emissions	Labor	Capital	Energy
Unit		100 Billion JPY	10,000 ton Carbon	100 kNm ³ (kilo-newton per cubic-meter) per Annual	100 kNm ³ (kilo-newton per cubic-meter) per Annual	10 ton per Annual	Index	Index	1,000 Tera Joule
2002	Avg.	22.3920	178.9503	25.0987	52.1242	83.8218	23.1470	69.3575	138.4510
	Max.	114.4226	1678.2387	138.5414	241.4170	336.1282	102.8552	341.4123	1031.8996
	Min.	1.9242	3.4962	0.8447	3.6130	3.4280	2.8959	6.6641	9.6391
	S.D.	24.0486	314.6423	28.5836	51.7796	80.0926	23.2401	68.2247	192.4770
2005	Avg.	26.6152	175.1315	22.2721	53.5589	80.9142	22.8297	78.4672	138.1335
	Max.	139.1626	1669.7059	107.2844	252.7304	353.3633	101.1612	398.2985	1026.8958
	Min.	1.9366	2.7995	1.0402	4.4471	3.9850	2.9795	7.7023	10.5616
	S.D.	28.5525	311.9574	23.8799	53.0294	81.2209	22.7059	77.0281	192.4507
2008	Avg.	27.9972	157.1507	16.1879	41.1374	64.8745	22.4823	77.5445	126.3314
	Max.	129.2511	1417.4103	75.2500	234.1000	296.4000	98.9933	402.2377	883.1531
	Min.	2.0585	2.5986	0.3300	1.0800	2.2000	3.1571	7.6103	10.9340
	S.D.	28.4268	274.4460	17.2381	46.3464	67.1028	22.1069	75.4925	170.6623
Total	Avg.	25.6681	170.4108	21.1862	48.9402	76.5368	22.8197	75.1231	134.3053
	Max.	139.1626	1678.2387	138.5414	252.7304	353.3633	102.8552	402.2377	1031.8996
	Min.	1.9242	2.5986	0.3300	1.0800	2.2000	2.8959	6.6641	9.6391
	S.D.	27.0024	298.9037	23.8197	50.4152	76.3195	22.5280	73.2690	184.2389

The real GPP is obtained from prefecture economic accounts prepared by Cabinet Office. The amount of carbon emissions is obtained from energy consumption statistics for each prefecture by Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry. The data source of other undesirable outputs: (a) SOx emissions, (b) NOx emissions, and (c) dust emissions; is the survey of air pollution substances conducted by the Ministry of Environment.

Table 1 indicates that the real GPP of Japanese prefectures increases over the observed period, while all undesirable outputs such as carbon emissions and two inputs (i.e., labor and energy) decrease during the same period in the manufacturing industries. An amount of capital increases over the observed period. This indicates that the Japanese manufacturing industries make their corporate efforts to improve their operational and environmental performance by decreasing the amounts of labor and energy inputs and increasing the amount of capital to introduce technology innovation.

4. Empirical Results

4.1 Efficiency Measures

Table 2 summarizes the two types of efficiency measures regarding manufacturing industries, which are measured by Models (1) and (3), respectively. Figure 2 visually describes the average efficiency in the three annual periods.

Table 2: Results of *PE* and *UEN*

Industries	Manufacturing Industries			
Year	2002	2005	2008	Total
Statistics	Productive Efficiency (<i>PE</i>)			
Avg	0.9384	0.9522	0.9646	0.9517
Max	1.0000	1.0000	1.0000	1.0000
Min	0.6860	0.7072	0.8331	0.6860
S.D.	0.0680	0.0605	0.0413	0.0583
Statistics	Unified Efficiency under Natural Disposability (<i>UEN</i>)			
Avg	0.8880	0.9076	0.9385	0.9114
Max	1.0000	1.0000	1.0000	1.0000
Min	0.4885	0.5155	0.7106	0.4885
S.D.	0.1189	0.1071	0.0754	0.1035

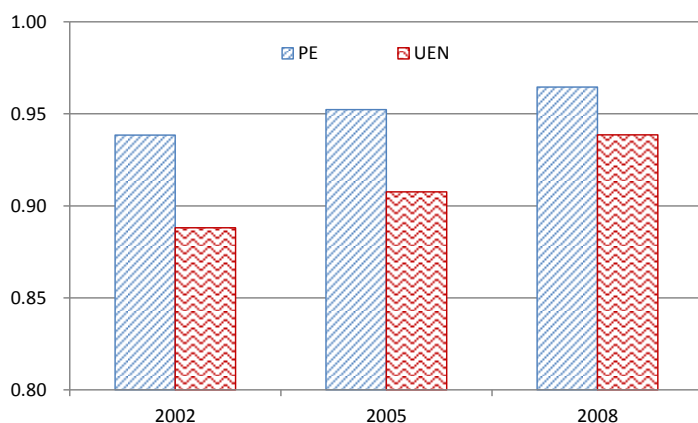


Figure 2: Efficiency Measures of Manufacturing Industries

The findings from Table 2 and Figure 2 are summarized as follows: First, two efficiency measures increased from 2002 to 2008. For instance, *PE* increased from 0.938 to 0.965 and *UEN* from 0.888 to 0.939 for the manufacturing industries in the three annual periods. This indicates that Japanese manufacturing industries made the corporate efforts for improving their performance on productive and unified efficiency. Second, the result indicated that the efficiency scores became lower when undesirable outputs, or environmental factors, were incorporated into the proposed DEA assessment. Furthermore, *PE* had the smaller variation among prefectures in a similar level of efficiency, than *UEN*. The result implied that manufacturing industries in all Japanese prefectures made similar level of efforts for improving their productive performance. In other words, the productive and environmental unified performance of Japanese manufacturing industries was less important than their productive performance.

4.2 Sources of Inefficiency

In this section, this study is interested in what production factors are sources of the

inefficiency explored in Section 4.1. Since this study employs non-radial DEA models, each slack is related to each production factor and the slack directly links to a level of inefficiency. Thus, it is possible for us to identify the sources of inefficiency by examining the level of slacks regarding production factors. To explore the research concern, this study measures a ratio of each adjusted slack to the total sum of adjusted slacks. For example, the inefficiency related to each input i ($i = 1, \dots, m$) is expressed by

$$R_i^x d_i^{x*} / \left(\sum_{i=1}^m R_i^x d_i^{x*} + \sum_{r=1}^s R_r^g d_r^{g*} \right) \text{ for Model (1), and}$$

$$R_i^x d_i^{x*} / \left(\sum_{i=1}^m R_i^x d_i^{x*} + \sum_{r=1}^s R_r^g d_r^{g*} + \sum_{f=1}^h R_f^b d_f^{b*} \right) \text{ for Model (3).}$$

The denominator of the above ratios indicates the level of inefficiency, which is expressed by the second term of the right-hand side of Equations (2) and (4), respectively.

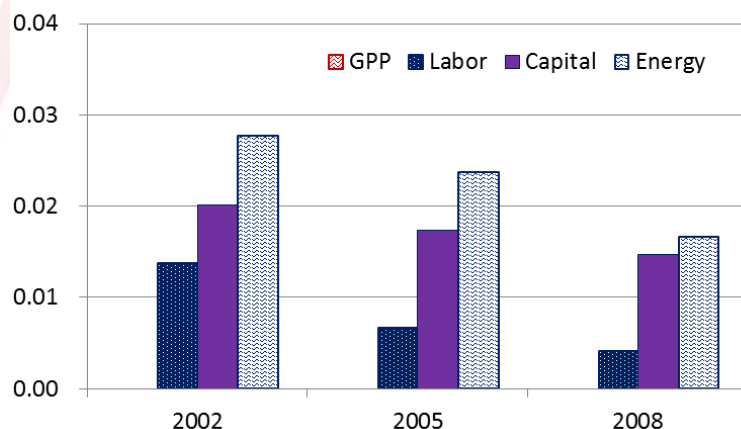


Figure 3: Slacks Used to Measure Productive Efficiency Measures

Figure 3 visually describes the average of each adjusted input slack to “productive inefficiency” from 2002 to 2008 on the manufacturing industries. The magnitude of the vertical axis in Figure 3 is standardized on the range from 0 to 0.04.

Figure 3 depicts that an amount of energy is the largest production factor to produce the productive inefficiency. This indicates that the level of energy efficiency is important for their operational performance.

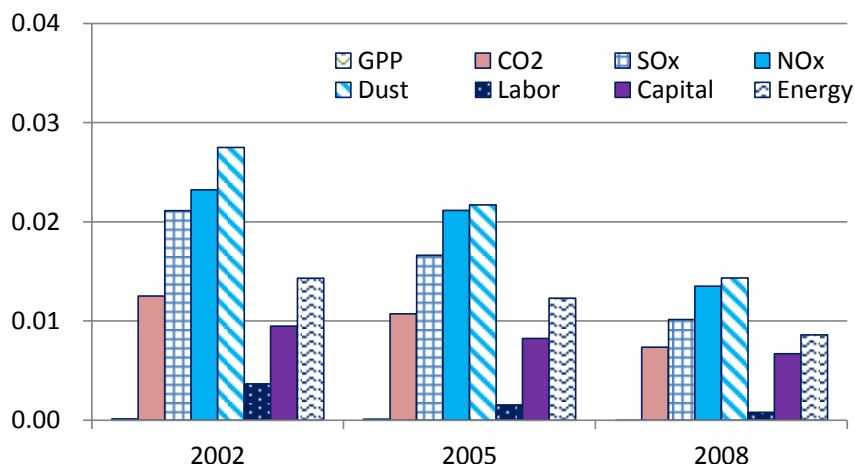


Figure 4: Slacks Used for Measuring Unified Efficiency under Natural Disposability

Figure 4 shows an annual change of slacks used to measure unified efficiency under natural disposability (*UEN*) on the manufacturing industries. It is easily found in Figure 4 that four undesirable outputs (i.e., CO₂, SO_x, NO_x and dust emissions) dominate their unified inefficiency measures. The amounts of energy and capital still explain a significant part of unified inefficiency. Therefore, the reduction of undesirable outputs and capital, and the improvement in energy consumption are important measures for regional manufacturing industries to attain a high level of unified (productive and environmental) performance. Figure 4 visually describes that the manufacturing industries in some prefectures attain a high level of unified efficiency by controlling their undesirable outputs, energy and capital.

In summary, undesirable outputs produce a large difference in efficiency measures among prefectures, because some prefectures successfully manage the reduction of undesirable outputs, while the others do not. Such a difference among prefectures is also due to their energy and capital usages.

4.3 Regional Differences in Efficiency Measures

The data set used in this study consists of Japanese 47 prefectures. They are geographically classified into nine regions from north to south: (a) Hokkaido, (b) Tohoku, (c) Kanto, (d) Chubu, (e) Kinki, (f) Chugoku, (g) Shikoku, (h) Kyushu and (i) Okinawa.

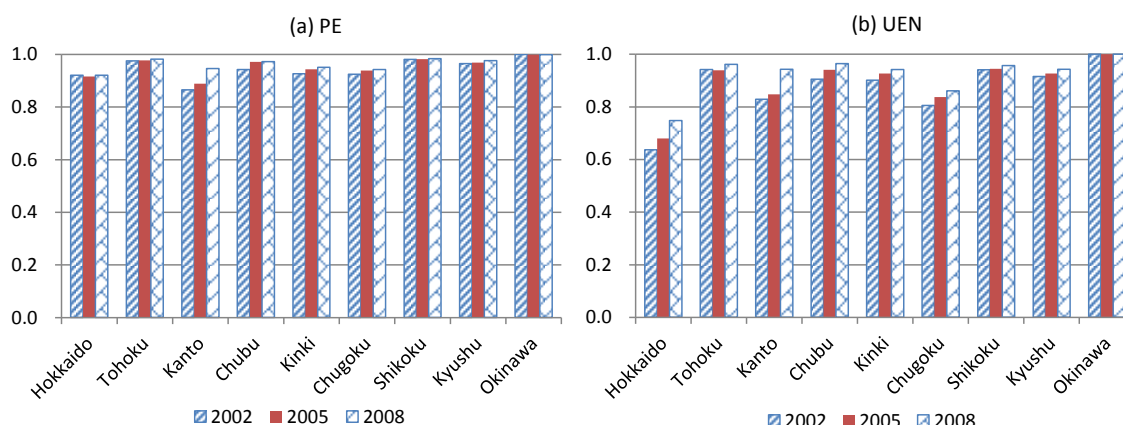


Figure 5: Regional Differences of Efficiency Measures in Manufacturing Industries

Figure 5 depicts the productive efficiency (PE) and the unified efficiency measure (UEN) of the nine regions. The left hand side of Figure 5 is related to the PE . The right hand side is for the UEN for the manufacturing industries.

The two efficiency measures exhibited different patterns among nine regions. For example, the regional variation on PE was relatively small, but the PE of Hokkaido was slightly lower than that of the other regions, whereas the other regions were almost same in the level of the PE . Shifting our interest from PE to UEN , the regional variations of UEN were larger than those of PE as discussed in Section 4.1, although there was a similar trend between PE and UEN . That is, Hokkaido was the lowest among the regions, followed by Chugoku with respect to both PE and UEN . The lower efficiency measures in Hokkaido and Chugoku implied that these areas may have a future potential to improve their unified efficiency measures by changing their industrial structures.

5. Conclusion

This study proposed the DEA models for the two efficiency measures such as PE and UEN . This study applied them to a data set, consisting of Japanese manufacturing industries in 47 prefectures. The measurement of PE did not incorporate undesirable outputs whereas those of UEN incorporated undesirable outputs in their assessments.

This study found four empirical results, which were summarized as follows. First, the PE and UEN in the manufacturing industry indicated an efficiency improvement from 2002 to 2008. Second, the level of efficiency decreased when the DEA model incorporated undesirable outputs. In particular, four undesirable outputs were major sources of inefficiency in UEN , which indicated there were wider variations among prefectures on controlling undesirable outputs, compared to the management efforts for increasing desirable outputs. The desirable output did not make a similar level of inefficiency. Meanwhile, the amount of energy was the largest source of inefficiency in PE . It also explained a large part of inefficiency in UEN for manufacturing industries. Third, the amount of capital caused a certain level of inefficiency in UEN of the

manufacturing industries. Finally, Hokkaido and Chugoku were lower than the other regions in terms of efficiency. The difference in efficiency measures of the two regions with the others are larger in *UEN* than *OE*.

These findings suggest Japanese regional industries need to make their further effort to reduce air pollution substances. The improvement can be achieved by investing in technology innovation. Such an effort requires a certain amount of capital for the investment. In addition, it is true that the investment takes a time until its result appears, depending upon the condition of macro economy, an investment cycle and other regional factors. In particular, the manufacturing industries in Hokkaido and Chugoku have potential to improve their productive and environmental performance by introducing technology innovation. This study did not examine such a positive adaptation of industries to the regulation.

Although this study examined *PE* and *UEN* regarding Japanese regional industries, their industrial structures were different among regions. Each region has its intrinsic industrial structure. The difference influences the level of efficiency measures concerning each region, particularly when the assessment included environmental factors such as GHG emissions. Thus, it is necessary for this study to investigate the relationship between the level of efficiency measures and the industrial structure of regions. That will be an important future research task.

Finally, it is hoped that this study makes a contribution on DEA environmental assessment and Japanese regional study. We look forward to seeing future research extensions as discussed in this study.

Acknowledgements

This work is supported by JSPS Grant-in-Aid for Scientific Research (C) 24530287.

References

- [1] Energy White Paper (2010), <http://www.enecho.meti.go.jp/topics/hakusho/2010energyhtml/index.html/>. (in Japanese).
- [2] Porter, M. E., van der Linde, C., 1995. Toward a new conception of the environment competitiveness relationship. *Journal of Economic Perspectives* 1995; 9: 97-118.
- [3] Sarica, K., Or, I. Efficiency assessment of Turkish power plants using data envelopment analysis. *Energy* 2007; 32: 1484-1499.
- [4] Fallahi, A., Ebrahimi, R., Ghaderi, S.F. Measuring efficiency and productivity change in power electric generation management companies by using data envelopment analysis: a case study. *Energy* 2011; 36: 6398-6405.
- [5] Dyckhoff, H., Allen, K. Measuring ecological efficiency with data envelopment analysis (DEA). *European Journal of Operational Research* 2011; 132: 312-325.
- [6] Korhonen, P.J., Luptacik, M., Eco-efficiency analysis of power plants: An extension of data envelopment analysis. *European Journal of Operational Research* 2004; 54: 437-446.
- [7] Kumar, S. Environmentally sensitive productivity growth: A global analysis using Malmquist-Luenberger index. *Ecological Economics* 2006; 56: 280-293.

- [8] Picazo-Tadeo, A.J., Reig-Martínez, E., Hernández-Sancho, F. Directional distance functions and environmental regulation. *Resource and Energy Economics* 2005; 27: 131-142.
- [9] Lozano, S., Gutierrez, E. Non-parametric frontier approach to modeling the relationship among population, GDP, energy consumption and CO2 emission. *Ecological Economics* 2008; 66: 687-699.
- [10] Pasurka Jr., C.A. Decomposing electric power plant emissions within a joint production framework. *Energy Economics* 2006; 28: 26-43.
- [11] Thakur, T., Deshmukh, S.G., Kaushik, S.C. Efficiency evaluation of the state owned electric utilities in India. *Energy Policy* 2006; 34: 2788-2804.
- [12] Zaim, O. Measuring environmental performance of state manufacturing through changes in pollution intensities: A DEA framework. *Ecological Economics* 2004; 48: 37-47.
- [13] Zhang, B., Bi, J., Fan, Z., Yaun, Z., Ge, J. Eco-efficiency analysis of industrial system in China: a data envelopment analysis. *Ecological Economics* 2008; 68: 306-316.
- [14] Zhou, P., Ang, B.W., Han, J.P. Total factor carbon emission performance: A Malmquist index analysis. *Energy Economics* 2010; 32: 194-201.
- [15] Zhou, P., Ang, B.W., Poh, K.L. A survey of data envelopment analysis in energy and environmental studies. *European Journal of Operational Research* 2008; 189: 1-18.
- [16] Sueyoshi, T., Goto, M. Methodological comparison between two unified (operational and environmental) efficiency measurements for environmental assessment. *European Journal of Operational Research* 2011; 210: 684-693.
- [17] Sueyoshi, T., Goto, M. Data envelopment analysis for environmental assessment: comparison between public and private ownership in petroleum industry. *European Journal of Operational Research* 2012; 216: 668-678.
- [18] Sueyoshi, T., Goto, M. DEA radial and non-radial models for unified efficiency under natural and managerial disposability: theoretical extension by strong complementary slackness conditions. *Energy Economics* 2012; 34:700-713.
- [19] Sueyoshi, T., Goto M. Returns to scale vs. damages to scale in data envelopment analysis: An impact of U.S. clean air act on coal-fired power plants. *OMEGA* 2013; 41: 164-175.

*Assessment of the Analgesic Activity of Musa Paradisiaca Linn Peels of the Family
Musaceae*

Rommel John Reyes, Ar-Raquib Abdulla, Jaime Jr Bisa, Henedina Maini, Judilyn
Solidum

Emilio Aguinaldo College, Philippines

0638

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Pain is the body's alarm system and is triggered in the nervous system. It signals that something is wrong. It may be sharp or dull, it may come and go, or it may be constant, in one part or all over the body. The *Musa paradisiaca* (L.) family Musaceae, commonly known as banana in English, is a perennial tree like herb grown indigenously in tropics and subtropics and also cultivated commercially in India for its fruits. The objective of this research is to assess the potential analgesic activity of *M. paradisiaca* Linn peels. Two methods were used for the evaluation of analgesic activity namely; Hot Plate Method and Tail Immersion Method. Results revealed that there were significant effect on the analgesic capability of the aqueous extract of *M. paradisiaca* L. both in 100 mg/kg and 200 mg/kg, and Morphine ($p < 0.05$), indicating a significant difference on the analgesic potential between aqueous extracts and standard morphine, both under the Hot Plate and Tail Immersion Methods. The results also revealed a statistically significant interaction between the effect on treatment groups and time, with a $p < 0.05$. Under the Hot Plate Method, the results revealed a no significant effect on the time interval of the aqueous extract of *M. paradisiaca* L. both in 100 mg/kg and 200 mg/kg, and morphine ($p > 0.05$), signifying that aqueous extracts, both in 100 mg/kg and 200 mg/kg, and morphine had the ability to exert optimized analgesic potential regardless of time. However, under the Tail Immersion Method, the result also revealed a significant effect on the time interval of the aqueous extract of *M. paradisiaca* L. both in 100 mg/kg and 200 mg/kg, and morphine ($p > 0.05$), signifying that aqueous extracts, both in 100 mg/kg and 200 mg/kg, and morphine had significant difference on the optimum time interval to exert the highest analgesic capability.

Key words: *analgesic, banana, peels, morphine, pain, Swiss albino mice, Musa paradisiaca*

INTRODUCTION

Background of the Study

Several studies had been made for the use of plant as the source of medicines by using their roots, leaves, stems, barks, flowers and fruits of plants. In this study, the researchers will be evaluating the peels of *Musa paradisiaca* Linn (Fam. Musaceae) for its possible analgesic effect.

Pain is the body's alarm system when something is wrong. It is a feeling triggered in the nervous system. It may be sharp or dull, it may come and go, or it may be constant. It may be felt in one part or all over the body.

Pain can be treated in so many ways. Though treatment varies depending on the cause of pain, pain relievers, acupunctures, and surgery are sometimes helpful. Under-treatment of pain is a poor medical practice that results in many adverse effects.^{[1][2]}

Pain relief as an international human right is recognized, but there is no express pain management mentioned, its implementation is being looked at. The International Covenant on Economic, Social and Cultural rights articulates the right "of everyone to the enjoyment of the highest attainable standard of physical and mental health" and WHO defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Adequate provision of pain management comfortable falls within these provisions.

Objectives

The general objective of this study is to assess the potential analgesic activity of *M. paradisiaca* Linne peels. The specific objectives of this study are as follows: First, provided that the aqueous extract of the *M. paradisiaca* do posses analgesic capability, the researchers would like to determine if there is a significant difference between the analgesic activity of the extract, the vehicle and standard drug. And, provided that the aqueous extract of the *M. paradisiaca* do possess analgesic capability, the researchers would like to determine the optimum time interval of the extract to exert the highest analgesic capability.

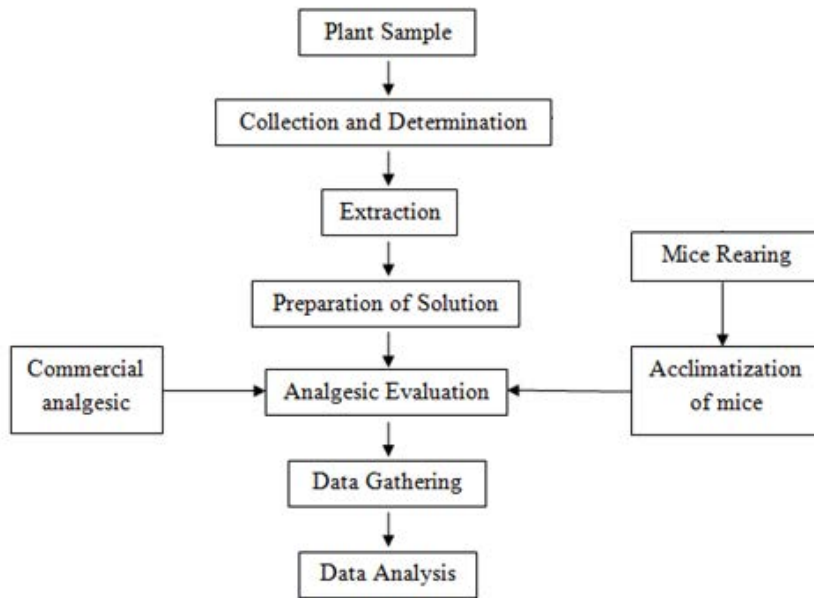


Fig. 1: Research Paradigm

The figure shows the steps on how the researchers executed the whole research. The activities done ranged from collection and determination of materials, preparation of extracts, preparation of solution for testing, evaluation of analgesic activity of both the commercial analgesic and the extract on acclimatized mice, up to data gathering and analysis using suitable statistical treatments.

Statement of the Problem

The Philippines possess varied natural resources which can be made into medicinal products. The researchers aims to answer the following questions:

1. Do the *M. paradisiaca* Linn peels possess analgesic activity?
2. Does it possess significant analgesic activity?
3. Is there a significant difference between the analgesic effects of the aqueous extract of the *M. paradisiaca* in varying time points?

Hypothesis

All statements were formulated in null form, reflecting the probable answers for the problems stated.

1. The extracts of *M. paradisiaca* Linn peels possess no significant analgesic activity.
2. There is no significant difference between the analgesic capabilities of the aqueous *M. paradisiaca* extract, vehicle and the standard drug.

Significance of the Study

The materials used in this study were considered wastes and of no use. These materials can be made into more productive material if proven to exhibit the activity being evaluated for. This study regarding the peels of *M. paradisiaca* Linn will be significant to the Public Health as this would serve as another breakthrough in the field of medicine.

This study may also serve as a guide and basis for students who may wish to continue and improve the research. It will also help the other professionals to spread the information on educating the public about the *M. paradisiacal*.

This study will also be significant to other researchers as they may continue this study to prove more about the *M. paradisiaca* Linn peels.

Scope and Limitation

The study assessed the potential analgesic activity of yellow-colored *M. paradisiaca* Linn peels, locally known as Saba. Collection of samples were conducted in chosen local markets within Metro Manila. The chemical composition of the peel was not determined in the study. This study was conducted at the School of Pharmacy Laboratory of Emilio Aguinaldo College-Manila. Instruments used came from the EAC-School of Pharmacy and/or from other institution, if needed.

REVIEW OF RELATED LITERATURE.

The healing power of plants have been known to man for generations.^[3] Plant drugs are frequently considered to be less toxic and free from side effects than the synthetic ones.^[4]

Plant used for evaluation: *M. paradisiaca* Linn. (Family Musaceae)

M. sapientum Linn, also known as Saba, is a herbaceous flowering plant with a height of 6 to 7.6 meters. The leaves that are spirally arranged which grows up to 2.7 meters long and 60 cm wide.^[5] Studies suggest that *M. sapientum* Linn possess many therapeutic activities.

M. sapientum Linn exhibit many pharmacologic activities.^{[6][7][8]} The dried powdered pulp of the banana has an anti-ulcerogenic activity against ulcers induced by histamine in guinea pigs and prednisolone in rats.^{[9][10][11][12]} The roots are used as antihelmintic while the peel and the pulp contain antibiotic and antifungal activity.^[13] It also has a hypoglycaemic activity.^[14] The fruit contains starch and carbohydrates in 20% to 50% in the pulp.

M. sapientum Linn has anti-diabetic activity.^[15] In the traditional medicinal systems of India, all the parts of *Musa* spp. (Family Musaceae) are used for the treatment of various diseases.^[13] Extensive investigation have proved the anti-ulcerogenic, ulcer healing activities and wound healing activity of plantain banana.^{[16][17]} Medicinal uses of banana (*Musa* spp. in general): Flower's extracts used to treat bronchitis, dysentery and on ulcers, Cooked flowers syrup used against Diabetes, Astringent plant sap used as a medication to cure hysteria, epilepsy, leprosy, fevers, hemorrhages, acute dysentery and diarrhea, and on hemorrhoids, insect and other stings

and bites; whereas young leaves used as poultices on burns and other skin afflictions; the astringent ashes of the unripe peel and leaves works against dysentery, diarrhea and malignant ulcers; Roots are an age-old application in digestive disorders, dysentery and other ailments and Seed mucilage cures ophthalmic cataracts and diarrhoea.^{[13][18]}

The pulp of the *M. sapientum* var. *paradisiaca* was studied to have an anti-ulcer effect and mucosal defensive factors for Normal and Non-Insulin Dependent Diabetes Mellitus (NIDDM). It was claimed that the ulcer protective and anti-diabetic effect of *M. sapientum* var *paradisiaca* is better compared to Sucralfate and Glibenclamide.^[18]

Musa paradisiaca (L.) (Musaceae) commonly known as banana in English, is a perennial tree like herb grown indigenously in tropics and subtropics and also cultivated commercially in India for its fruits.^[19]

The various effects of *M. paradisiaca* Linn. are documented in traditional as well as scientific literature. The main pharmacological effects of this plant are- Hepatoprotective, hair growth promoter, diuretic, analgesic, antiulcer, wound healing, antioxidant, hypoglycemic, antiurolithiatic activity, mutagenic effects and haemostatic activity in which few are reported.^[20]

The analgesic activity of aqueous extract of the plant was evaluated using the hot plate method and writhing test in mice. The hot plate method is useful in detecting centrally acting analgesics whereas acetic acid induced writhing method is useful to detect peripheral analgesic effects. Acetic acid, which is used as an inducer for writhing syndrome, causes analgesia by liberation of endogenous substances, which then excite the pain nerve endings. The fact that aqueous extract of *M. paradisiaca* showed analgesic activity in both the models studied, indicate that this effect could be due to the presence of two components; one acting centrally and the other via peripheral route from the above results, it can be deduced that aqueous extract has shown dose dependent activity. As the phytochemical screening has shown the presence of carbohydrates, sterols, proteins, flavonoids, alkaloids in aqueous extract of *M. paradisiaca* leaves, its potent activity may be attributed to the presence of these phytoconstituents.^[21]

Investigation with unripe bananas showed that it contains high anti-microbial activities. Unripe banana had more antibacterial activity when used with two different solvents, water and ethanol, compare to lemon grass and turmeric that had good anti-microbial activity with only ethanolic extract.^[22]

M. sapientum L. Extract was claimed to be a weight-gain reducer. It alters the phospholipid content of the stomach and the duodenum.^[23]

Hot plate and tail flick tests are most sensitive methods to centrally acting analgesics. The stem of *M. sapientum* L. possesses potential analgesic activity in both ethanolic and water extracts.^[24]

Methods to be used for the analgesic activity of *M. paradisiaca* L (Family Musaceae): Hot plate Method and Tail Immersion Method.

The hot plate test is a simple behavioural screen for estimating the effects of test substances on the threshold for pain sensitivity. It is based on the principle of the rodents' responses while being placed onto a hot surface. The principal parameter assessed in the hot plate test is the latency to the first paw-lick response.^{[25][26]}

Hot plates are a very convenient source of heat. The change in temperature occur somewhat slowly, thus making it good way for testing pain sensitivity.^[27]

The Tail-Immersion Method, however, is based on the principle of the tail of the rodents soaked into a water bath with a constant temperature. The principal parameter of assessment is the first flicking of tail within a time limit.^[24]

A hot water bath is a very effective source of heat when a temperature below 80°C is required. A beaker (250mL or 400mL) is partially filled with water and heated on a hot plate to regulate the temperature. A thermometer is clamped into position in the water bath to allow the monitoring of the temperature.^[25]

Animal species: Swiss Albino Mice

A particular in-bred strain implies that mice must live long enough to produce offspring, but beyond that minimal requirement there are great differences between strains in characteristic lifespan. According to Comfort (1959), the typical lifespan of mice in various strains is ranging from 1.3 to 3 years. Mice from strains having the shortest lifespan are usually extremely susceptible to a specific kind of neoplasm. On the other hand, certain long-lived strains and hybrids have been much favoured in radiation experiments.

The widely distributed Swiss albino mice, largely non-inbred, are mainly derived from two males and seven females which Clara J. Lynch of the Rockefeller Institute obtained from A. de Coulon of Lausanne in 1926. Random-bred mice are more widely used than either in-breds or hybrids in commercial assay work, where the cost is also considered other than the sensitivity. In acclimatization, eating is cyclic and well known to all mouse breeders, for the sound of gnawing on pellets becomes audible in the mouse quarters late in the day. The cereal foods such as rolled oats, oatmeal, whole and ground rice, macaroni, and vermicelli are the first food of choice for mice based on the first supplies to be attacked on a well stocked grocery store. Drinking, like eating, is cyclic and occurs mostly during the night. Mice given water *ad libitum* typically consume 4 to 6 ml each 24 hours. Mouse breeders are also well aware of the propensity for fighting shown by many strains, particularly by males. Severe wounds are inflicted in combat, and battles to the death are not uncommon. Laboratory mice housed in cages typically develop a social organization based upon exclusive dominance of one male. Courtship follows a pattern similar to that of other laboratory rodents but has species-specific characteristics. The basic sequence consists of elements described as sniffing, following, mounting, mounting-with-intromission, and post-copulatory grooming. In relation to the maintenance conditions for the mice, temperature control is widely regarded as essential in the animal room. Mice, however, can adapt successfully to temperatures as low as -3°C provided that ample nesting materials are provided.^[28]

Morphine

Morphine is classified under the category of opioid analgesics. It is one of the classic opioids often used as a standard to measure comparative potency among opioid drugs. Morphine interacts with other drugs, such as inhalants and injectable anaesthetics and analgesics, to reduce the overall necessary dose of anaesthetics or analgesics. Regardless of route of administration, morphine has a relatively short duration of action, thus limiting its use in a laboratory animal setting wherein a 24-hour intensive care is not routinely provided. In rats and mice, 10mg/kg of morphine provides analgesia adequate to relieve severe pain for only 2 to 3 hours. More complete analgesia can be achieved if morphine is administered with acetaminophen. ^[29]

METHODOLOGY

Plant Materials

The researchers were able to prepare 500g of dried *M. paradisiacal* Linn peels from the collected peels from local markets and banana cue vendors within selected areas by cutting them into bits, after thoroughly washing them in running water. These were air-dried under shade for 1 week, and then subjected it to oven-drying at 105°C for 5 hours. The dried samples were then macerated with about 1.5L of water to ensure that the samples were immersed into the water, for 24 hours, with intermittent stirring. After maceration, the mixture was filtered to collect the extract. The extract then collected amounted to 759 mL. This was evaporated until viscous character was obtained. The evaporated extract weighed 144.21 g, with a yield of 28.84 %. From this concentrated extract, 500mL solution with a concentration of 10mg/mL was prepared.

Test Animals

Albino Mice weighing from 20g to 25g were used. The animals were subjected to veterinary check-up to make sure that they are healthy. The animals were acclimatized to the laboratory conditions for not less than 10 days after their arrival. The animals were housed in groups under standard light/dark cycle of 12/12 hours with food and water provided *ad libitum*.

Food was withdrawn six hours prior to drug administration till completion of the experiment on the day. All experiments were performed during the light period.

Administration of Standard Drug, Vehicle, and AMP

The administration of the AMP was done at the rate of 100mg/kg and 200mg/kg in mice. The vehicle dose was 5ml/kg. The standard drug, morphine was administered at a dose of 10mg/kg. All administrations were done intra-peritoneally.

Experimental Method

1. Hot Plate Method

Swiss albino mice were divided into four groups each containing five animals. The hot plate was maintained at 55° to 56°C. The animals were placed on the hot plate and the time until either licking or jumping occurs were recorded by a stop-watch, with an interval of 0, 15, 30, 60 and 90 minutes after vehicle, standard and test drug administrations. The test was limited up to 15 seconds to prevent tissue damage.

2. Tail Immersion Method

Swiss albino mice were divided into four groups each containing five animals. The tail of the mouse was immersed to a constant level of 3cm in a water bath maintained at $55\pm 0.5^\circ$. The time to flick-the-tail from the water was recorded. A maximum immersion time of 30 seconds was set as the limit to prevent thermal injury to the animals. A significant increase in reaction time compared with control animals was considered a positive analgesic response.

The experiments was conducted in three trials.

Statistical Analysis

All results were expressed as mean \pm SEM. The comparison of the results from the extract and standard drug to the vehicle were analyzed statistically using Two-Way ANOVA.

RESULTS AND DISCUSSION

This chapter aims to present all of the results obtained by the researchers throughout the study. This chapter presents the study through the use of tables.

The researchers were able to prepare 500mL solution of extract with a concentration of 10mg/mL. The solution was prepared from 144.21g of extract, having a yield of 28.84%

After conducting the experiment, the researchers were able to obtain varying results from the *M. paradisiacal* L. extracts of doses 100mg/kg and 200mg/kg. Results were also obtained from Morphine and the vehicle.

Treatment	0	15	30	60	90
Morphine	12.86 \pm 0.19	6.67 \pm 0.31	6.68 \pm 0.25	9.83 \pm 0.33	11.11 \pm 0.24
Vehicle	3.66 \pm 0.65	3.39 \pm 0.69	3.7 \pm 0.35	5.24 \pm 0.75	3.56 \pm 0.80
100mg/kg	5.04 \pm 0.27	5.34 \pm 1.69	5.13 \pm 0.38	4.95 \pm 0.65	3.41 \pm 0.49
200mg/kg	5.52 \pm 0.77	9.45 \pm 1.02	6.57 \pm 1.35	4.69 \pm 0.24	4.86 \pm 0.36

Table 1 Hot Plate Test Results

Treatment	0 (sec)	15 (sec)	30 (sec)	60 (sec)	90 (sec)
Morphine	1.81 \pm 0.23	2.68 \pm 0.30	2.71 \pm 0.23	2.49 \pm 0.38	1.93 \pm 0.24
Vehicle	2.66 \pm 0.65	1.27 \pm 0.09	1.44 \pm 0.08	2.02 \pm 0.12	1.49 \pm 0.15
100mg/kg	1.69 \pm 0.29	1.29 \pm 0.02	1.79 \pm 0.18	2.28 \pm 0.43	1.44 \pm 0.13
200mg/kg	1.59 \pm 0.22	2.07 \pm 0.38	3.34 \pm 0.67	2.15 \pm 0.37	1.54 \pm 0.20

Table 2 Tail Immersion Test Results

A two-way Analysis of variance (ANOVA) was conducted to determine the difference between the analgesic effects of the aqueous extract of *M. paradisiaca* L. based on the standard drug, morphine and the time interval of the extract to exert the highest analgesic capability. Shapiro-Wilk test was used as a numerical means of assessing normality in parametric testing and this was further verified using Kolmogorov-Smirnov test. The test revealed a statistically no significant normality for the treatment groups, and the time intervals.

	Treatment	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Trials	Morphine	.182	15	.192	.900	15	.097
	Vehicle	.197	15	.122	.921	15	.198
	100 mg/kg	.176	15	.200(*)	.906	15	.117
	200 mg/kg	.208	15	.080	.917	15	.174

Table 3 Kolmogorov-Smirnov and Shapiro-Wilk Test for treatment groups for Hotplate method

	Time	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
trials	0	.287	12	.007	.814	12	.013
	15	.109	12	.200(*)	.960	12	.785
	30	.155	12	.200(*)	.966	12	.867
	60	.237	12	.061	.865	12	.056
	90	.295	12	.005	.829	12	.021

Table 4 Kolmogorov-Smirnov and Shapiro-Wilk Test for time intervals for Hotplate method

	Treatment	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
trials	Morphine	.190	15	.155	.900	15	.097
	Vehicle	.195	15	.131	.921	15	.198
	100 mg/kg	.176	15	.200(*)	.910	15	.117
	200 mg/kg	.208	15	.080	.919	15	.176

Table 5 Kolmogorov-Smirnov and Shapiro-Wilk Test for treatments for Tail Immersion method

	Time	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
trials	0	.287	12	.007	.815	12	.013
	15	.109	12	.200(*)	.940	12	.785
	30	.155	12	.200(*)	.970	12	.867
	60	.237	12	.061	.830	12	.056
	90	.295	12	.005	.819	12	.021

Table 6 Kolmogorov-Smirnov and Shapiro Test for time for Tail Immersion method

Referring from the performed statistical analysis, Two-way ANOVA, results revealed that there was a significant difference between the effects of the aqueous extract of *M. paradisiaca* L., both in 100 mg/kg and 200 mg/kg, and Morphine ($p < 0.05$), indicating a significant difference on the analgesic potential between aqueous extracts and standard morphine, both under the Hot Plate and Tail Immersion Methods.

However, in contrast with the Vehicle, the extract with a dose of 100mg/kg possess no significant difference. On the other hand, the extract with a dose of 200mg/kg does possess significant difference against the vehicle. Thus, only the aqueous extract having a dose of 200mg/kg possesses analgesic activity, higher than the negative control, the Vehicle, but lower than morphine

(I) Treatment	(J) Treatment	Mean Difference (I-J)	STD ERROR	Sig.	95% Confidence interval	
					Lower bound	Upper Bound
200 mg/kg	Morphine	-3.2120	.54818	.000	-4.8117	-1.6123
	Vehicle	2.3087	.54818	.002	.7089	3.9084
	100mg/kg	1.4453	.54818	.090	-0.1544	3.0451

Table 7: Scheffe test for the 200 mg/kg extract.

Under the Hot Plate Method, the results revealed a no significant effect on the time interval of the aqueous extract of *M. paradisiaca* L. in 200 mg/kg, and morphine ($p > 0.05$), signifying that the aqueous extract, with a dose of 200 mg/kg, and morphine had the ability to exert optimized analgesic potential regardless of time.

However, under the Tail Immersion Method, the results revealed a significant effect on the time interval of the aqueous extract of *M. paradisiaca* L. in 200 mg/kg, and morphine ($p > 0.05$), signifying that aqueous extract, with a dose of 200 mg/kg, and morphine had significant difference on the optimum time interval to exert the highest analgesic capability.

CONCLUSION

Using statistic it is concluded that there is a significant difference on the analgesic capability of the extract of *M. paradisiaca* L., both in doses of 100mg/kg and 200mg/kg, and Morphine, using the Hotplate method and Tail Immersion method. There is no statistical difference between the vehicle and the 100mg/kg dose from the extract but not with the 200mg/kg dose.

Using the hotplate method, results revealed a no significant effect on the time interval of the treatment group. The treatment had the ability to exert optimized analgesic effect regardless of optimum time. However, for the tail immersion method, results revealed a significant effect on the time interval of the treatment group. There is a significant difference between the treatment groups on the optimum time interval to exert the highest analgesic capability. Also, using Scheffe post hoc analysis, the results obtained differ significantly between the 100mg/kg and 200mg/kg AMP treatments, therefore signifying that the analgesic effect of the aqueous extracts treatment are dose dependent.

After obtaining the results, the researchers would therefore conclude that the aqueous extracts of the peel of *M. paradisiaca* L. possess potential analgesic activity but not as potent as morphine. The higher dose showed analgesic property better than the lower dose.

RECOMMENDATIONS

The researchers would like to recommend the following: (a) Aside from the peels of the *Musa paradisiaca* L. we would like to recommend the assessment of the analgesic property of the other parts of the plant. (b) Increasing the concentration of the extract would probably result to the increase analgesic ability. (c) Isolation and purification must be done to improve pharmacologic potential since the extract used in this research we're crude extracts.

BIBLIOGRAPHY

- [1] Carr DB, Jacox AK, Chapman CR, Ferrell BR, Fields HL, Heidrich G III, Hester NK, Hill CS Jr., Lipman AG, McGarvey CL, Miaskowski CA, Mulder DS, Payne R, Schechter N, Shapiro BS, Smith RS, Tsou CV, Vecchiarelli L. Acute Pain Management: Operative or Medical Procedures and Trauma. Clinical Practice Guideline. Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, US Department of Health and Human Services, 1992. AHCPR Pub. No. 92-0032.
- [2] MacIntyre P, on behalf of the Working Party of the Australian and New Zealand College of Anaesthetists. Acute Pain Management: Scientific Evidence, 2nd ed. Melbourne, Australia: Australian and New Zealand College of Anaesthetists, 2005. Available at: <http://www.nhmrc.gov.au/publications/synopses/cp104syn.htm>
- [3] Veilleux, C. and King, S. (1993). *An introduction to ethnobotany, shaman pharmaceuticals*. New York: Viking Penguin Books. pp1-2.
- [4] Momin, A. (1987). Role of indigenous medicine in primary health care. 1st International seminar on Unani medicine. New Delhi, pp 54.
- [5] Quisumbing, E. (1978). *Medicinal plants of the Philippines*. Quezon City: JMC Press, INC.
- [6] Bannerman, R. H. (1982). World Health Forum 3(1), 8-26,
- [7] Fansworth, H. R., Akerele O. (1982). Bulletin of the WHO 03 (6) 965-982,
- [8] Sanyal, A. K., Pandey, B. L. and Goel, R. K. J. (1982). Ethnopharmacol. 5, 79,
- [9] Sanyal, A.K., Das, P.K., Sinha, S., & Sinha, Y.K, (1961). Banana and gastric secretion. *J Pharm Pharmacol*;13:318-9.
- [10] Sanyal, A.K., Gupta, K.K., & Chawdhury, N.K. (1964). Studies of peptic ulceration Part I: Role of banana in phenylbutazone induced ulcers. *Arch Int Pharmacodyn.* ;149:393-400.
- [11] Sanyal, A.K., Gupta, K.K., Chowdhury, N.K. (1963). Banana and gastric secretion. *J Pharm Pharmacol*;15:283-4.
- [12] Sanyal, A.K., Banerjee, C.R. & Das, P.K. (1965). Studies on peptic ulceration. Part II : Role of banana in restraint and prednisolone induced ulcer in albino rats, Arch. Int. Pharmacodyn. Ther., Vol. 155

- [13] Gurumaa, A. (2008). Go Banana: Banana Guide benefit and Nutrition facts. Retrieved from <http://www.gurumaa.com/health-go-bananas.php>
- [14] Hood, A. M., and Lowbury, E. J. L. (1954). Nature and Land. 173, 402-3,
- [15] Jain, S. A. and Sharma B. A. A. (1967). Planta Medica 17, 99-100,
- [16] Goel, R.K., Sairam, K. (2002). Anti-ulcer drugs from indigenous sources with emphasis on *Musa sapientum*, *Tamrabhasma*, *Asparagus racemosus* and *Zingiber officinale*; *Indian Journal of Pharmacology*;34: pp 100-110.
- [17] P.K.Agarwal, A.Singh, K.Gaurav, Shalini Goel, H.D.Khanna and R.K.Goel. (2009). Evaluation of wound healing activity of extracts of plantain banana (*Musa sapientum* var. *paradisiaca*) in rats; *Indian Journal Exp Biol*; 47: pp 32-40.
- [18] Kumar M. M, Joshi M. C, Prabah T., Dorabubu M. and Goel R. K. (2005). Effect of plantain banana on gastric ulceration in NIDDM rats: Role of gastric mucosal glycoproteins, cell proliferation, antioxidants and free radicals: *Indian Journal of Experimental Biology*, 44, April 2006, pp. 292-299
- [19] Tarafdar A, Bhattacharya S, Pandey J.N and Biswas M. (2011) thin layer chromatographic profiling and evaluation of analgesic activity of *Musa paradisiaca* leaf extracts in mice. *Pharmacologyonline* 1: 1260-1265 (2011)
- [20] Kumar et al (2012) Phytoconstituents and Pharmacological activities of *Musa paradisiaca* Linn. *Asean Journal of Biochemical and Pharmaceutical Research Issue 4 (Vol. 2) 2012*
- [21] G.H. Rabbani, T. Teka, B. Zaman, M. Majid N Khatun & G.J.Fuchs., *Gastroenterol.*, 2001,121, 554.
- [22] Fagbemi, J. F., Ugoji E., Adenipekun T., and Adelowotan O. (2009). Evaluation of the antimicrobial properties of unripe banana (*Musa sapientum* L.), Lemon grass (*Cymbopogon citrates* S.) and turmeric (*Curcuma longa* L.) on pathogens. *African Journal of Biotechnology*, 8 (7), pp. 1176-1182.
- [23] Eriyamremu G. E., Asagba S. O., Osagie V. E., Ojeaburu S. I. and Lolodi O. (2007). Phospholipid Profile of the Stomach and Duodenum of Normal Rabbit Fed with Supplements of Unripe Paw Paw (*Carica papaya*) and Unripe Plantain (*Musa sapientum*) Extract. *Journal of Applied Sciences*, 7 (22): 3536-3541.
- [24] Ingale, Suvarna P., Ingale, Pramod L., & Joshi, Anagha M. (2009). To study analgesic activity of stem of *Musa sapientum* Linn. *Journal of Pharmacy*. 2(9), 1381-1382
- [25] Eddy, N.B. and Leimbach, D. (1953). Synthetic analgesics. II. Dithienylbutenyl- and dithienylbutymamines. *J Phrm Exp Ther*, 107:385-393
- [26] Vogel, G.H., Hock, J.F., Maas, J. and Mayer, D. (2006) *Drug discovery and evaluation: safety and pharmacokinetic assays*. Springer:Germany. pp 29-30.

[27] Pavia, D.L., Lampman, G.M., and Kriz, G.S. (2002). *Microscale and macroscale techniques in the organic laboratory* (1st ed). United States of America: Brooks/Cole, a division of Thomson Learning, Inc.

[28] Coleman, Douglas L., et al. (1966). *Biology of the laboratory mouse*, 2nd ed. Dover Publications: New York, USA.

[29] Fish, R.E., Brown, M.J., Danneman, P.J., & Karas, A.Z.(2008). *Anesthesia and analgesia in laboratory animals*. USA: Academic Press.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, serif font. The text is enclosed within a circular graphic composed of two overlapping, thick, curved lines. The upper-left portion of the circle is a light red color, while the lower-right portion is a light blue color, matching the text. The lines are slightly irregular, giving the logo a hand-drawn or artistic feel.

iafor

*Evaluation of Diuretic Activity of Ethanolic Extracts of Plumeria Acuminata W.T.
Aiton (Fam. Apocynaceae) Leaves In Rats*

Omar A. Villalobos, Asmirah A. Solaiman, Paula Denise G. Jimenez, Joanna Marie V. Franco, Nikka G. Mago, Danette Nica Nicdao, Mary Sol Apita, Kathrina Mae Dulva, Judilynn N. Solidum

Emilio Aguinaldo College-Manila, Philippines

0661

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Plumeria acuminata W.T. Aiton or Kalachuchi is a small, deciduous tree, 3 to 7 meters high. The leaves are crowded at the terminal end of the branch, commonly oblong in shape, 20 to 40 centimeters long, 7 centimeters wide, spirally arranged at the ends of the branches. Diuretic drugs are essential in diseases like congestive heart failure, nephritic syndrome, cirrhosis, renal failure, hypertension and pregnancy toxemia. Kalachuchi may contain diuretic properties. The study generally aimed to evaluate diuretic activity of the Kalachuchi leaves through ethanol extraction in rats. Specifically, the study aimed to determine the diuretic activity exhibited by the plant extract as compared to control group; to identify the diuretic effects of high and low doses of the extracts used in the study; to determine the effect of the *Plumeria acuminata* Aiton extracts on the electrolyte levels of the urine as compared to standard drug HCTZ. The diuretic activity was investigated in albino rats using standard method as described by Kau et al. The diuretic activity was assessed in terms of urine output and levels of sodium and potassium excreted in the urine. The result obtained revealed that the urine volume significantly increased by the high dose of *Plumeria acuminata* (400 mg/kg B.W.) in comparison with the control group. Urine electrolyte was also affected by the extracts as compared to the standard drug HCTZ (Hydrochlorothiazide). We can conclude that ethanolic extract of *Plumeria acuminata* W.T. Aiton leaves produced notable diuretic effect which appeared to be comparable to that produced by the reference diuretic HCTZ. The present study provides a quantitative basis for the use of *Plumeria acuminata* W.T. Aiton as a diuretic agent. We further recommend investigation on other parts of *Plumeria acuminata* W.T. Aiton that will be considered as diuretic agent.

Keywords: Diuretic Activity, Urine Electrolytes, Urine Volume, Hydrochlorothiazide

I. INTRODUCTION

Background of the Study

In the traditional system of medicine and folklore, plants as a whole or their parts have been used in all types of diseases [1]. About 65% of world populations have access to local medicinal plant knowledge system [2]. Traditional systems of medicine are popular in developing countries and up to 80% of population relies on traditional medicines or folk remedies for their primary health care needs [4]. Diuretics are drugs that increase the rate of urine flow, sodium excretion and are used to adjust the volume and composition of body fluids in a variety of clinical situations. Drug induced diuresis is beneficial in many life threatening disease conditions such as congestive heart failure, nephritic syndrome, cirrhosis, renal failure, hypertension and pregnancy toxemia [5]. Most diuretic drugs have adverse effects on quality of life including impotence, fatigue and weakness [6]. Herbal medicines are popular in developed as well as developing countries for primary health care because of their wide biological and medicinal activities, higher safety margins and lesser costs [7]. Diuretics are drugs that act on the kidneys and are able to increase the volume of urine excreted hence are used in cardiac failure, chronic and moderate cardiac insufficiencies, acute oedema of the lung, nephritic edema syndrome, arterial hypertension, and diseases related with the retention of fluids. Diuretic drugs cause net loss of Na⁺ and water in urine. Naturally occurring diuretics include caffeine in coffee, tea, and cola. These inhibit Na⁺ reabsorption in the renal tubule. [8]. Thiazide is the most widely used kind of diuretic drug. This is a sulfonamide derivative. Its chemical structure is related to carbonic anhydrase inhibitor. It acts mainly in the distal tubule and inhibits the reabsorption of Sodium by inhibition of Na/Cl cotransporter at the luminal membrane. The drug increase the concentration of Na and Cl in the tubular fluid because thiazides increase the Na in the filtrate arriving at the distal tubule, more K is also exchange for Na and result in continual loss of K in the body [9].

According to Stuart, "*Plumeria acuminata* Aiton is a small, deciduous tree, 3 to 7 meters high, with a crooked trunk, smooth and shining stems, succulent, with abundant sticky, milky latex. Bark has a smooth, papery outer layer which is grey, shining, and constantly exfoliating in small flakes. Wood is yellowish-white and soft. Branches are thick, fleshy, swollen and leafy at the tips. Leaves are crowded at the terminal end of the branch, commonly oblong in shape, 20 to 40 centimeters long, 7 centimeters wide, spirally arranged at the ends of the branches. Flowers are numerous, fragrant and large, the upper portion whitish, while the inner lower portion yellow, 5 to 6 centimeters long. Fruits are linear-oblong or ellipsoid follicles, with a pointed tip, 15 to 20 centimeters long, 1.5 to 2 centimeters in diameters. Seeds are numerous and winged. There are several species of cultivated Plumiera, very similar to *P. rubra* but for the color of the corolla. Powdered leaf yielded alkaloids, cyanogenic glycosides, phenolic compounds, flavonoids, terpenoids, tannins, and saponins"[10]. According to Gumathi et al 2012, "*Plumeria acuminata* belonging to the family Apocynaceae is widely distributed throughout the Southern parts of India. In traditional medicinal system different parts of the plant have been mentioned to be useful in a variety of diseases. The bark has been reported to be useful in hard tumors, diarrhoea and gonorrhoea. The leaves are reported to have anti-inflammatory, rubefacient in rheumatism and have strong purgative effect. Its branches are used like those of 'chitraka' to produce abortion. Previous findings revealed that the

methanol extract of *P. acuminata* leaves showed significant anti-inflammatory activity , antipyretic and antinociceptive activity , antioxidant and free radical scavenging activity and antimicrobial activity”[11]. *Plumeria acuminata* belonging to the family Apocynaceae has an LD50 of 562 mg/kg. [12]

Objectives

The general objective of the study is to determine the diuretic activity of *Plumeria acuminata* leaves in Rats. Specifically, the study aimed to determine the diuretic activity exhibited by the plant ethanolic extract as compared to control group; to identify the diuretic effects of high and low doses of the extracts used in the study; to determine the effect of the *Plumeria acuminata* Aiton extracts on the electrolyte levels of the urine as compared to standard drug HCTZ.

Scope and Limitations of the Study

The scope of the study will cover the diuretic activity of Kalachuci. The study will focus on the leaves part of Kalachuchi. It will also cover analysis of sodium and potassium electrolytes of the urine output . The study is limited to *Plumiera acuminata* W.T. Aiton species only. The study is also limited to hydrochlorothiazide as standard drug.

II. METHODOLOGY

Research Design

This study followed the experimental design. Kalachuchi leaves were explored for its diuretic effects. Both negative and positive control groups were used for comparison of diuretic properties.

Collection of Plant Material

Leaves of Kalachuchi that was used in this study. These were collected from the Bicol Region. The procured plant was authenticated and analyzed at the Philippine National Museum, Botany Department.

Preparation of Plant Extract

Leaves of Kalachuchi were washed and cleaned thoroughly with tap water. It was air dried. The dried plant part was to a mechanical grinder. The plant material (500 grams) was then macerated with 2L of 80% Ethanol [13]. The solid part was separated from the solvent used. The solvent was dried in a tared evaporating dish using water bath. Prior to use, the sample was stored in a refrigerator.

Experimental Animals

Albino rats weighing 150-200 grams of either sex was used for the study. The albino rats were housed in the animal room of Emilio Aguinaldo College. These were fed with standard rat food and distilled water *ad libitum*. Animals were grouped accordingly:

- Group 1 Negative Control Group (given 5 ml/kg body weight of deionized water)
 - Group 2 Positive Control Group (HCTZ 10 mg/kg)
 - Group 3 Extract Low Dose (200 mg/kg)
 - Group 4 Extract High Dose (400 mg/kg)
- (Nper group=6)

Animals were deprived of food prior to experiments. Rats were fasted overnight, but with free access to tap water to ensure uniform hydration and to minimize variability in water volume [14].

Diuretic Activity

Diuretic activity was determined by the adapted methods of Kau *et al*, 1984 [14]. The animals were fasted overnight (6-8 h) prior to the test but with free access to water only, then were given an oral loading of normal saline (0.9%) of 0.05 ml per g body weight. Immediately after administration, the rats were paired and placed in metabolism cages. Urine was collected and measured in a graduated cylinder and its volume was recorded at 2 h intervals for 8 h. Cumulative urine excretion was expressed as ml. Electrolyte (Na⁺ and K⁺) concentrations were estimated from the urine sample of each pair of rats at the end of the experimental period (8 h.) and expressed as mequiv/8hours.[14]

Statistical Analysis

The results were expressed as mean values \pm S.E.M. (standard error of mean) for pairs of rats. Statistical comparison was carried out by analysis of variance (ANOVA) followed by *post hoc* tests and Dunnetts and Fishers test for multiple comparison using XLStat® software and Microsoft Excel® . $P \leq 0.05$ was considered significant.

III. RESULT AND DISSCUSSION

The results of the evaluations carried out on the extracts are listed in Tables 1 and 2. Tables 1, 2, shows the urinary volume (ml), while Tables 3 and 4 shows the excretion of electrolytes (Na⁺ and K⁺ content) in urine obtained from the rates of different treated groups.

Urine Volume

Table 1 shows the urine volume (ml) excreted every 2 hours for 8 hours during diuretic activity. Both the high and low doses of the extracts simulate the urine output of HCTZ

but not the control. It is the high dose however that approximates the activity of HCTZ even at 6h urine collection. Table 2 shows that the reference drug, HCTZ shows significant effect on urine volume by 82 % (0.003) as compared to the negative control group. The ethanolic extracts also showed significant effect on the urine volume by 78 % (0.012) of low and 81% (0.036) of high dose against the negative control group. This results show that HCTZ and the high and low extracts show diuretic properties as opposed to the deionized water which was set as the negative control.

Electrolyte Excretion

Table 3 shows the sodium and potassium content excreted in the urine , results showed that the lower dose and higher dose of ethanolic extract showed no significant difference in the amounts of electrolytes in the urine as compared to the negative group. When compared to the standard drug HCTZ it showed significant difference in urine electrolytes analyzed. It could be that the exact mechanism of diuretic action of Kalachuchi leaves differ with that of HCTZ. Also, the extract must be purified in order to achieve its maximum potential and mechanism of action as a diuretic.

Table 1. Effect of *Plumeira acuminata* leaves ethanol extracts on urine volume every 8 hours.

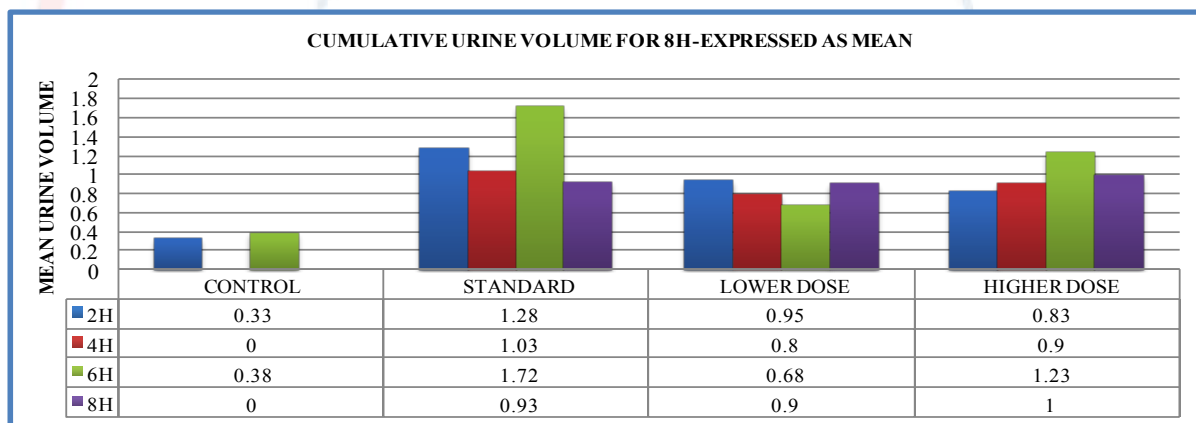


Table 2. Urine volume per group

GROUPS	DOSE (mg/kg BW)	URINE VOLUME (MEAN ± SEM)
NEGATIVE CONTROL	5 (ML)	0.72 ± 0.17
POSITIVE CONTROL STANDARD HCTZ	10	4.05 ± 0.99*
EXTRACT	200	3.33 ± 0.28**
EXTRACT	400	3.97 ± 0.59***

Data are expressed as mean ± SEM value of the urine.

* p<0.003 ** p<0.012 *** p<0.036 compared with the control group (ANOVA).

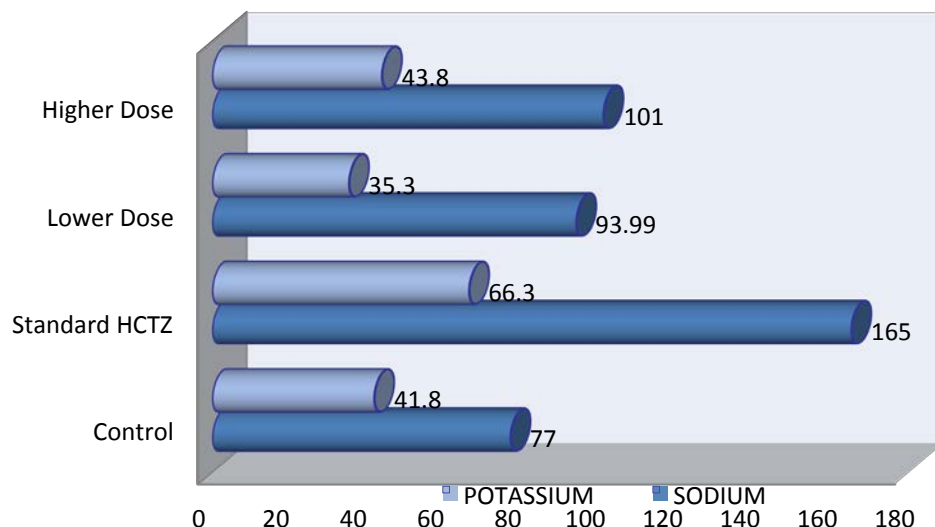
Table 3. Amount of sodium and potassium per group.

GROUPS	DOSE (mg/kg BW)	SODIUM (meq) MEAN ± SEM	POTASSIUM (meq) MEAN ± SEM
CONTROL	5 (ml)	77 ± 1.34	41.8 ± 0.72
STANDARD HCTZ	10	165 ± 11.75	66.3 ± 4.72
Extract	200	93.99 ± 1.72*	35.3 ± 0.64*
Extract	400	101 ± 1.55*	43.8 ± 0.67*

Data are expressed as mean ± SEM value of the electrolytes.

* p<0.05 as compared with the reference drug HCTZ (ANOVA)

Table 4. Graph showing the electrolyte output.



CONCLUSIONS AND RECOMMENDATIONS

The results of this study showed that the leaves of *Plumeria acuminata* W.T. Aiton or Kalachuchi showed diuretic effects. The diuresis shown was similar to HCTZ for both high and low doses of the extract but different from the negative control group results. The amounts of sodium and potassium in the urine is significantly different from the amount of electrolytes when using the positive control HCTZ. It may be that the mechanism of diuretic action of the Kalachuchi extracts is different from the reference drug.

It is recommended that a more in depth study be conducted on the plant in focus in order to determine the actual mechanism of drug action. Also toxicologic profiling of the plant must be studied to assure the safety of the public once it is released for use. Other parts of Kalachuchi must also be explored for diuretic activities.

ACKNOWLEDGEMENT

We wish to acknowledge the support of Emilio Aguinaldo College for this study. Further we wish to thank Prof. Ileana RF Cruz for the support she gave on this research. Further, we state our gratitude to Mr. Cristan C. Agaceta and Ms. Joanna Marie F. Blanco, for the valuable aid they gave in relation to this endeavor.

REFERENCES

[1] Yogesh shivhare, Priya singh, Sunita singh, *Der Pharmacia Sinica*, **2010**, 1, 40-45. (online) Available at: <http://pelagiaresearchlibrary.com/der-pharmacia-sinica/vol1-iss3.html> [Accessed date: 1/30/13]

- [2] Shrutu srivastava, Pradeep singh, Garima mishra, *Der Pharmacia Sinica*, **2011**, 2, 118-128. (online) Available at: <http://pelagiaresearchlibrary.com/der-pharmacia-sinica/vol1-iss3.html> [Accessed date: 1/30/13]
- [4] Vipin K garg, Sarvesh Kpaliwal, *Der Pharmacia Sinica*, **2011**, 2, 86-90. (online) Available at: <http://pelagiaresearchlibrary.com/der-pharmacia-sinica/vol1-iss3.html> [Accessed date: 1/30/13]
- [5] Hulatti KK, Sharadha MS, Kuppasth IJ, *Der Pharmacia Sinica*, **2011**, 2, 129-134. (online) Available at: <http://pelagiaresearchlibrary.com/der-pharmacia-sinica/vol1-iss3.html> [Accessed date: 1/30/13]
- [6] Agunu A, Abdurahman EM, Andrew GO, Muhammed Z, *J Ethnopharmacol*, **2005**, 96, 471-475. (online) Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15619566> [Accessed date: 1/30/13]
- [7] Agus ZS, Goldberg M, *J Clin Invest*, **1971**, 50, 1478-1489. (online) Available at: <http://www.jci.org/articles/view/106633> [Accessed date: 1/30/13]
- [8] Umesh Kumar Sharma, Uma Shankar Sharma, Abhishek Singh, Vijit Agarwal, *Journal of Pharmacology Research*. **2010**, 1(2):17-20 (online) Available at: http://www.bioinfo.in/journalcontent.php?vol_id=131&id=59&month=12&year=2010 [Accessed date: 1/30/13]
- [9] Harvey, et al. 2000. Lippincotts Illustrated Reviews: Pharmacology. 2nd ed. Lippincotts Williams and Wilkins. Newyork. Pp.245
- [10] Stuart, G. Philippine Medicinal Plants. (online) Available at: <http://www.stuartxchange.com/Kalachuchi.html> [accessed date: 1/30/13]
- [11]. Gomathi et al. 2012. CHRONIC TOXICITY STUDIES OF *PLUMERIA ACUMINATA* AND *GALEGA PURPUREA* IN EXPERIMENTAL ANIMALS. Available at: Gomathi *et al.*, IJPSR, 2012; Vol. 3(7): 2107-2112
- [12] IJEB6 Indian Journal of Experimental Biology. (Publications & Information Directorate, CSIR, Hillside Rd., New Delhi 110 012, India) V.1- 1963-Volume(issue)/page/year: 22,487,1984
- [13] Cantoria, M. 2003. Pharmacognoy in Action and Practice. The NRCP. Taguig
- [14] Kau S. T., Andrews D., Method for screening diuretic agents in rats, *J. Pharmacol. Meth*, 1984; 11: 67.

*How Does the Energy Industry Deal with Climate Change? - Perception and Actions
of the Energy Industry on Climate Change.*

Yeon Ji Kim*¹, Ju Youn Kan*²

*¹Korea University, Korea, *²National University of Singapore, Singapore

0707

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The extent and pace of climate change is already beyond our expectation. Its impacts are now experienced in every country. There is no time to lose; not only to mitigate green gas emission for slowing down the current pace of change, but also to learn how to live with expected impacts, which were induced by previously emitted green gases. The energy industry, a motive power for economic development, is the main culprit of climate change but, at the same time, it is also vulnerable and sensitive to the change.

The paper quantitatively and qualitatively analyzes perception and actions of major energy companies and discovers good examples for responding to climate change.

First, this paper explores how the key bodies in the energy industry perceive and respond to climate change. The study utilizes companies' sustainability reports including annual reports from major 77 energy companies from the fortune 500 businesses (2012), and analyzes the disclosure patterns of the Global Reporting Initiatives (GRI) indicators. It also refers to the Carbon Disclosure Project (CDP) Global 500 on the Climate Change responses. Second, this paper selects the best cases of climate change response by the industrial value chain from production to transmission and scrutinizes them. It is discovered that many companies consider climate change as a challenge as well as an opportunity, but the extent of their responses were varied. It also proposes some suggestions on climate change response policies of the energy industry. The findings of this paper have practical significance, as it is one of rare researches on a specific private sector's response to climate change. Furthermore it has policy implications for decision makers not only in the business sector but also in governments to support sustainable businesses and sustainable world.

1. Introduction

The extent and pace of climate change is already beyond our expectation. Its impacts are now experienced in every country. Rapid climate change has been severe and has created many problems throughout the world. Among the various definitions available for climate change, the definition offered by the United Nations Framework Convention on Climate Change is the most comprehensive. According to this definition, climate change is the change in the statistical properties of the climate system over long periods of time, regardless of cause. (IPCC, 2001) Moreover, climate change refers to a change in climate that is directly or indirectly attributed to specific human activity that alters the composition of the global atmosphere, and this change is above and beyond the natural climate variability observed over comparable time periods. (IPCC, 1994)

Demand for energy and associated services, to meet social and economic development and improve human welfare and health, is increasing. (IPCC, 2011) All societies require energy services to meet basic human needs and to serve productive processes. Since approximately 1850, global use of fossil fuels has increased to dominate energy supply, leading to a rapid growth in carbon dioxide (CO₂) emissions. (IPCC, 2011) Accordingly, the energy industry is being blamed for much of the observed climate change because this industry is a major source of carbon dioxide, which has been shown to contribute to climate change. However, this industry is also vulnerable to impacts of climate change, and those impacts must be analyzed to make plans not only for mitigation but adaptation to climate change. These activities will eventually increase the sustainability of the energy industry. This paper analyzes the risks and opportunities of the energy industry created by climate change, and summarizes how the energy industry copes with these risks and opportunities. This paper also highlights the current and emerging best practices within the energy industry and provides future recommendations for policies regarding climate change for policy makers and managers in the energy industry.

Companies in this sector have large fixed assets with long lifetimes assets that are vulnerable to climate impacts predicted to become increasingly severe over time. (Ceres, 2011) Therefore, it faces climate change impacts on its own operations. Furthermore, the mining companies face potentially significant risks from the physical effects of climate change, largely because the sector is very water- and energy intensive and operates in some very politically challenging countries. (Ceres, 2011) These activities will help the energy industry's sustainability. This paper is to discover the risks and opportunities of climate change in the energy industry and summarize how the energy industry copes with these risks and opportunities. To promote the idea in the industry it also highlights the current and emerging best practices. Finally it will help provide recommendations for policy makers and managers in the energy industry.

2. Research Resource and Structure

Companies that compete globally are increasingly required to commit to and report on the overall sustainability performances of operational initiatives. (Carin Labuschagne, 2003) The Global Reporting Initiative's (GRI) and Carbon Disclosure Project (CDP)

provide with very useful tool to figure out the sustainability trend. The GRI's vision is that reporting on economic, environmental, and social performance by all organizations becomes as routine and comparable as financial reporting. (GRI, 2009) Companies will disclose all relevant sustainability information using GRI guidelines, as well as additional sector-relevant indicators. (Ceres, 2011) Carbon Disclosure Project (CDP)—Since 2003, the CDP has been requesting information from corporations on their greenhouse gas emissions footprint and the risks, including physical risks, related to climate change. In 2011, more than 3,700 companies responded to the CDP questionnaire. This research focuses on the energy industry in terms of the climate change. Scope of energy industry is vast and it also has the anterior and posterior effects. Given the immense and diverse nature of this industry, this research cannot cover all corporations within this market segment. Therefore, the focus of this research is limited to corporations in the energy industry that were named on the Fortune 500 list in 2012. This includes also companies in the category of Oil, Gas, Fuels, Energy Equipment, and Services and corporations within the energy industry as defined by the GRI and the CDP. This paper explores how the key bodies in the energy industry perceive and respond to climate change. The study utilizes companies' sustainability reports including annual reports from major 77 energy companies.

3. Climate Change Risk and Opportunity

Climate change can definitely affect business operations. Indeed, these changes can present both risks and opportunities. Table 1 shows the climate change phenomena and the predicted future trend for each phenomenon. Potential impacts of climate change – on natural resources, unmanaged ecosystems, sea level rise and water resources – are hard to be estimated and make prevention actions.

Table. 1 Climate Change Phenomenon Likely to Affect to the Energy Industry (IPCC) ¹

Phenomenon	Likelihood of trend
Contraction of snow cover areas, increased thaw in permafrost regions, decrease in sea ice extent	Virtually certain
Increased frequency of hot extremes, heat waves and heavy precipitation	Very likely to occur
Increase in tropical cyclone intensity	Likely to occur
Precipitation increases in high latitudes	Very likely to occur
Precipitation decreases in subtropical land regions	Very likely to occur
Decreased water resources in many semi-arid areas, including western U.S. and Mediterranean basin	High confidence

¹ Definitions of likelihood ranges used to express the assessed probability of occurrence: *virtually certain* >99%, *very likely* >90%, *likely* >66%.
 Source: Summary for Policymakers, IPCC Synthesis report, November 2007 <http://www.ipcc.ch/>

Corporations can make decisions whether to take action or not in the face of specific results of climate change. If they decide to take action, two approaches are available, i.e., mitigation and adaptation. According to the Intergovernmental Panel on Climate Change (IPCC) definition, climate change mitigation focuses on efforts to reduce greenhouse gas (GHG) emissions and/or enhance the removal of these gases from the atmosphere through carbon sinks. (B. Metz et al., 2001) In contrast, adaptation to global warming is a response that seeks to reduce the vulnerability of biological systems to climate change effects. Even if emissions are stabilized relatively quickly, climate change and its effects can last many years, thereby making adaptation necessary. (Farber, Daniel, 2007) In actuality, adaptation is a necessary strategy for all players in the energy industry and should be used to complement any climate change mitigation efforts. Adaptation, sustainable development, and enhancement of equity can be mutually reinforcing. (Grida.no , 2001)

4. Perception of Climate Change from a Corporate Perspective

The energy industry heavily depends on natural resources, such as fossil fuels, water, and land. Moreover the energy industry will be confronted with the resource management crisis. Water is one of the critical resources. Water risk was raised by business executives in the World Economic Forum in Davos, 2013. More than 1.2 billion people already face water scarcity. By 2025, two-thirds of the world population will experience water stress. (Bloomberg 2013) The issues of complex linkages between food, energy, and water will be raised more and the energy sector will take more risk on their operation. Water stress will be more severe according to the IPCC scenario. In fact, 76% of the total water demand comes from the energy industry in Northeast Asia with the current pattern of energy use and energy mix. The energy companies in this study have indicated that they have adopted a heightened sense of awareness of the risks and opportunities induced by climate change. According to the CDP survey in 2012, the energy industry recognizes more climate risks (e.g., managing emissions and disclosing the alignment of the overall business strategy) than opportunities.²

The energy companies indicate a heightened sense of awareness of the risks and opportunities. According to the CDP survey in 2012, the energy industry considered climate change as a risk rather than an opportunity. Such as managing emissions and disclosing an alignment of the overall business strategy.³ Threats to business continuity due to increases in intensity and frequency of extreme events caused by climate change can be significant risks created by climate change. These extreme events can threaten the raw material supply and distribution chains, which would clearly affect the industry's ability to produce the needed energy. In actuality, adaptation is a necessary strategy for all stakeholders in the energy industry and should be used to complement any climate change mitigation efforts.

Uncertainty about climate change regulations and increased costs due to the

² Survey rate is not the same at the each industry level within the energy industry.

³ Survey rate is not the same at the each industry level in the energy industry.

introduction of carbon taxes can create significant doubt in the business environment and business operations. Therefore, the changes made by the government in an effort to address climate change risk also make an impact on the financial side of the energy companies. Moreover, in terms of environmental management, optimistic emission reduction efforts result in significant cost implications for all energy sector companies. Additionally, changes in consumer needs from conventional energy to renewable energy are changing the face of the energy industry. For a conventional energy corporation, this could possibly present a major negative impact on their revenue.

Despite the many associated risks, climate change also creates some benefits. For example, companies that are up-to-date with climate change policy changes can make additional revenue from reducing emissions, and they can be a player in the emission trading market. Also it is expected to see new market creation (ex. energy efficiency technologies, renewable energy) and it will create massive investment.

5. Disclosure Analysis

This paper is based on disclosure information collected in the form of the GRI indicator. The GRI disclosure index is composed of the items. Table 2 described and covers all corporate activities in relation to climate change. The ten indicators in the GRI index relate to the adaptation and mitigation activities associated with climate change.

Table. 2 GRI Indicators relating to Climate Change

Indicator	Explanation
EC2	Financial implications and other risks and opportunities for the organization's activities due to climate change.
EN2	Percentage of materials used that are recycled input materials.
EN5	Energy saved due to conservation and efficiency improvements.
EN6	Initiatives to provide energy-efficient or renewable energy-based products and services, and reductions in energy requirements as a result of these initiatives.
EN7	Initiatives to reduce indirect energy consumption and reductions achieved.
EN10	Percentage and total volume of water recycled and reused.
EN18	Initiatives to reduce greenhouse gas emissions and reductions achieved.
EN13	Habitats protected or restored.
EN14	Strategies, current actions, and future plans for managing impacts on biodiversity.
EN26	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.

Figure 1 shows the percentage of energy industry companies on the 2012 Fortune 500 list that used the GRI indicators for their sustainability reporting. It is worthy of note that the general energy industry has a high rate of reporting. Nevertheless, engineering companies report at the minimum rate. Also, note that the companies that published sustainability reports without reporting the GRI indicator were not included in this quantitative analysis.

Figure 2 shows that the disclosure rate in the energy industry by sector. The disclosure rate is very high in the oil and gas equipment industry, whereas the pipeline industry has the lowest disclosure rate as it is associated with many environment impacts and sensitive issues. The disclosure patterns for environment information and climate change information is similar in most segments of the industry, but the reports from the electric, mining/crude oil, and petroleum refining segments reveal more climate change activities than general environmental activities.

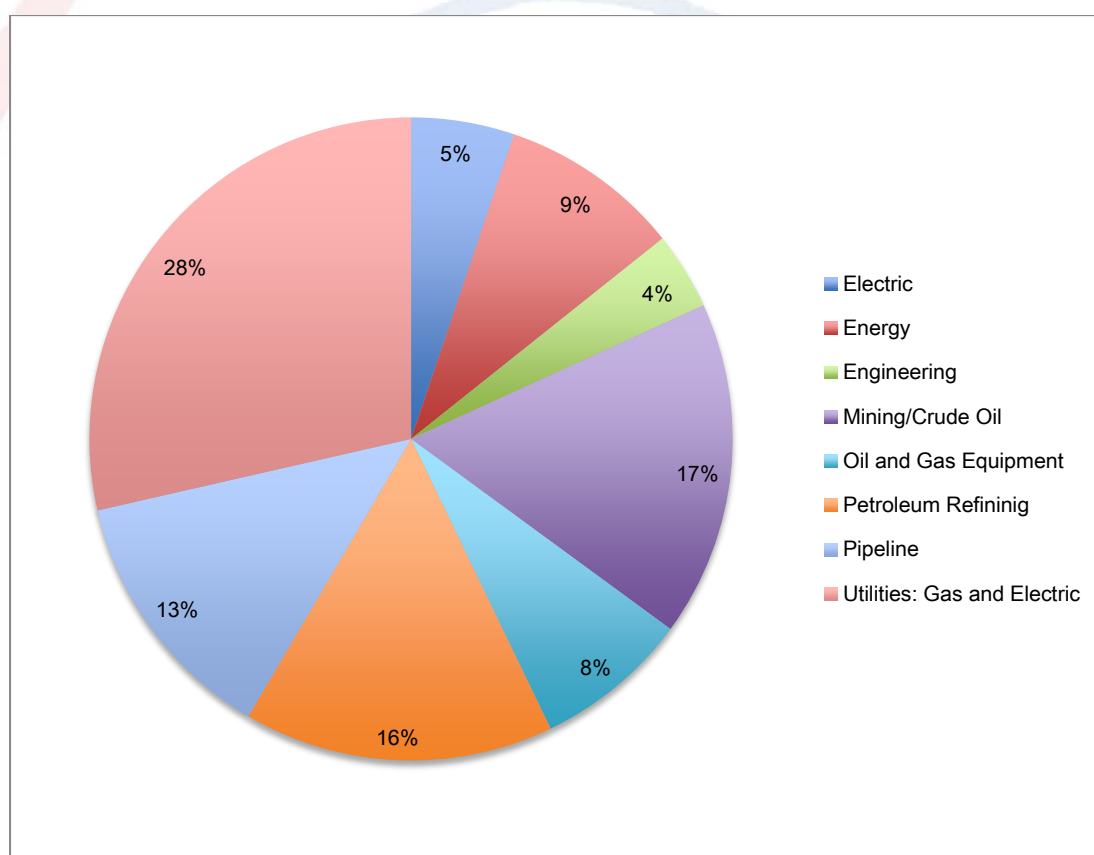


Figure 1: Reporting Rate by Sector in the Energy Industry

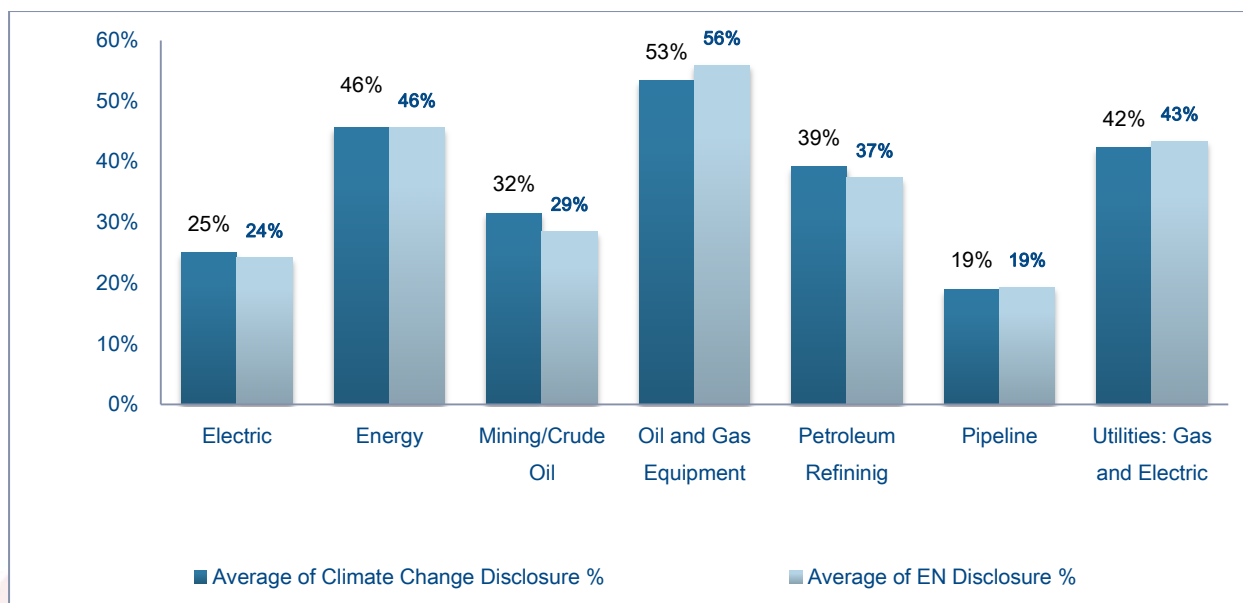


Figure 2: Comparison of Disclosure between Climate Change and Environment by Sector

The nature of the disclosure can be categorized into the following four categories: recognition, adaptation, mitigation, and the others. The average of adaptation disclosure in the energy sector is higher than the mitigation disclosure. The percentage of material used is the lowest disclosed indicator. Recognition of climate change is also not highly disclosed as it is an initial step to respond to climate change. Companies often report to recognize climate change in a certain year, and they only report to the follow-up measures in the following years. Adaptation and mitigation activities are often treated as the activities of risk management, and new market development and creation in the energy industry.

Figure 3: Disclosure Rate By Category (i.e., recognition, adaptation, mitigation, and the others)

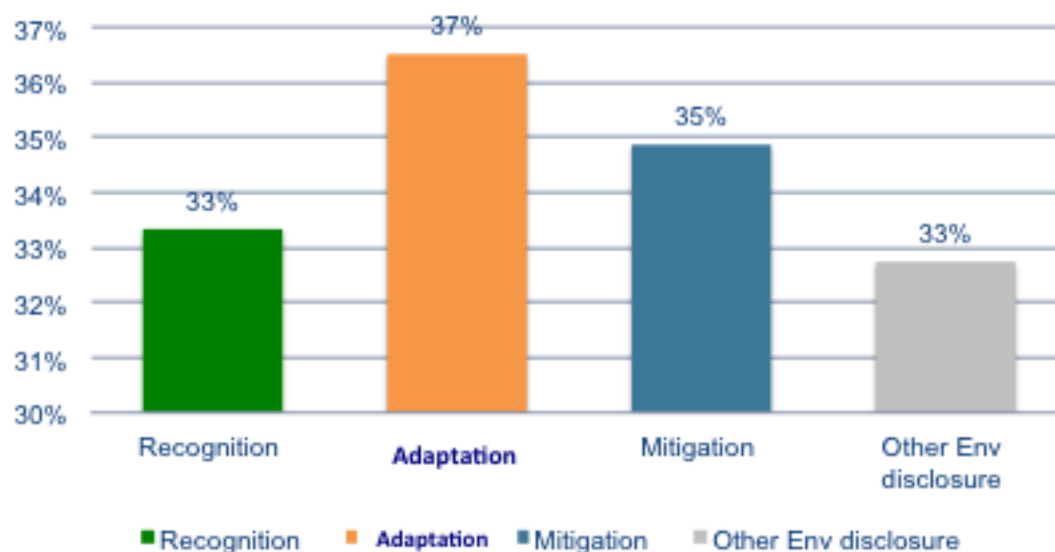
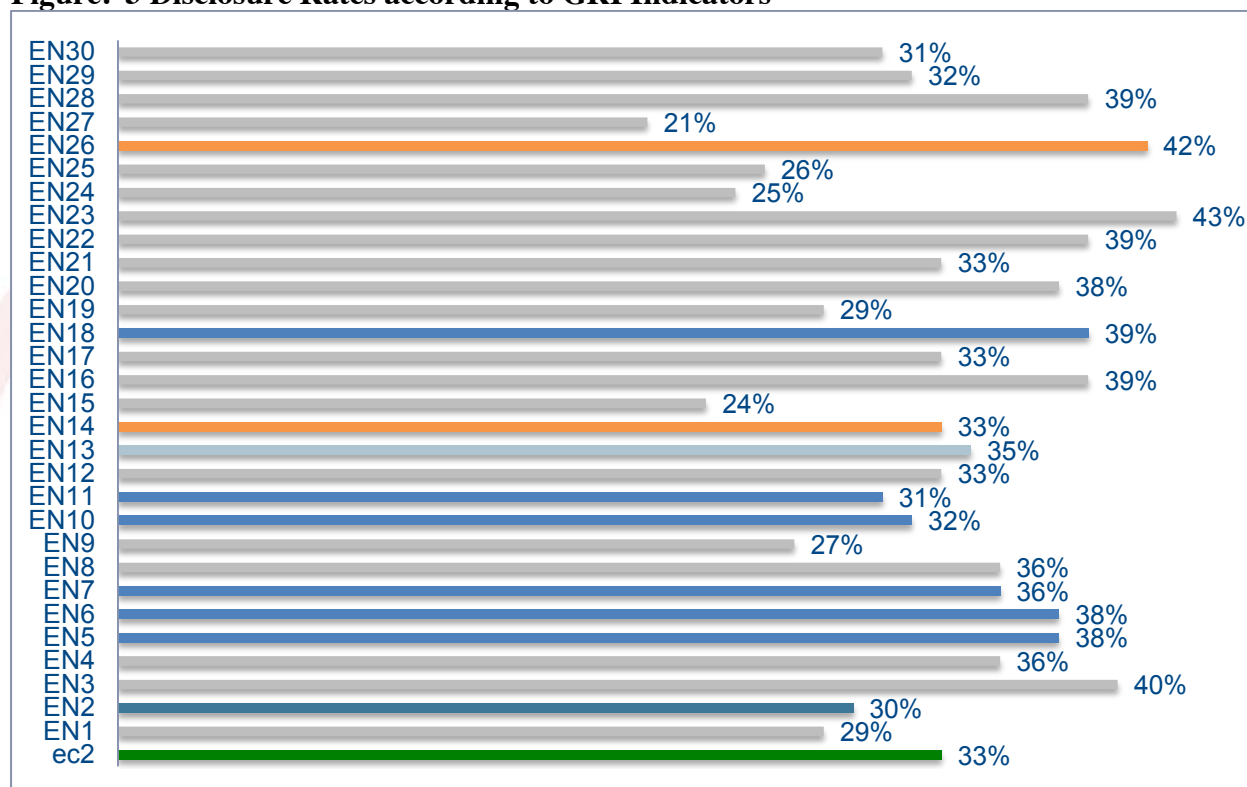


Figure 4 shows the disclosure rate for each indicator. Companies are very active in reporting EN 27 and EN15. Among the adaptation indicators, EN 26 got the highest disclosure rate. In terms of mitigation, EN 18 had the highest disclosure rate, and EN2 had the lowest.

Figure. 3 Disclosure Rates according to GRI Indicators



6. Action Analysis - Adaptation/Mitigation

This paper analyzes the self-reported information in relation to climate change of the Fortune 500 energy corporations. Although the presented data is based on limited information, it illustrates the level and scope of activities on climate change within the industry. Figures 5 and 6 show some companies' activities related to climate change adaptation and mitigation. It is challenging to illustrate their activities as its extent and pattern are varied. However, to identify the difference among the companies, the paper categorizes the companies according to their business type (e.g. upstream, and downstream), and pays attention to the difference between the categories. There is some limitation in this analysis. First, the boundary between downstream and upstream is unclear. Second, it is difficult to assess the companies' activities as some of them are only pledged and not yet proved to be implemented.

⁴ Fortune 500, 2012 Oil and gas and utility industry, 38 out of 72 were only eligible produced the reliable information, 2010 -2012 data

Consequently, more activities related to adaptation are found than the activities in relation to mitigation. For the adaptation strategies, weather is a very important action variable. Such companies as EVN conducted risk site assessments. The facilities of Encana, Wood Group, and FirstEnergy are well suited to endure potential temperature and weather-related shifts. Moreover, some companies took action on adaptation in their business plans by implementing employee training and resource management. Based on their recognition that water will be affected by climate change, Transocean and Sempra Generation implemented water recycling in effluent processing to allow the reuse of residual water. Exxon spanned multiple industries and developed new technologies that can improve resilience to climate change. Occidental Petroleum adopted a long-term view of research on climate change and the potential human influences on the climate. Furthermore, some companies (e.g., the EDF Group) even tried to promote energy efficiency with the end user.

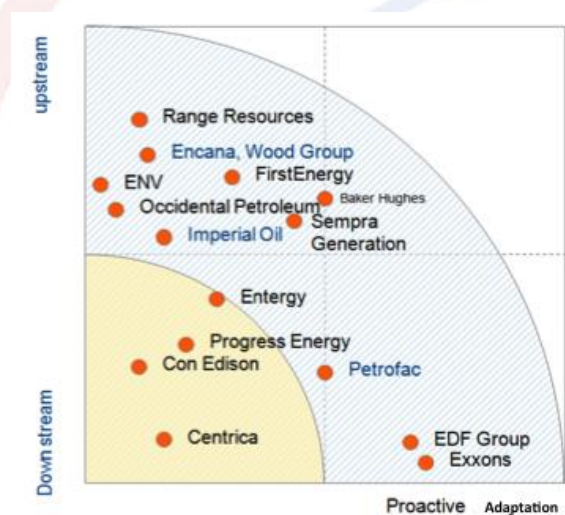


Figure 5. Adaptation Activities Analysis

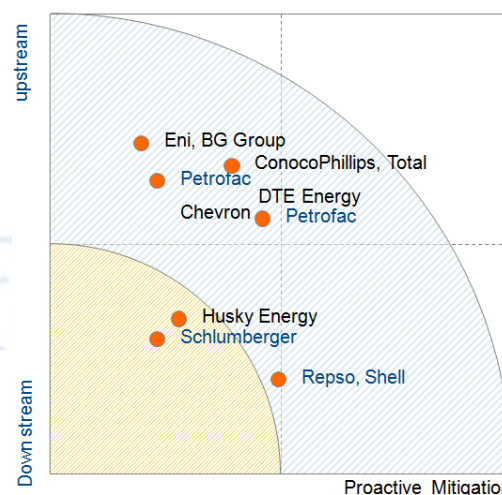


Figure 6 Mitigation Activities Analysis

Mitigation related activities were not reported as much as the adaptation related activities, but some promising activities was found in the disclosed information. Profac, Chevron, and British Gas expanded their operations into the renewable sector. CoconoPhillips diversified their energy sources. In terms of the carbon issues, Schlumberger, Husky Energy, Eni, and DTE Energy actively used carbon capture and storage (CCS) technologies.

7. Findings and Discussions

Climate change will likely impact the production, demand, and distribution of energy. As the energy industry has contribute to increasing CO₂, the action made by the energy business for climate change can help to mitigate the speed of climate change over all. At the same time, the energy industry is the one to be prepared for responses to this rapid change in order to survive. It is encouraging that this industry is showing

signs of recognizing the risks and opportunities induced by climate change. Adaptation and mitigation actions are slightly propagated in the oil and gas industry. Even though there are some recognition and engagement actions, by the nature of corporate pursuit of profits, their actions are very limited.

According to the Environmental Protection Agency (EPA, U.S.), climate change will likely impact the production, demand, and distribution of energy. Although the energy industry has contributed to the increase in carbon dioxide in the atmosphere, the actions taken by the energy industry in an effort to address climate change can help to mitigate the overall speed of climate change. Furthermore, this industry needs to be prepared for these rapid changes in order to survive. The fact that this industry is showing signs of recognizing the risk and opportunities induced by climate change is encouraging. However, adaptation and mitigation actions in the oil and gas segments still are few. Even though we can identify some prevention and engagement actions, these actions are limited due to their impact on profits. Nevertheless, mitigation and adaptation actions will improve corporate sustainability. In conclusion, to promote actions on the industrial level, strategic alliances are needed. Additionally, stakeholder management, including customers, is needed. Moreover, some actions are also needed on the policy making level. Global agenda setting, and quality and quantity assessment in terms of mitigation and adaptation are needed. The GRI index is fairly a good indicator and can be used generally to share the company information with the related stakeholders. Political power and market power is very essential to make a real change. The industry by itself is difficult to be changed. Therefore, appropriate incentives as well as supports from outside are necessary for the industry to be change. Especially, political stability can act as an incentive. Furthermore, carbon taxes and subsidies for low carbon technology can also help the overall corporate strategy. If the carbon trading market is normalized and fully established with various stakeholders including the corporate that emit carbon dioxide, those corporate will be more active on these issues. These components are interlinked with one another. Last but not the least, education on sustainability and climate change to the public (e.g., stakeholders, customers, and communities) is also important. Many companies have mentioned that the change in consumer's attitude is one of the highest risks associated with climate change. This type of education will be eventually a help to the corporation's business.

8. Concluding Comments and Research Implications

One of the more significant findings deducted from this study is that many companies in the energy industry starts to consider climate change as a challenge as well as an opportunity, but the extent of their responses were varied. The findings of this paper have practical significance, as it is one of rare researches on a specific private sector's response to climate change. Furthermore it has policy implications for the decision makers not only in the business sector but also in governments to support sustainable businesses and sustainable world.

To date, little research relating to climate change adaptation and mitigation in the oil and gas industry has been published. There is no unified method to check corporate actions related to climate change. Cost-benefit analysis is only applicable if the variances of both costs and benefits are finite. In the case of climate change, the

variances of the net present marginal costs and benefits of greenhouse gas emission reduction need to be finite. Finiteness is hard, if not impossible to prove. (Richard, 2003) However, an experimental and trial analysis can be initiated first, and it will eventually be a help to make the market more climate change friendly.

Even though this study could serve as a good start toward creating a research model, it is limited in terms of the quality and quantity of the data used. This research is entirely based on corporate sustainability reports. It must be noted that self-reports from corporations can be biased. Also, there is a possibility that some corporations may be active in these issues without reporting their activities. Furthermore, the disclosure information reported may not accurately reflect their actual adaptation or mitigation actions. Indeed, the quantity of information does not necessarily relate to the quality of action, and the reporting culture and rules vary according to the source of energy and the region in which the energy is produced. The current indicator frameworks that are available to measure overall business sustainability do not effectively address all aspects of sustainability at operational level, especially in developing countries such as South Africa. Social criteria, specifically, do not receive due considerations. (Carin Labuschagne, 2003)

The time period for which the data represents is also very limited. In fact, the corporate sustainability report covers a period no longer than 5 years. Most of companies also publish the reports less than two times. Lack of available information makes difficult for this research to figure out a significant trend of the energy industry. Moreover, comparing the actions of the companies is also difficult due to time and regional variations. This research used the sustainability report that has been published for the past 3 years. Nevertheless, the time period for the data collection is hard to coordinate for all of the companies because the regional and national laws do not apply to the each company in the same manner. Lastly, this paper is based on the energy companies on the Fortune 500 list; therefore, it is not a good representation of the renewable energy industry, which is still in its infancy.

References

- CDP - Driving sustainable economies <https://www.cdproject.net>
Global Reporting Initiative <https://www.globalreporting.org/>
Modeling the Impacts of Climate Change on the Energy Sector: a Swiss perspective ,
Camille Gonsethy and Marc Vielle, Research group on the Economics and
Management of the Environment(reme.epfl.ch)30 mai 2012
(Annex I. In: Climate Change 2007: Mitigation. Contribution of Working Group III to
the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (B.
Metz et al. (eds.))
[Farber, Daniel A. Adapting to Climate Change: Who Should Pay"], 23 FLA. ST. U.
J. LAND USE & ENVTL. L. 1, 8 (2007)
Climate Change 2001: Impacts, Adaptation and Vulnerability". Grida.no.
Retrieved 2010-08-29
Climate Change. Education Center – Arctic Climatology and Meteorology. NSIDC
National Snow and Ice Data Center. ; Glossary, in IPCC TAR WG1 2001.
The United Nations Framework Convention on Climate Change". 21 March
1994.Adapting to Climate Change: A Guide for the Energy and Utility Industry

Tiffany Finley, Associate, Advisory Services Ryan Schuchard, Manager, Climate and Energy, BIS

IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation- This Summary for Policymakers was formally approved at the 11th Session of Working Group III of the IPCC, IPCC, 2011

Assurance statement practice in environmental, social and sustainability reporting: a critical evaluation B O'Dwyer, DL Owen - The British Accounting Review, 2005

Corporate environmental disclosures about the effects of climate change E Stanny, K Ely - Corporate Social Responsibility and Environmental Management, Volume 15, Issue 6, pages 338–348, November/December, 2008

Assessing the sustainability performances of industries

Carin Labuschagne, Alan C. Brenta, Ron P.G. van Erck, Journal of Cleaner Production Volume 13, Issue 4, March 2005, Pages 373–385, 2003

From Risk to Opportunity Insurer Responses to Climate Change , E Mills Ceres Report, 2009

Corporate governance and climate change: Making the connection DG Cogan ,Ceres, 2006

The Road to 2020: Corporate Progress on the Ceres Roadmap for Sustainability, Ceres, 2011

Physical Risks from Climate Change: A guide for companies and investors on disclosure and management of climate impacts, Ceres, 2011

Water Risk to Business Is No Small Drip (Bloomberg 2013.01.30)

Is the uncertainty about climate change too large for expected cost-benefit analysis? Richard S. J. Tol , Climatic Change, 2003

Estimates of the damage costs of climate change. Part 1: Benchmark estimates, Richard S.J. Tol, Environmental and Resource Economics, 2002

*Emerging Issue in a Proper Recycling Technology for the Non-Metallic Portion
Separated from Printed Circuit Board Scrap: A Pyrolysis Based Recycling Approach*

Songpol Boonsawat*¹, Sunil Heart*¹, Premrudee Kanchanapiya*², Erik L. J. Bohez*³,
Yuttakan Makphan*⁴

*¹Griffith University, Australia, *²National Metal and Materials Technology Center,
Thailand, *³Asian Institute of Technology, Thailand, *⁴Institute of Renewable Energy
of Asia Pacific, Thailand

0742

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013



iafor

iafor
The International Academic Forum
www.iafor.org

INTRODUCTION

Nowadays, E-waste is one of the fastest growing waste streams worldwide. In 2009 alone, approximately 53 million tonnes of e-waste were generated. It is continuing to grow up by 3-5 % per Annum or approximately three times faster than other individual waste stream in solid waste sector (Schwarzer et al., 2005). Printed circuit board (PCB) is an essential component of electric and electronic equipment thus this resulting a significant increased number of PCB waste generated per year. Recycling is becoming an essential part to be considered due to the material diversity, and its complex structure. Although, the development of newer technologies and methods to recycle PCB have been investigated for decades. The recycling process in many developing regions are still primitive, and they are based on the separation of the precious element from PCB waste and reused it as material utilization.

Many of the material in PCB waste are able to be recovered and reused. However, the separation process is a key process for the successful of the further material recovery process. Amongst other things, the metals can be gather and recover to a like new material whilst plastics and other non metallic materials can also be recovered in some way. Non- metallic material after the precious metal separation process are not coped with the proper treatment such as landfill or combustion. Landfilling can seriously harm the environment by heavy metals leaching into the soil and ground water. Whilst, combustion of these products can release large quantities of hazardous chemical to surroundings. The ashes from combustion are often contaminated with toxicant element such as lead and other heavy metals. Although recently some hazardous chemicals, including flame retardants and heavy metals such as lead, mercury, chromium and cadmium have been banned from PCB industry. Still a vast amount of older PCB waste once they are discarded. The important constraints of these composite materials are how to be recovered correctly. Typically, thermosetting plastic can not be treated with the normal heating in order to be reformed. This resulting that the proper techniques shall be with other distinctive heating process. The crucial point is that thermoset plastic would be the ignition under oxygen atmosphere. However, there is a technique known as pyrolysis. It is the process with the capability to convert organic compound into gas and liquid within the reactor where heated and absence of oxygen. The aim of this paper is to provide an overview of an alternative proper treatment for this emerging issue and given its current approach techniques and comparisons. The paper will address the issue of using pyrolysis method for PCB waste recycling and, will explore the initiative as it is a proper recycling process of this waste stream. Throughout the paper, the emphasis will be on comparing the current available treatment which have been using worldwide and the pyrolysis method applied for recycling.

PCB material recycling method

Recycling of PCB is a serious concern not only of the environment but also the recovery of valuable materials. A successful recycling approach of PCB should take into consideration of recycled items support in order to compensate for the recycling cost, the investment and the environmental impacts. Recycling of PCB in particular is still a challenging task due to the diversity of these materials and the evolution of toxic substances. In the past, recovering of precious metal from PCB such as copper (Cu) was carried out on a large scale for a positive economic revenue and in terms of material utilization, whilst the non metallic material were treated with traditional process such as landfilling, combustion and reused as filler material. The environmental awareness pushed now toward a more comprehensive processes which includes recovering and recycling of ceramics and organic fractions in substitution to not eco-efficient disposal in this traditional pathway. Pyrolysis recycling is attractive because it allows recovering organic products in flammable gas, oil, and carbon solid residue. However, there

are additional controls needed to be considered in terms of flame retardants and toxic substances included in non metallic fraction can pollute the environment. In normal PCB recycling process required several steps such as disassemble of components (for printed circuit board assembled (PCBA) if necessary), physical recycling and then chemical recycling. Metal recovery can be performed by pyrometallurgical process. Crushing and separation are the key point for the successful improvement of further treatment. Non metallic fraction (NMF) after precious metal separation are now needed to be considered. In general, NMF consists of ceramics, short length glass fiber and thermoset plastic. From aforementioned data detailing that pyrolysis is suitable with organic products including plastics while thermoset plastics requires exceptional heating without oxygen, thus pyrolysis seems to be suitable for these materials. However the toxicant substances generation need to be investigated.

Problems associated with current PCB disposal treatment

Landfilling

As the non-metallic powder containing heavy metals, landfill may cause potential danger to the environment and security, for the leachate would penetrate to groundwater. On the other hand, it increases the scarcity of land, and it is a serious resource wasting (W. Li et al., 2012).

Combustion

Incineration, non-metallic powders carry a large number of low calorific value composite, such as glass fibers and other inorganic constituents. As a result, the heat generated in the incineration is not high enough. Meanwhile, it may produce large amounts of dioxins and other carcinogens, causing serious environmental contamination (W. Li et al., 2012).

Reused by apply into new products

According to the different of the composite materials, non metallic material could be applied to make types of product. For example, asphalt, cement mortar and environmental friendly concrete members (W. Ru et al., 2011). Glass reinforced plastic materials can be used to apply with fiber reinforce plastics FRP. Non metallic material was applied in powder form with the short length glass fiber. The short has improved FRP mechanical and physical performance especially bending strength. Reused as phenolic molding compound e.g. Filler material can be improved their flexural strength, impact strength, water absorption and the heat resistance (W. Li et al., 2012).

Pyrolysis method associated with PCB

There are two scenarios of the pyrolysis associated with the PCB waste. First, in case that non metallic materials have been separated from metal portion before processed with the pyrolysis method. Otherwise, PCB waste would be processed only with pyrolysis without mechanical separation. Mechanical separation enhances the further heating process because of the increased contacting area with heat. However, size reduction from mechanical separation limits the further used of glass fiber and requires high energy consumption of crushing equipment because of the hardness and tenacity of PCB product.

Pyrolysis of thermosetting plastic in PCB

Pyrolysis is a thermochemical decomposition of organic material in the heating reactor by using elevated temperature without participation of oxygen in the chemical reaction. Thermosetting plastic is the main organic material included in PCB. The differences in thermal property of the materials in PCB are quite wide and can be ranged up from thermoset plastic, fiber glass and ceramic respectively. Hence, there is an opportunity to a total separation of this complex material for a further material utilization process. Pyrolysis technique can be used in both before or after metal separation. The pyrolysis process turns

resin plastics into flammable gas and condense into flammable liquid form. Fuel oil is the main output product from pyrolysis process. Most of the past research operated pyrolysis temperature approximately range from 400 ~ 550 C. and condense at different range of temperature. An extremely low temperature of gas compensation gave highest output yields. However, in this case the hydrogen chemical reaction may not be fully finished. As a result, the output product has become a wax form and requires a fuel distillation process. On the other hand, the condensate of pyrolysis gas with a narrow range of temperature has given a better result in the quality of flammable liquid (fuel oil) but lower in quantity yield from the pyrolysis gas condensation process.

Recycling of glass fibers from pyrolysis

After pyrolysis process, glass fiber and ceramics have been found in solid residue with carbon deposited on the surface. It can be operated with 450 C. to completely burn carbon off, and then clean up by rinsed several times with distilled water to remove ash and finally air dry (Cui et al., 2010; Guan et al., 2008).

CONCLUSIONS

As the most potential approach for PCB recycling, the pyrolysis technique still need a high level of skill and equipment. Meanwhile, these primitive treatments for the overabundant amount of PCB waste generated per year are not sustainable and eco-friendly. From past research indicated that pyrolysis process is able to recover organic part of PCB into flammable liquid and gases. This could be a potential approach for PCB recycling in the near future. However the flame retardant and product additive in PCB may influence on the quality of the output products, this aspect need to be further investigated. The current disposal treatments of non metallic material from PCB waste are totally improper. They cause secondhand pollution and resource wasting. The results of this study have pointed out that pyrolysis method can be applied for PCB recycling process and suit for using as material recycle treatment for the non-metallic fraction from PCB waste.

REFERENCES

Cui Quan, Aimin Li, Ningbo Gao, Zhang dan, 2010. Characterization of products recycling from PCB waste pyrolysis. *Journal of Analytical and Applied Pyrolysis*, 89(1):102-106

Guan Jie, Li Ying-Shun, Lu Mai-Xi, 2008. Product characterization of waste printed circuit board by pyrolysis. *Journal of Analytical and Applied Pyrolysis*, 83(2):185-189

Schwarzer, S., Bono, A.D., Peduzzi, P., Giuliani, G. & Kluser, S. (2005). E-waste, the hidden side of IT equipment's manufacturing and use. *UNEP Early Warning on Emerging Environmental Threats No.5*.

Wang R, Wang PM, Zhang TF. A non-metallic powders of waste printed circuit boards environmentally friendly cement mortar in China Patent No.: 201110178408.4, 2011.

Wenhong Li, Yan Zhi, Qingyin Dong, Lili Liu, Jinhui Li, Shili Liu, Henghua Xie, 2012. Research progress on the recycling technology for nonmetallic materials from wasted printed circuit board. *The 7th International Conference on Waste Management and Technology. Procedia Environmental Sciences* 16 (2012) 569 – 575

Widening Access or Narrowing Student Choice? The Re-emergence of Elitism in the UK Higher Education System

Steve Talbot, James Johnston, Alan Reeves

University of the West of Scotland, UK

0752

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Higher education systems in many parts of the world have struggled to reconcile falling state support with widening access and increasing participation of previously excluded groups. Evidence from the UK higher education system suggests that this tension has led to the re-emergence of a bifurcation of the education system along social class lines. The paper explores the experience of the different categories of UK-university as they manage the changed socio-economic environment in which they operate. Contrary to the aims of much EU policy and the various structural changes introduced within the higher education sector since the 1960s, lessons from the UK experience suggest that a form of elitism has re-emerged in the provision of certain subjects. We show how a combination of market forces, government policy and other developments in the UK higher education landscape may lead to the withdrawal of the key subjects for many vulnerable groups. We look at economics provision across the UK to show how a silent process of differentiation and stratification may take place and that this may be to the detriment of national policies on social inclusion in higher education.

Introduction

Like many EU countries the UK has undergone major structural change to its system of higher education provision. While the nature of the driver for change within individual countries is unique, the main collective force for change is the desire to improve the international competitiveness of the EU region. The desire at the EU level is to replicate the perceived dynamics of the US system of higher education, which is deemed to have furnished impressive economic and innovative performance. Trow (2000) casts doubts on the robustness of the resultant European model of the university and its ability to meet the challenges associated with globalisation due to an innate lack of flexibility of governance. Critically for Trow, and others, European models of Higher Education are characterised by high levels of government involvement, unlike in the US where market forces play a much larger role (Huisman, Meek and Wood 2007). The reliance on markets as an arbiter of US higher education provision reflects the significant structural change at two key junctures in its past¹ when it was necessary to rapidly expand higher education provision and the legacy of this change is deemed to have bestowed the competitive advantage of flexibility and adaptability on US universities. As Trow (2000) notes, the structural changes reflected wider societal change within the US (e.g. abolition of slavery) and consequently the ability of US universities to act autonomously in terms of provision and enrolment. The result is that the US is traditionally seen as more responsive to changes in the market for education and is able to pioneer new access arrangements such as credit transfer and articulation with high schools.

To emulate the success of the US higher education system and to meet the increased challenges of globalisation, the role of European universities has been gradually changing over the past 30 years. To better reflect the US model a conscious effort has been made to combine the traditional university missions of research and teaching with a new, third mission. EU universities now have an explicit mission of socio-economic engagement (Nelles and Vorley 2010) aimed at unlocking the knowledge within universities through a partnership between government, industry and Higher Education (Etzkowitz and Leydesdorff 2000). This utilitarian vision of the university mission has been heavily supported by national (Mawson 2007) and supranational bodies, especially within the EU (EU 2006, EU 2008) and further afield (OECD 2007). The move to a more utilitarian approach was an EU-wide phenomenon with the creation of the European Higher Education Area and compatible overarching frameworks for qualifications that were part of the Bologna process instigated in 2000, although Teichler (2008) questions how successful this has been. Adding to the momentum towards a utilitarian approach to the Higher Education sector, the 2007 Lisbon Declaration of the European Universities' Association recognised the concerns of universities by stating the need for university autonomy but deferred to the 'managerial and economic priorities' of governments (Anderson 2010). Traditional university activities of research, teaching and knowledge transfer activities are

¹ Two key junctures were the end of the civil war and the early part of the twentieth century.

deemed to become more effective at the socio-economic level if universities are encouraged to engage in each sector of the triple helix model: the knowledge society, economic competitiveness and social cohesion. Explicitly, the overall aim of EU higher education policy is to make the European university system a model of best practice by ensuring that there are sufficient resources, effective networks and increased outreach and international appeal of European universities (The Role of the Universities in the Europe of Knowledge COM 2003/58).

In the UK there has been a gradual move towards a triple-helix-type model for higher education. In 1963 the Robbins Report (Committee on Higher Education 1963) paved the way for the creation of the third mission by recognizing the need to overcome the damaging effects of an overly-differentiated provision of post-school education by creating so-called chartered universities (i.e. new non-traditional universities). In 1992 the Further and Higher Education Act recognised the need to widen further socio-economic engagement in higher education by removing the distinction between universities and polytechnics/colleges. As a consequence, the UK Higher Education sector has become an intricate pattern of institutions able to perform the functions of a university, Tight (2011) with the result that the UK a more diverse Higher Education system than many European countries (Huisman, Meek and Wood 2007). While education is a devolved responsibility in Scotland, the Robbins and Dearing changes were fully adopted. This top-down approach to higher education reform resulted in a small country (Scotland) having nineteen university-type institutions (Universities Scotland 2012) and appearing to offer US-style flexibility and improved student choice. Allied to these changes there was a further weakening of the demarcation between higher education and further education through a series of articulation agreements between some universities and the further colleges. The result is that in Scotland 17 per cent of higher education-level students attend programmes delivered at Further Education institutions (Mullen 2010) leading to further education becoming more like US community colleges rather than old style technical colleges (Gallacher 2006). For the purposes of this paper it is the nature of the articulation between further education colleges and the universities that is the main area of contention when looking at issues of social inclusion.

Is there evidence of widening access?

Scottish policies designed to widen access to higher education to previously excluded groups has been a success. In 2009, the Scottish Funding Council (SFC) introduced the 'Framework for Equality, Access and Inclusion' which set out and summarised the actions of the various stakeholders at national, regional and local level tasked with assisting in widening access but particularly to improve access to higher education. Data appears to confirm this policy has been successful, with around 20 per cent of entrants to undergraduate study entering universities through the articulation route

whereby students study Scottish Credit and Qualification Framework² (SCQF) Level 7³ (Higher National Certificate) and Level 8 (Higher National Diploma) at a further education college before continuing to Level 9 (degree) at a degree awarding institution (Universities Scotland). SCQF Levels 7 and 8 define the first two rungs on the Scottish higher education ladder and by offering Levels 7 and 8 further education institutions play an important role in the pursuit of wider access. Figures show that in 2010-11, 185,290 Scottish students studied at Scottish higher education institutions while a further 37,220 students attended further education colleges to study for Higher National Certificates (17,968) and Higher National Diplomas (19,252). Thus around 17 per cent of students at Levels 7 and 8 attended a further education institution. (The figure for higher education is around 20 per cent higher if non-Scottish students are included but it is difficult to get a precise picture due to the way the data are gathered (Croxford, Howieson and Steele 2011). However, as will become clear, taking the further education route to Levels 7 and 8 before attempting to complete a degree at university means that much of the richness of higher education landscape will be denied to those on this route. In addition, it is the socially excluded who traditionally take this route and therefore have a much more limited higher education horizon than those accessing higher education with school-based qualifications.

Impact of policy

While access to higher education has undoubtedly been widened, the real issue when discussing social inclusion is whether all groups have the same access to the whole higher education landscape. The nature of the issue is more subtle than gross numbers of the socially excluded actually attending university. There is a silent dynamic at work that operates on the demand for higher education and on the supply of higher education which leads to a bifurcation of the sector to the detriment of disadvantaged groups. The result is a higher education system characterised by product differentiation among universities and access stratification on socio-economic class grounds among students (Gallagher 2006). While the emergence of differentiation and stratification in the UK higher education sector has been established (see for example Gallagher 2006, Croxford and Patterson 2006) but what have not been identified before are the details of the silent dynamic at work. We present evidence that may be of interest to universities in other countries on the details of the silent dynamic and

² The Scottish Credit and Qualifications Framework Partnership promotes lifelong learning in Scotland.

³ For a detailed explanation of the academic framework and the respective positions of HNC and HND level qualifications in the Scottish higher education framework see:

[http://www.scqf.org.uk/content/files/SCQF_Level_Descriptors_for_website_-_Feb_2010\(2\).pdf](http://www.scqf.org.uk/content/files/SCQF_Level_Descriptors_for_website_-_Feb_2010(2).pdf)

how it appears to work against the aims of policies designed to alleviate social exclusion.

The relevance of widening access policies to the provision of university programmes is that if population groups previously under-represented in higher education have aptitudes and programme preferences that are systematically different from those of the groups that have traditionally populated the UK higher education system, and students entering universities through access programmes tend to study at certain types of institutions, then the pattern of demand faced by new universities will change and will also be different from the pattern of demand faced by old universities, with some programmes being a lot easier to fill than others. It is clear that students from lower socio-economic classes are much more likely to attend new universities and, to the extent that not having traditional academic qualifications will be reflected in different university programme preferences, will want to study other subjects.

As the discussion so far indicates, the number of students attending higher education has increased and the role of the further education sector has helped provide a pathway for many students new to higher education. However, a major imperfection in the UK system means that 'some students are disadvantaged at school compared to pupils at private schools and cannot get to the university they deserve' (Simister 2011:135). Gallacher (2006) shows how a dual process involving social stratification and differentiation by higher education institutions appears to militate against the erosion of this imperfect system preventing the establishment of a more meritocratic system. We now look at the experience of a subject, which has traditionally been viewed as one of the more difficult subjects and one requiring relatively high entry qualifications.

The emergence of differentiation in economics provision in Scottish higher education and the role of university autonomy

Recent research by the authors into the current state of economics degrees within the UK found that something quite profound has happened and that this had wider societal implications: economics had become an elite subject whose provision is restricted to a few elite universities. To help explain this it is possible to view economics provision as having two distinct elements, teaching (named economics degrees) and research. Analysis of the data reveals that old universities were much more likely to offer an undergraduate degree in economics than new universities and the difference is prominent. Indeed, the best predictor of whether a university offered an economics exit title was almost certainly whether it was categorised as old or new. The data set includes 65 new and 54 old universities. Approximately three quarters (48 out of 66) of the universities offering single programmes in economics, business economics or financial economics were old. In contrast, three quarters of new universities did not offer an economics exit award in 2011-2012.

In terms of named degree programmes and research, economics has disappeared in all post-1992 institutions in Scotland. So-called Chartered universities (those established under Robbins in 1963) while still offering economic degree programmes have to some extent retreated from economics research defined as entry in the Economics and Econometrics Unit of Assessment of the Research Assessment Exercise (RAE). Only the four ancient universities maintain the duality of economics provision and economics research as defined above. This is an important point as this duality maintains the elitism of these universities and hence the future employment prospects of their students. The consequence of structural change in higher education is quite clear: economics has become an 'elite' subject increasingly the preserve of the ancient universities who draw their students mostly from the most advantaged sectors of society. Shattock (2001) identifies a set of themes that support this structural divide between what he calls the 'old' universities and the post-1992 institutions with one outcome being the retreat of some subjects from the latter group. Such research supports the notion of a process of rationalisation, whereby some institutions abandon certain subject areas and our research confirms that in Scotland this process has impacted on economics provision. A similar pattern emerges for the UK as a whole, with the best predictor of whether a university offers an economics title being whether it is old or new, with 75 per cent of old institutions offering economics degrees in contrast to only 25 per cent of post-1992 institutions.

Lessons for others

A key lesson for universities in other countries is the role played by universities in this process of rationalisation. In Scotland as in the rest of the UK, universities enjoy a high degree of autonomy in terms of deciding what provision they will offer prospective students. The continuing autonomy of universities appears to have resulted in a degree of rationalisation of economics beyond what any government would have seriously been able to propose without a major campaign of resistance by the economics profession. It is this autonomy which has enabled the re-emergence of a differentiated higher education landscape that was supposed to have been removed in the UK by the structural changes of 1963 and 1992. The interesting aspect is the emergence of clear differences in the extent of economics provision along the structural divide: all ancient and two chartered universities (Dundee and Stirling) had economics programmes and economics research, two of the chartered universities had economics programmes but no economics entry in the research assessment exercise (Strathclyde and Heriot-Watt) and finally all of the post-1992 institutions had no economics programmes and no economics research.

As mentioned earlier, the key issue is not access to higher education (access has been widened) but the gap between the most advantaged and the least advantaged in gaining admission to the ancient and chartered universities. Because many post-1992 institutions have abandoned key subject areas it is to be expected that job prospects

and access to the professions will be constrained. Scotland is not alone in this as a similar picture seems to emerge from England. According to the Office for Fair Access (OFFA), while there have been substantial increases in participation in higher education among the least advantaged 40 per cent of young people over the last fifteen years, the participation rate among the same group of young people at the top third of universities has remained virtually unchanged over the same period (Office for Fair Access 2010). Moreover, the most advantaged twenty per cent of young people were around six times more likely than the least advantaged group to attend in the mid-1990s and this increased to around seven times by the mid-2000s. Thus, the evidence suggests that strategies to improve access have only been partially successful as equality in participation has not been achieved. This is our main thesis: that access to higher education has improved but it is not equal access to all subjects; for many students from disadvantaged backgrounds the door to economics remains almost closed. This raises some serious issues for policymakers.

Changes described in this paper would also seem to reflect a change in the nature of higher education, particularly in the new universities, where the emphasis is on training people for work rather than providing an education per se. In other words, the utilitarian approach favoured by Dearing has some unexpected results. With increased specialisation in the sector overall, the task of educating students in the traditional manner and subjects has to a much greater extent been allocated to the old universities. The recent criticisms from employer organisations appear to suggest that the new universities are not always being successful in their allotted role (CBI/NUS, 2011). If market rates of pay are a reflection, at least in part, of worker productivity, the fact that economics graduates earn relatively high levels of remuneration (Chevalier, 2011) suggests, all else being equal, that the study of economics raises to a greater extent than some other subjects the ability of individuals to contribute to economic growth and to enjoy the rewards from doing so. If members of lower socio-economic groups are unable to access the subject due to it being withdrawn from the sorts of universities that these sorts of people typically attend, this will risk damaging their career prospects. It is not possible to quantify the number of people who may select 'second best' subjects or who may decide not to go to university at all as a result of their preferred option not being available but it is potentially a serious loss. In a sense the market might be failing to allocate enough resources to the study of economics and this may be grounds for government providing some sort of subsidy for the study of economics in the new universities.

However, market forces, government policy and other changes in the UK higher education landscape would appear to have conspired to set the UK higher education system on a path that has reduced the opportunity for people from lower socio-economic groups to participate in the public debate on this vital issue. The reason for this is that if access to old and new universities is stratified along social class grounds (and there is a lot of evidence to suggest that this is the case - see for example, Gallacher, 2006 and Boliver, 2011) and if new universities are increasingly removing

economics degree programmes (and the evidence presented above shows that this is increasingly the case) then students from lower socio-economic groups will have less access to the study of economics at an advanced level. The resultant weakening in the voice of these groups may have skewed the national debate on the crisis in unexpected and undesirable ways. This is something which universities in other parts of the world need to be aware.



References

Anderson, R. (2010). The 'idea of a university' today. **History and Policy**. [online]. Available at: <http://www.historyandpolicy.org/papers/policy-paper-98.html> (Accessed 8 March 2012)

Boliver, V. (2011). Expansion, differentiation, and the persistence of social class inequalities in British higher education. **Higher Education**, 61 (3): 229-242.

Chevalier, A. (2011). Subject choice and earnings of UK graduates. **Economics of Education Review**, 30 (6): 1187-1201.

Committee on Higher Education (1963). **Higher Education: Report of the Committee Appointed by the Prime Minister Under the Chairmanship of Lord Robbins 1961-63**, Cm 2154. London: HMSO.

Croxford, L., Howieson, C. and Steele, D. (2011). Recording and reporting student articulation from Scottish colleges to Scottish HEIs through UCAS: ELRAH Research report and specification of change requirement. [online]. Available at:

<http://www.elrah.ac.uk/Documents.aspx?itemID=bc5bdc4e-9933-41e4-ab7f-745f88c0f247>

(Accessed 2.12.2012).

Croxford, L and Paterson, L. (2006). Trends in social class segregation between schools in England, Wales and Scotland since 1984. **Research Papers in Education**, 21(4), 381-406.

Etzkowitz, H. and Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university–industry–Government relations. **Research Policy**. 29, 109–123.

EU, Commission of the European Communities (2006). **Cluster modernisation of higher education**. Brussels, Doc. MHE 7.

EU, Commission of the European Communities (2008). **Towards more knowledge-based policy and practice in education and training**. Brussels: EU, SEC (2007) 1098.

Gallacher, J. (2006). Widening access or differentiation and stratification in higher education in Scotland. **Higher Education Quarterly**, 60 (4), 349–369.

Huisman, J., Meek, L. and Wood, F. (2007). Institutional Diversity in Higher Education: a

Cross-National and Longitudinal Analysis. **Higher Education Quarterly**, 61: 563–577.

Mawson, J. (2007). Research councils, universities and local Government – building bridges? **Public Money and Management**. 7(4), 265-272.

Mullen, F. (2010). **Widening Access to Higher Education Policy in Scotland**. SPICe Briefing SB 10-09. Edinburgh: Scottish Parliament.

Nelles, J. and Vorley, T. (2010). From policy to practice: engaging and embedding the third mission in contemporary universities. **International Journal of Sociology and Social Policy**. 30 (7/8), 341-353.

OECD (2007). **Higher Education and Regions: globally competitive, locally engaged**. Paris: OECD.

Office for Fair Access (2010). **What more can be done to widen access to highly selective universities?** Bristol: Office for Fair Access.

Shattock, M. (2001). The academic profession in Britain: A study in the failure to adapt to change. **Higher Education**, 41, 27–47.

Simister, J., (2011). Elitism and meritocracy in UK universities: the UK needs investment in its labour force. **Higher Education Quarterly**, 65 (2), 113–144.

Teichler, U. (2008). The changing patterns of the higher education systems in Europe and the future tasks of higher education research. In J. Brennan, J. Enders, J. Valimaa,

Tight, M. (2011). How many universities are there in the United Kingdom? How many should there be? **Higher Education**, 62 (5): 646-663. [online]. Available at: <http://www.springerlink.com/content/3146w04v65x78605> (Accessed 29 February 2012).

Trow, M. (2000). From mass higher education to universal access: the American advantage. **Minerva**, 37, 1–26.

Universities Scotland. [online] Available at: <http://www.universities-scotland.ac.uk/> (Accessed 4 December 2012).

June 2013

Parametric Study of Earth-to-Air Heat Exchanger in Malaysian Climate

Md Najib Ibrahim, Aliyah Nur Zafirah Sanusi, Maisarah Ali, Soran Hama Aziz
Ahmed

International Islamic University Malaysia, Malaysia

0140

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The technology, where the ground was used as a heat sink to produce cooler air, has been an area of interest in Malaysia even before National Green Technology Policy was launched in 2009. This simulation study is based on ASHRAE Weather database, local data collected in previous field studies at Universiti Teknologi Malaysia Skudai Campus in Johor and International Islamic University Malaysia Gombak Campus in Selangor. This study investigates the parameters influencing the cooling potential of Earth-to-Air Heat Exchanger (EAHE).

Keywords: ground cooling, green technology

1 INTRODUCTION

Green technology is a top priority in Malaysia. The 2013 Budget gave an additional RM2 billion for green technology projects under the Green Technology Financing Scheme (Intan Farhana Shazwan (2013)). Since January 2010, a total of RM1.5 billion has been made available for soft loans to interested parties with low interest rates. One of the less explored green technologies is earth cooling.

Heating and cooling needs of building can be significantly reduced by utilization of the stored energy derived from the earth. Earth-to-Air Heat Exchanger (EAHE) is a metal or plastic pipe buried underground through which the air passes from one end to another. EAHE is also known as Earth-air-pipe system (Huijun et al., 2007), Earth tube heat exchanger (Miroslaw, 2011; Trombe et al., 1991), Earth tube system (Jacovides et al., 1995; Kwang and Richard, 2008), Earth-air-tunnel system (Rakesh et al, 2003), and underground air pipe air conditioning system (Sawhney et al., 1999). During heating season the ambient air that flow through EAHE is pre-warmed before entering building. The direction of heat transfer is reversed that the ambient air is pre-cooled in summertime.

This earth pipe cooling technology has been explored by many researchers and used by building designers as cooling means for various building types in temperate countries as well as hot and arid countries, where the results have been significant and positive. Min (2004) analyzed application of EAHE in Montreal, Canadian climate. Kwang and Richard (2008) conducted parametric study of EAHE in USA at four different locations (Spokane, WA: mild and dry; Peoria, IL: mild and wet; Phoenix, AZ: hot and dry; Key West, FL: hot and wet). Fabrizio et al. (2011) evaluated the energy performances achievable using EAHE in different Italian climates (i.e. Naples, Rome, & Milan). Ghosal and Tiwari (2006) integrated the EAHE with the greenhouse located in Delhi, India. Vikas et al., (2010) analyzed the performance of the system in dry climate of the Western India . Darkwa (2011) evaluated the EAHE system as an energy saving technology for a typical hot and humid location in Ningbo, China. Al-Ajmia et al., (2006) predicted the outlet air temperature and cooling potential of EAHE in a hot and arid climate in Kuwait.

However, information on earth pipe cooling technology in Malaysia is scarce. The first known research to study viability of earth cooling in the country was funded by Universiti Teknologi Malaysia (UTM) and was conducted in its Skudai Campus, in a suburban area 18 km from Johor Bahru City (Md Najib Ibrahim, 1988). The field measurements were conducted in 1986 near one of its buildings. At that time the 1,222 hectare new campus, a former rubber estate, was occupied by only a small number of buildings, therefore the microclimate of the campus was different from Johor Bahru, Malaysia. In the morning of rainy season temperature as low as 24°C were recorded. At that time it was found the cooling potential of earth cooling was not significant since ambient temperature was relative low.



Fig. 1 Location of Ground Cooling Studies in Malaysia

Reimann, Boswell & Bacon (2007) reported earth cooling was incorporated into CoolTek house, in Melaka, Malaysia. The earth cooling system consists of a sub-soil chamber and a sub-soil duct. The sub-soil chamber was constructed from 50 mm thick 1000 mm diameter concrete culvert, containing five concrete filled ceramic pipes standing on a concrete plinth of 300 mm depth with heavy concrete, surface insulated lid. It was connected with 10 meter sub-soil duct with an air intake opening. It was generally concluded that the potential for earth cooled ventilation was relatively small.

Aliyah Sanusi, Li Shao and Md Najib Ibrahim (2013) reported a field investigation of earth pipe cooling technology, conducted in International Islamic University Malaysia (IIUM), Gombak Campus, Kuala Lumpur. It was found at 1 m underground, the result is most significant, where the soil temperature is 6°C and 9°C lower than the maximum ambient temperature during wet and hot and dry season, respectively. It was also found Energy Plus simulation results correlate well with the field work.

This paper presents a more detail simulation study on the parameters influencing the cooling potential of earth pipe cooling in Malaysia. Specifically the objectives of study are as follows:

1. To determine when outlet air temperatures T_{PO} is lower than ambient air temperature T_A
2. To determine when the cooling potential ΔT (the difference between T_A and T_{PO}) is maximum

3. To determine the influence of diameter, air velocity, and pipe length on the ΔT

2 SIMULATION METHOD AND RESULTS

An EAHE model (known in the software as earth tube) was created in EnergyPlus Version 7.1. Three simulations were conducted on the model. In Simulation 1, air velocity and pipe length were set as constant while pipe diameter is varied. In Simulation 2, pipe diameter and pipe length were set as constant while air velocity is varied. In Simulation 3, pipe diameter and air velocity were set as constant while pipe length is varied. The weather **DATA FOR KUALA LUMPUR** from ASHRAE database and soil data taken from an experimental site at IIUM Campus Gombak were used in the simulations.

2.1 Simulation 1: Influence of pipe diameter

Fig. 2 shows typical daily profile of ambient air temperature T_A and outlet air temperatures T_{PO} in June (hot season) when the air velocity, length and depth are set at 4 ms^{-1} , 50 m and 1 m respectively and pipe diameter is varied from 1 to 14 inches. Three patterns were observed. First, all T_{PO} are lower than T_A after 11.00am. Second, all T_{PO} is higher than the T_A after 7.30pm. Third, T_A as well as T_{PO} peaks at around 2.00 to 3.00pm

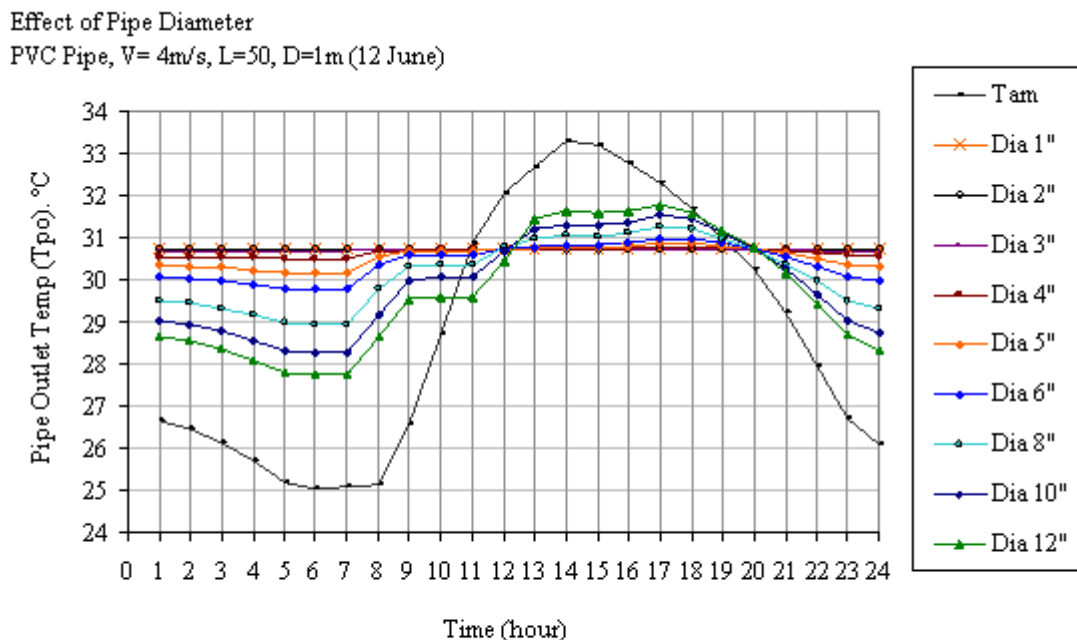


Fig 2 Profile of ambient air temperature T_A and outlet air temperatures T_{PO}

The effect of pipe diameter between 1 pm to 7 pm is further analysed and is shown in Fig. 3. The cooling potential is represented by ΔT . $\Delta T = T_A - T_{PO}$. Two patterns were observed. First, ΔT is almost constant at for small pipes up to 4 inches. Second, for pipes larger than 4 inches, ΔT decreases with an increase in pipe diameter.

2.2 Simulation 2: Influence of air velocity

Simulation 1 shows maximum ΔT occurs when pipe diameter is below 4 inches. In this simulation the pipe diameter was set at 3 inches. The pipe length was set at 50 m. Fig. 4 shows typical daily profile of T_A and T_{PO} in June (hot season) when the air velocity is varied from 1 to 10 ms^{-1} . Two patterns were observed. First, all T_{PO} is lower than T_A after 11.00am. Second, all T_{PO} is higher than T_A after 7.30pm.

Effect of Pipe Diameter on Temperature Difference
 PVC Pipe, $V = 4\text{m/s}$, $L = 50$, $D = 1\text{m}$ (12 June)

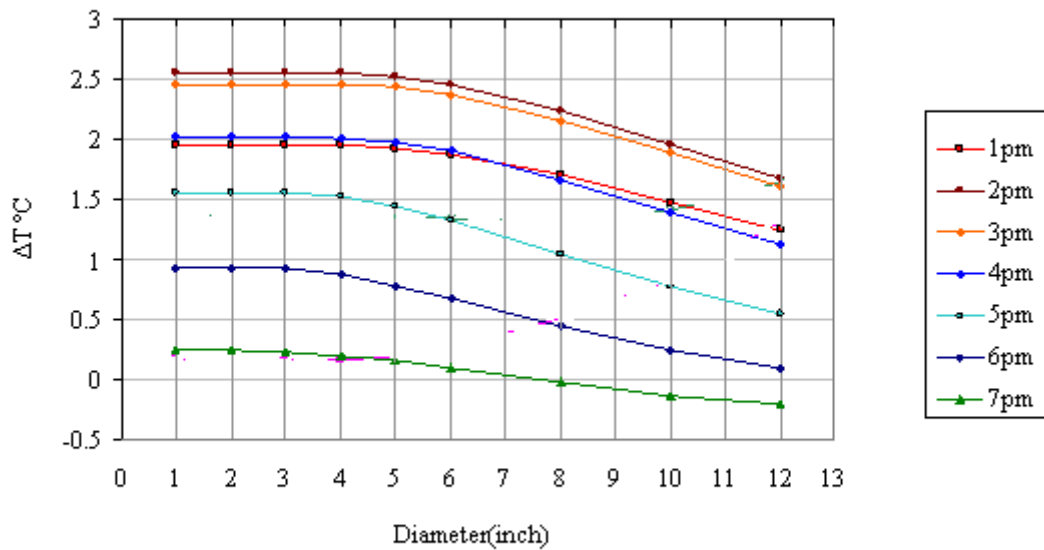


Fig. 3 Profile of Cooling Potential

Effect of velocity

PVC Pipe, Dia= 3", L=50, D=1m (12 June)

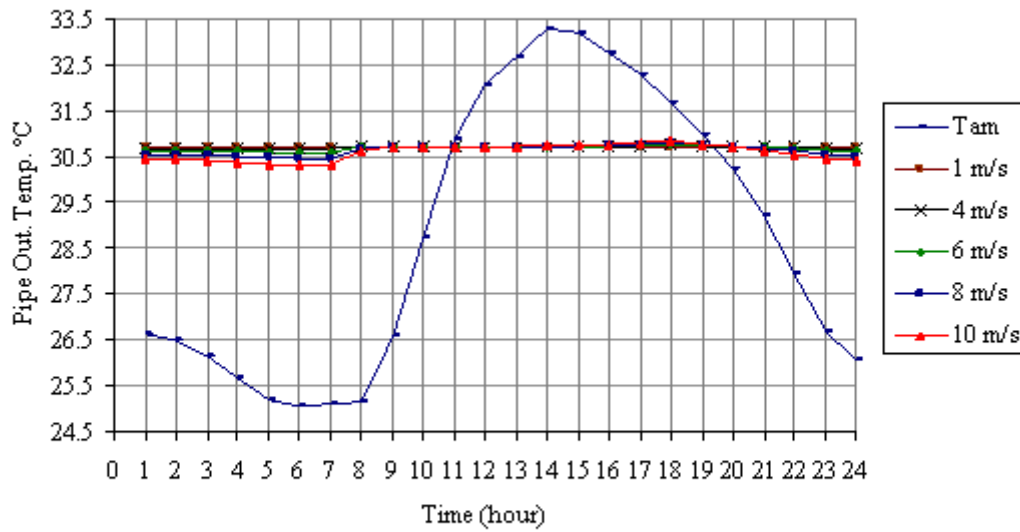


Fig.4. Profile of Outlet Air Temperatures and Ambient Temperature

Further analysis was conducted between 11.00 am to 7.00 pm. The effect of air velocity at peak temperatures on EAHE cooling is shown in Fig. 5. It shows Cooling Potential, ΔT , is constant.

Effect of velocity on Temperature Difference

PVC Pipe, Dia= 3", L=50, D=1m (12 June)

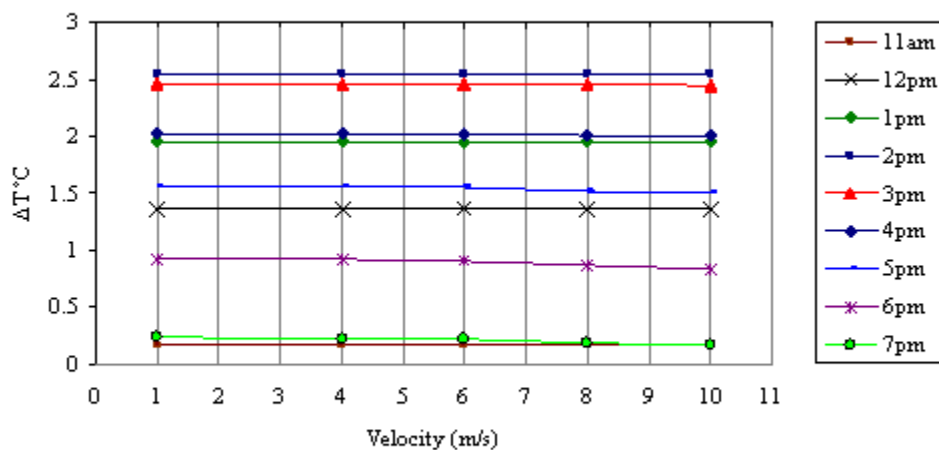


Fig. 5 Profile of Cooling Potential

2.3 Simulation3: Influence of pipe length

Simulation 2 shows ΔT is independent of air velocity. Therefore the lowest air velocity 1 ms^{-1} is used. Fig. 6 shows typical daily profile of T_A and T_{PO} in June (hot season) when the pipe length is varied from 25 to 80 m. Two patterns were observed. First, all T_{PO} is lower than T_A after 10.30am. Second, all T_{PO} is higher than T_A after 8.30pm.

Effect of Pipe Length
 PVC Pipe, Dia= 3", D=4m, V=1m/s, (12 June)

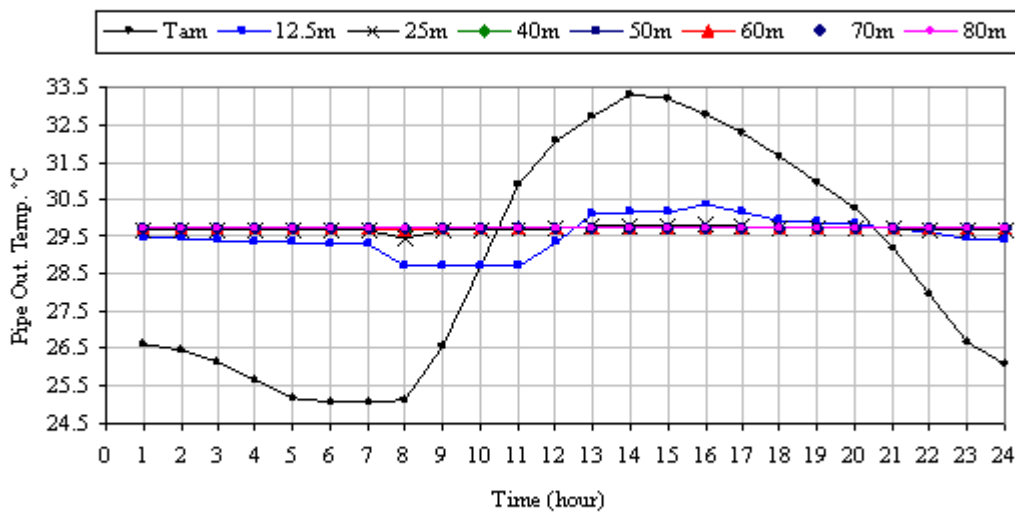


Fig. 6 Profile Outlet Air and Ambient Temperatures

Further analysis was conducted at 1.00pm and 8.00 pm. The effect of pipe length at peak temperatures on EAHE cooling potential is shown in Fig. 7. It shows ΔT is increases with an increase of pipe length until 50m length. At longer pipe length ΔT remains constant.

Effect of Pipe Length on Temperature Difference
 PVC Pipe, Dia= 3", D=4m, V=1m/s, (12 June)

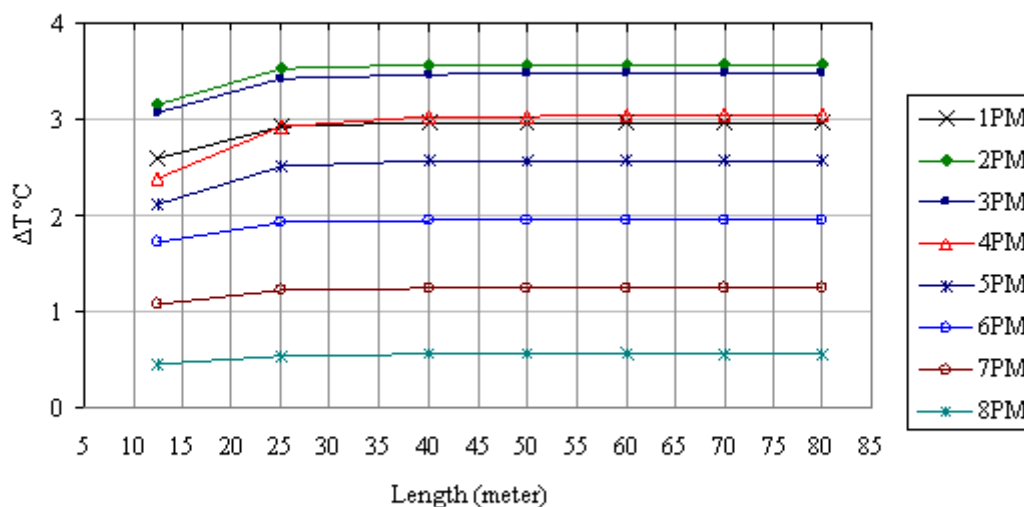


Fig. 7 Profile of Cooling Potential

3 DISCUSSION

It is interesting to note the cooling potential, ΔT , observed in the simulations is smaller than that observed in field investigation. Aliyah Sanusi, Li Shao and Md Najib Ibrahim (2013) reported ΔT through field investigation was between 6°C and 9°C . Whereas ΔT observed in simulation was less than 3.5°C . The disagreement is expected since in this study EnergyPlus was used without any modification in algorithm or standard data in library. For example, 'soil condition' in basic set up was 'heavy and damp'. In this case,

4 CONCLUSION

The simulation results show that the cooling potential, ΔT , is influenced by pipe diameter only. It is independent of pipe length and air velocity

REFERENCES

- Al-Ajmia, F., Loveday, D.L., and Hanby, V.I. (2006). The cooling potential of earth-air heat exchangers for domestic buildings in a desert climate. *Building and Environment*. Volume 41, Issue 3, March 2006, Pages 235–244.
- Aliyah N.Z. Sanusi, Li Shao & Najib Ibrahim (2012). Passive Ground Cooling System for Low Energy Buildings in Malaysia (hot and humidclimates). *Renewable Energy*. Volume 49, January 2013, Pages 193–196
- Darkwa, J., Kokogiannakis, G., Magadzire C.L., and Yuan K. (2011). Theoretical and practical evaluation of an earth-tube (E-tube) ventilation system. *Energy and Buildings* 43 (2011) 728–736.

- Fabrizio Ascione, Laura Bellia, and Francesco Minichiello. (2011). Earth-to-air heat exchangers for Italian climates. *Renewable Energy* 36 (2011) 2177-2188.
- Ghosal, M.K. and Tiwari G.N. (2006). Modeling and parametric studies for thermal performance of an earth to air heat exchanger integrated with a greenhouse. *Energy Conversion and Management* 47 (2006) 1779–1798.
- Huijun Wu, Shengwei Wang, and Dongsheng Zhu. (2007). Modelling and evaluation of cooling capacity of earth–air–pipe systems. *Energy Conversion and Management* 48 (2007) 1462–1471.
- Intan Farhana Shazwan (2013), Malaysia's Green Tech Financing to hit RM1.2b this year. *The Star*. January 15, 2013
- Jacovides C. P. and Mihalakakou G. (1995). An underground pipe system as an energy source for cooling/heating purposes. *Renewable Energy*, Vol. 6, No. 8, pp. 893-900, 1995.
- Kwang Ho Lee and Richard K. Strand. (2008). The cooling and heating potential of an earth tube system in buildings. *Energy and Buildings*. Volume 40, Issue 4, 2008, Pages 486–494.
- Kwang Ho Lee, and Richard K. Strand. (2006). Implementation of an earth tube system into energyplus program. Second National IBPSA-USA Conference Cambridge, MA August 2-4, 2006
- Md Najib Ibrahim (1988). *Kajian Fisiabiliti Senibina Bawah Tanah*. Research Report. Universiti Teknologi Malaysia (unpublished report)
- Min Zhong Zhao. (2004). Simulation of earth-to-air heat exchanger system. Master Thesis. Concordia University, Canada
- Mirosław Zukowski, Beata Sadowska, and Wiesław Sarosiek. (2011). Assessment of the cooling potential of an earth-tube heat exchanger in residential buildings. The 8th International Conference, May 19–20, 2011, Vilnius, Lithuania.
- Rakesh K., Ramesh S., and Kaushika S.C. (2003). Performance evaluation and energy conservation potential of earth–air–tunnel system coupled with non-air-conditioned building. *Building and Environment*. Volume 38, Issue 6, June 2003, Pages 807–813.
- Reimann, G. Boswell, H. & Bacon, S. (2007), Ground Cooling of Ventilation Air for Energy Efficient House in Malaysia: A Case Study of The Cooltek House. Conference on Sustainable Building South-East Asia (SB07SEA 5th to 7th November 2007 Kuala Lumpur Convention Centre, Kuala Lumpur, Malaysia
- Sanusi Aliyah N.Z. (2012). Low energy ground cooling system for buildings in hot and humid Malaysia. PhD. Thesis, International Islamic University Malaysia & De Montfort University, UK
- Sawhney, R.L., Buddhi, D., Thanu, N.M. (1999). An experimental study of summer performance of a recirculation type underground air pipe air conditioning system. *Building and Environment* 34 (1999) 189-196.
- Trombe, A., Pettit M. and Bourret B. (1991). Air cooling by earth tube heat exchanger: experimental approach. *Renewable Energy* Vol. 1, No. 5/6, pp. 699-707, 1991.
- Vikas Bansal, Rohit Misra, Ghanshyam Das Agrawal, and Jyotirmay Mathur. (2010). Performance analysis of earth–pipe–air heat exchanger for summer cooling. *Energy and Buildings* Volume 42, Issue 5, May 2010, Pages 645–654.

Promoting Sustainability In Selected African Fashion Design Institutions

Anne Mastamet-Mason, Ruth J L Cheluget, Roselyn Kent-Onah
Tswane University of Technology, South Africa

0196

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Topic: The Asian Conference on Sustainability, Energy & the Environment

Key words: Education for Sustainable Development, Fashion Design Programme; African Institutions of Higher Learning

The period 2005-2014 has been identified as the Decade of Education for Sustainable Development (DESD). The Decade highlights education and learning as vehicles through which sustainable agenda could be driven in the universal search for sustainable development. Education for Sustainable Development (ESD) gives a clear direction on the multifaceted interdependence between human needs and the ecosystem. Higher Education Institutions educate people who develop and manage future society. Therefore, the concepts of sustainability need to be taken seriously by fashion and textile higher educators, since major environmental and ethical concerns are particularly relevant to the fashion industry. Since, universities provide students with interdisciplinary knowledge, it is important that these institutions become proactively responsive to socio-environmental issues for the sake of the environment and social concerns of workers in factories. Education is essentially supportive to humanity, mostly when making the right and responsible choices. Regrettably, most African higher education institutions with reference to those offering Fashion Design Programmes do not contain sustainable development awareness, which emphasises positive education strategies and action plans. This study used qualitative approach to evaluate fashion design curricula in selected Universities in Africa. The findings show that there are traces of sustainable development concepts integrated into support subjects and not in the core subjects of Fashion Design Programmes. With inclusion of sustainability issues, students can experience the powerful contribution fashion and textile education can make towards creating an eco-fashion world. They can fully engage with the relevant sustainability agenda and begin to find clear paths to new forms of practice.

iafor

The International Academic Forum

www.iafor.org

INTRODUCTION AND BACKGROUND

Sustainability emphasises on the activities that should be ecologically sound, socially just, economically feasible and civilised, and the need to sustain them even by future generations (Newman, 2005:27-31). Sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). Declaration from the 1977 United Nations (UN) Conference on Environmental Education stressed the importance of ESD as imparting knowledge and practical skills that could promote positive attitude towards environment. Further, many governments have prioritised the challenge of sustainable development since the 1992 Earth Summit held in Rio, Brazil. Since 2004, the United Nations General Assembly has acknowledged that quality education is the key for sustainable future. Besides, a new ten-year international program on sustainable consumption (2002-2011) warrants that new and innovative strategies to address the unsustainable consumption will continue to be a priority to many governments. Additionally, there are many published guidelines by the United Nations to steer decisions (Lozano & Peattie, 2011). The period 2005-2014 was identified as the Decade of Education for Sustainable Development (DESD), while UNESCO continues to provide leadership on international management and support. The Decade highlighted education and learning as vehicles through which sustainable agenda could be voiced in the common pursuit of sustainable development (UNESCO, 2006). World’s higher education institutions (HEIs) could take advantage of the decade to cultivate sustainable behaviour that upholds healthy living (Haigh, 2007). As earlier stated, ESD reconciles the complex interdependence between human needs and the natural environment as it addresses the pillars of sustainable development (Society, Environment, Economy and Culture). According to UNESCO (2004) cited by Venkataraman, (2009:2), ESD “encompasses environmental education but sets it in the broader context of socio-political issues of equity, poverty, democracy and quality of life”. Education is a powerful instrument that helps humanity in making appropriate and more responsible choices (Newman, 2005; UNEP, 2010). Through education, people are informed about the dangers of irresponsible lifestyles and how they can exercise freedom to act accountably. It is through education that people learn how to make informed choices (Su, 2006:453; Venkataraman, 2009).

There are enormous societal challenges in adapting sustainable lifestyles and practices, but education is reported as the best means to make transition happen (Fashion Futures, 2010). The textile and apparel manufacturing industry contributes to environmental degradation and also raises issues of social concerns among the workers in the apparel factory. According to Fashion Futures 2025 (2010:12), the fashion industry is “locked into a cycle of unsustainability using more and more of the earth’s resources and in some cases exploiting cheap labour supplies in return for ever decreasing profit margin”. This, therefore, demands that Fashion Design Programmes should be designed in such a way that it fosters sustainable development awareness and responsibility for the purposes of promoting significance and furthering the welfare of society. It is possible to address the challenges and opportunities of sustainable development, when every fashion designer is armed with ‘environmental literacy’ and when sustainable concepts are embedded in all the core subjects of the programmes. It may be argued that educating undergraduate fashion students, who will be the future fashion designers and managers in the fashion industry, will

accelerate positive changes relevant to industry practices to towards the improvement of environmental performance. Likewise, fashion educators should be role models for sustainable development and also focus on creating learning modules which inculcates understanding, positive attitudes, morals and principles in fashion design students. Students graduating from Fashion Design Programmes will eventually make decisions in the industry where they are employed. It is therefore important that these students are well informed of the socio-environmental implications of the clothing and textile manufacturing. Lozano, R., Lukman, Lozano, F., Huisinigh & Lambrechts, 2011:3) stress that Universities have ethical obligation to work in favour of healthy environment.

Most higher education declarations, charters and partnerships until Lüneburg (2001) declaration for sustainable development include the following:

- Focus on environmental degradation, threats to society, and unsustainable consumption;
- Ethical or moral obligation of university leaders and faculties to work towards sustainable societies, including the intergenerational perspective;
- Inclusion of SD throughout the curricula in all disciplines;
- Encouragement of SD research;
- Movement towards more sustainability orientated university operations;
- Collaborations with other universities;
- Collaboration and engagement with stakeholders, such as the public, governments, non-governmental organisations (NGOs) businesses and outreach (Calder & Clugston, 2003 and Wright, 2004 in Lozano, R. *et al.*, 2011:3).

With the various declarations, a growing number of higher education institutions (HEIs) have began engaging in curricula transformation and integrating sustainable development (SD) into their curricula, research, actions, assessment and reporting among others (Fien, 2002; Cortese, 2003; Thomas, 2004; Boks & Diehl, 2006). Furthermore, many universities worldwide have signed agreements to include sustainable topics in curricula of all disciplines (Thomas, 2004). For example, the Talloires Declaration was signed in October 1990 by twenty university rectors, presidents, and vice chancellors from different parts of the world with aim of advocating for sustainable practises in their institutions. Between 1990 and 2007, the number of signatures increased to 356 (ULSF, 2007 in Lozano, R., et al, 2011).

The declaration emphasised that:

- There should be an increase in awareness of environmentally sustainable development in institutions;
- Institutions should create an institutional culture of sustainability;
- Institutions should educate environmentally responsible citizens, and promote environmental literacy for all;
- Institutions should practice institutional ecology and an involvement of all stakeholders; and
- All the above directives should be maintained (ULSF, 1990).

Regardless of the declarations and a number of efforts by some HEIs, incorporating ESD remains a challenge to most universities (Wemmenhove & de Groot, 2001; Boks & Diehl, 2006). Lozano, R., *et al.* (2011:8) asserts that most universities lag behind in implementing ESD. They report that “only 15 out of 14,000 world universities have published sustainable reports” (Ibid, page 2). Despite agreements made in Abuja during the 12th General Conference on Sustainable Development in Africa (AAU, 2009), most African Universities have not yet bought into the concept of ESD being included in all disciplines or curricula (Matten & Moon, 2004; Lozano, R, 2006). Although African governments are proactively encouraging sustainable concepts in education through a number of reports and proposed strategies, regrettably, implementation of such strategies are quite slow and lack enforcement directives. The structures and funding of higher education system in African universities are also limited (Wemmenhove & de Groot, 2001). Most governments in Africa do not reward the adoption of sound environmental practices in institutions unlike in developed countries, where there is at least some commitment from the governments. For example, such dedication is emphasised in the UK’s official sustainable development strategy, which stresses that “sustainability literacy be made a core competency for all professional graduates” (Her Majesty, Government, 2005:39). The London college of Fashion inspires students continually to deliver innovative solutions for the changing world (Fashion Futures 2025, 2010:7). In Canada, the Manitoba province has initiated many activities that prepare students to practise sustainable lifestyles. Some of the activities include, “funding support of education for sustainability, establishing policies that integrate sustainable development concepts into provisional curricula, establishing sustainability indicators and reporting on indicators, developing regulations and policies that work towards greening operations of educational institutions and supporting educators in the field” (McDonald, 2006:1011).

Fashion/Clothing design curricula currently being used in Kenyatta University (Kenya), Auchi Polytechnic (Nigeria) and Tshwane University of Technology (South Africa), have been in existence for many years with minimal annual, yet the changes do not incorporate issues of sustainable development relevant to the profession. Further, sustainable development awareness, which emphasizes constructive education strategies and action plans particularly within the core subjects of the programme are missing. Aspects of education for sustainable development are already taught in developed countries, although as earlier mentioned, there is still a general lack of agreement on what constitutes ESD in most institutions (Su, 2006:453, Lozano, Lukman, Lozano, Huisingh & Lambrechts, 2011). Most Universities do not quite understand the vision of ESD on the conceptual level (UNEP, 2010) and more so within the context of Fashion Design Programmes. On the level of course content, some of the subjects taught in the classrooms are fragmented and are occasionally dependent on fashion design competitions organised by private companies such as South African Cleaner Production Organisation (“No Kak”¹ competitions) and some other companies sponsoring eco-fashion competitions. In Nigeria and Kenya, a subject dedicated to issues of climate change is taught across all the fields offered in the university. Such subject offers general knowledge about climate change, but does not address how the fashion and textile industry contributes to climate change and the social welfare of the workers in the industry. Issues of

¹ No Kak simply means no rubbish in Sesotho language

environment are meagrely and randomly introduced by lecturers during practical subjects, although, most often, those lecturers struggle to impart adequate knowledge required to combine theory, with research and practice. Developing knowledge of sustainable development is important to the Fashion Design Programmes because many students graduating will gain employment in the fashion and clothing industry which is known for socio-environmental concerns. The aim of ESD in the context of Fashion Design Programmes is to ultimately improve the industry performance with regards to environment and social welfare of the workers. For this to occur, it is necessary to incorporate certain “eco-ethical” aspects specific to the profession within the core subjects (textile science, garment, pattern design and creative design) of the Fashion Design Programmes. Furthermore, Nicolaides (2006:422) stresses that since universities are integral parts of ‘global village’, they need to give attention to research interests in the area of sustainability and also contribute to knowledge that can “add value to long term goal of fully sustainable environment”. It is therefore an ethical imperative that this research was undertaken to explore how higher Education institutions especially Fashion institutions, can contribute to the goal of fully sustainable environment as noted by Nicolaide.

The aim of this research was therefore to review the Fashion Design undergraduate programmes in Tshwane Univeristy of Technology (South Africa), Kenyatta University (Kenya) and Auchi Polytechnic (Nigeria), so as to understand the situation of the present curricular in line with the socio-environmental issues in the three countries.

METHODOLOGY

This was a pilot study for a broader research yet to be undertaken regarding situation of ESD in Fashion institutions in South Africa, Kenya and Nigeria. The broad research to be undertaken will not only examine the curricula, but will also interview consumers, lecturers, students and role players in government and fashion industry. A thorough literature review was undertaken to understand and identify which aspects of sustainability need to be included in the Fashion Design Programmes, the socio-environmental impact of the fashion industry and how the industry can improve on its performance. This will help determine what level of eco and ethical literacy is required of fashion design consumers, educators and students. Approaches to curriculum design and development for the purposes of determining what is considered good practices with regard to developing eco/ethical will be established. Being a pilot study for an ongoing broader research, this research used qualitative method to obtain adequate data that could inform strategies to be used for a research with a wider scope of socio-environmental issues covering most of the themes of the higher education declarations, charters and partnerships for the attainment of sustainable development.

Fashion design curricula from Tshwane University of Technology, Kenyatta University and Auchi Polytechnic were screened to gain an insight into the present situation regarding socio-environmental issues. Only core subjects (pattern design, garment cutting and making, textile/material science and creative design) of the programme and their study guides/course outlines were screened. Fashion marketing subject offered at Kenyatta University has social aspects of workers in the Fashion industry and therefore was included in the study even though it may not be seen as a

core subject of Fashion Design Programmes. Consents to undertake this study were obtained from Fashion Design Departments of the three institutions mentioned above.

RESULTS

Since the aim of this research was to review the Fashion Design Programmes in the selected institutions, the results in Tables 1, 2 and 3 are presented according to the institutions that were studied.

Table 1: Curriculum situation of the Fashion Design Programmes in Tshwane University of technology, South Africa

SUBJECTS/ MODULES	ENVIRONMENTAL ISSUES	ETHICAL ISSUES	Remarks
	Screened documents (curriculum and study guides)	Screened documents (curricula and study guides)	
Pattern Design	<p><u>Curriculum</u></p> <p>No written description on environmental issues</p> <p><u>Study guides</u></p> <p>Some themes/briefs about work to be done include issues of environment on paper usage, patterns to be prepared for ethical designs</p>	<p><u>Curriculum</u></p> <p>No written description on ethical issues</p> <p><u>Study guides</u></p> <p>No written description on ethical issues</p>	Minimal ESD is identified in the curriculum. Although the study guides contain more issues of ESD, these issues are bound to be withdrawn, if subject lecturers were changed. Since ESD is not embedded within the curriculum, it can easily be ignored and seen as not an important subject.
Garment Cutting and Making	<p><u>Curriculum</u></p> <p>No written description on environmental issues</p> <p><u>Study guides</u></p> <p>Some themes/briefs about work to be done include issues of environment, particularly, selection of materials to be used, utilisation of fabric waste, re-furbishing of old clothes among others</p>	<p><u>Curriculum</u></p> <p>No written description on ethical issues</p> <p><u>Study guides</u></p> <p>No written description on ethical issues</p>	Nothing reflecting ESD
Textile/Material Science	<p><u>Curriculum</u></p> <p>No written description on environmental issues</p> <p><u>Study guides</u></p> <p>Some of the theoretical topics have some negligible</p>	<p><u>Curriculum</u></p> <p>No written description on ethical issues</p> <p><u>Study guides</u></p> <p>No written description on ethical issues. Some themes</p>	Minimal issues observed only with the study guides

	environmental issues	on projects reflect some elements of ESD	
Creative Design/Fashion Illustration	<p>Curriculum</p> <p>No written description on environmental issues</p> <p>Study guides</p> <p>Some themes/briefs about fashion illustrations to be drawn, include issues of environment, particularly, selection of materials to be used, utilisation of fabric waste, re-furbishing of old clothes. Story boards are guided by pictures of real life situations of climate change</p>	<p>Curriculum</p> <p>No written description on environmental issues</p> <p>Study guides</p> <p>Some themes/briefs about fashion illustrations to be drawn include issues on the abuse of labour. Sources of inspiration are true reflection of social issues in the factories where the wages are below minimum requirements, use of child labour, working conditions of the sweat shops among others. Story boards are guided by pictures of real life situations</p>	Nothing reflecting ESD in the curriculum. The study guides contain more issues of ESD; these issues are bound to be withdrawn, if subject lecturers are changed. Since ESD is not embedded within the curriculum, it can easily be ignored and seen as not a major subject.
<p>Observation: Although study guides show inclusion of some socio-environmental aspects, these issue could be taken more seriously if they were embedded in the curriculum. Students may not take issues outside curriculum seriously and hence learning may not take place. There is no subject/module or subjects/modules that address(es) how the fashion industry impacts negatively on the lives of the factory workers and how the textiles industry affects the environment right from the farm until when the fabric is completed. Textile products from the petro-chemicals as well as regenerated fabrics have vast environmental and health implications on workers, but are not reflected in the curriculum at Tshwane University of Technology.</p>			

Table 2: Curriculum situation of the Fashion Design and Marketing Programmes in Kenyatta University, Kenya

SUBJECTS/MODULES	ENVIRONMENTAL ISSUES	ETHICAL ISSUES	Remarks
	Screened documents (curriculum and study guides)	Screened documents (curricula and study guides)	
Pattern Design	<p>Curriculum</p> <p>No written description on environmental issues</p> <p>Study guides</p> <p>No written description on environmental issues</p>	<p>Curriculum</p> <p>No written description on ethical issues</p> <p>Study guides</p> <p>No written description on ethical issues</p>	No ESD embedded in either curriculum or study guides

<p>Garment Cutting and Making</p>	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> No written description on environmental issues</p>	<p><u>Curriculum</u> No written description on ethical issues</p> <p><u>Study guides</u> No written description on ethical issues</p>	<p>No ESD embedded in either curriculum or study guides/course outlines</p>
<p>Textile/Material Science</p>	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> Some of the theoretical topics have some negligible environmental issues</p>	<p><u>Curriculum</u> No written description on ethical issues</p> <p><u>Study guides</u> No written description on ethical issues</p>	<p>No ESD embedded in either curriculum or study guides, but only negligible issues of environment are written.</p>
<p>Creative Design/Fashion Illustration</p>	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides/Course outline</u> No written description on environmental issues</p>	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study Guides/Course Outlines</u> No written description on ethical issues</p>	<p>No ESD embedded in either curriculum or study guides</p>
<p>Fashion Marketing</p>	<p><u>Curriculum</u> No environmental issues written.</p> <p><u>Study guides/ Course outline</u> No environmental issues written</p>	<p><u>Curriculum</u> Minimal issues on social aspects of the workers. Sweat shops, child and women labour in the apparel and textile industry are highlighted.</p> <p><u>Study guides/ Course outline</u> Some topics address the social aspects of the workers in the apparel and textile industry</p>	<p>Some elements of Social aspects of the factory workers are included. However, there is need to also address the rise of eco-conscious consumers and the reasons behind the growth of sustainable consumption and disposal practices of the apparel consumers</p>
<p>Observation: There are negligible socio-environmental issues highlighted in only two subjects/modules and study guide. This point out the need to look at the textile and apparel production processes and how it could impact negatively on the environment. It is also important to understand elements of sustainable behaviours of the apparel and textile product consumers. For example, it is imperative that the consumers understand how the entire life cycle of a textile product can affect the environment negatively.</p>			

Table 3: Curriculum situation of the Fashion Design and Textile Design Programmes in Auchi Polytechnic, Nigeria

SUBJECT S/MODULES	ENVIRONMENTAL ISSUES	ETHICAL ISSUES	Remarks
	Screened documents (curriculum and study guides)	Screened documents (curriculum and study guides)	
Pattern Design	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> No written description on environmental issues</p>	<p><u>Curriculum</u> No written description on ethical issues</p> <p><u>Study guides</u> No written description on ethical issues</p>	No ESD embedded in either curriculum or study guides
Garment cutting and making	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> Some traces about environment, particularly on selection of materials and utilisation of fabric waste fabrics to come up with a garment</p>	<p><u>Curriculum</u> No written description on ethical issues</p> <p><u>Study guides</u> No written description on ethical issues</p>	No ESD embedded in either curriculum or study guides
Textile/Material science	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> Some of the theoretical topics have some negligible environmental issues</p>	<p><u>Curriculum</u> No written description on ethical issues</p> <p><u>Study guides</u> No written description on ethical issues</p>	Some negligible elements of ESD are embedded in the study guide. If ESD is not embedded within the curriculum, it can easily be seen as not a major subject and therefore not taken seriously.
Creative Design	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> No written description on</p>	<p><u>Curriculum</u> No written description on environmental issues</p> <p><u>Study guides</u> No written description on</p>	No ESD embedded in either curriculum or study guides.

	environmental issues	environmental issues	
--	----------------------	----------------------	--

Observation: There are negligible environmental issues highlighted in only one subject/module and study guide. This point out the need to look at the textile and apparel production processes and how the processes could impact negatively on the environment. It is also important to understand sociological aspects of the workers in the textile and apparel industry and elements of sustainable behaviours of the apparel and textile product consumers. For example, it is imperative that the consumers understand how the entire life cycle of a textile product can affect the environment negatively.

CONCLUSIONS

It is evident in this study that the prescribed Fashion Design curricula of the studied institutions do not adequately promote ESD, even when study guides particularly at Tshwane University of Technology had included both social and environmental aspects. Also, the adoptions of policies of Agenda 21 by majority of African governments notwithstanding, institutions of higher learning have not employed the recommendations to any great extent within the Fashion Design Programmes.

It must also be noted that the elements of ESD found in the study guides are purely initiatives of creative lecturers who attempt to put into practice what society advocates and not necessarily what the curricula stipulates. Yet, institutions of higher learning will continue to be key players in bringing about positive change through research and by the equipment of their students with skills and knowledge to handle socio-environmental challenges. The findings of this study also point out the need for more environmentally literate fashion graduates who can design eco-products and be able to influence future production of Eco-fashion in the apparel industry as well as influence consumers to make sustainable consumption and disposal of textile and apparel products. This indicates the need for the HE sector to address these issues. Level of environmental literacy can only bring about change towards ESD if the Fashion Design curriculum is carefully developed with negotiations and input from all the stakeholders involved by coming up with a multi-stakeholders perspective of curriculum negotiated with the industry, the government and the consumers of the textile products as highlighted in the Talloires Declaration of 1990.

REFERENCES

ASSOCIATION OF AFRICAN UNIVERSITIES REPORT. 2009. 12th Conference on Sustainable Development in Africa: The Role of Higher Education. [Online]. Available at http://gc.aau.org/report/declaration_12th_gc_aau9.pdf. Accessed 21/04/2013.

- BOKS, C, DIEHL, JC. 2006. Integration of sustainability in regular courses: experiences in industrial design engineering. *Journal of Cleaner Production*, 14(9–11):932–9.
- CALDER, W., CLUGSTON, R.M., 2003. International efforts to promote higher education for sustainable development. *Planning for Higher Education*, 31, 30e44.
- CORTESE, AD. 2003. The critical role of higher education in creating a sustainable future. *Planning for Higher Education*, 31(3):15–22.
- COTGRAVE, AJ & KOKKARINEN, N. 2010. “Developing a model promoting sustainability literacy through construction curriculum design”. *Structural Survey*, 28(4):266-280.
- FASHION FUTURES. 2010. *Global scenarios for a sustainable fashion industry*. London: Fashion Futures.
- FIEN J. 2002. Advancing sustainability in higher education: issues and opportunities for research. *Higher Education Policy*, 2002; 15:143–52.
- HAIGH, M. 2007. Greening the University Curriculum: **Appraising** an International Movement, *Journal of Geography in Higher Education*, 29 (1): 31–48.
- IAU. 2011. *World Higher Education Database*. Houndmills, Hampshire: Palgrave Macmillan:
- LOZANO R. 2006. Incorporation and institutionalization of SD into universities: breaking through barriers to change. *Journal of Cleaner Production* 2006; 14(9–11):787–96.
- LOZANO, R, LUKMAN, R, LOZANO, FJ, HUISINGH,D, & LAMBRECHTS, W. 2011. Declarations for sustainability in higher education: becoming better leaders, through addressing the university system. *Journal of Cleaner Production*, xxx (2011) 1e10.
- McDONALD, C. 2005. Moving forward on educating for sustainability in Manitoba, *Journal of Cleaner Production*, 14:1010-1016.
- MATTEN, D & MOON, J. 2004. Corporate social responsibility education in Europe. *Journal of Business Ethics*, 54:323–37.
- NICOLAIDES, A. 2006. “The implementation of environmental management towards sustainable universities and education for sustainable development as an ethical imperative” *International Journal of Sustainability in Higher Education*, 7(4):414-424.
- NEWMAN, L. 2005. *Uncertainty, innovation, and dynamic sustainable development*, *Sustainability: Science, Practice, & Policy*, 1 (2), 27-31. [Online]. Available at <http://ejournal.nbii.org> Accessed 8/01/2013.

SU, J. 2006. Integrating Sustainability in Apparel and Textiles Higher Education. *Environmental Informatics Archives*, 4:453-458.

THOMAS, I. 2004. Sustainability in tertiary curricula: what is stopping it happening? *International Journal of Sustainability in Higher Education*, 5(1):33 - 47

ULSF, 2007. Talloires Declaration Institutional Signatory List Retrieved 24th Septemr, 2007, from. http://www.ulsf.org/programs_talloires_signatories.html.

UNEP, 2010. *Here and Now: Education for sustainable consumption*. By Marrakech process Task force on ESC led by Italy, in collaboration with Hedmark University College in Norway.

UNESCO. 2006. *Globalisation and education for sustainable development*. Pieters-Leeuw:

UNESCO.

UNESCO, DESD Draft Implementation Plan, Volume 1 (Paris: UNESCO, 2004), http://portal.unesco.org/education/en/file_download.php/03f375b07798a2a55dc39db7aa8211Final+IIS.pdf (accessed December 2008).

VENKATARAMAN, B. 2009. Education for Sustainable Development, Environment. *Science and Policy for Sustainable Development*, 51:2, 8-10.

WEMMENHOVE, R & de GROOT, WT. 2001. Principles for university curriculum greening. An empirical case study from Tanzania. *International Journal of Sustainability in Higher Education*, 2(3):267-83.

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT. 1987. *Our Common Future*, Oxford, NY: Oxford University Press.

WRIGHT, T., 2004. The evolution of sustainability declarations in higher education. In: Corcoran, P.B., Wals, A.E.J. (Eds.), *Higher Education and the Challenge of Sustainability: Problematics, Promise, and Practice*. Kluwer Academic Publishers, Dordrecht, The Netherlands

*Sustainable City Indicators for Greater Mekong Sub-Region: Cases from Thailand and
Lao PDR*

Alice Sharp, Niparat Sritharet, Apinan Pongmethakul, Sirin Jaithieng
Thammasat University, Thailand

0245

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Countries in the Greater Mekong Sub-region (GMS) agreed in 1992 to develop international cooperation aiming for economic development, which will in turn improve the quality of life of local citizens. However, economic development, if unplanned, may cause adverse impacts to local society. New cities in this region have arisen at a rapid rate as so-called informal settlements, as a result of poor city planning and low cooperation between local government and citizens. This study has aimed to analyze factors contributing to the development of sustainable cities from the viewpoint of local citizens. In this study, two cities were chosen from Thailand and Lao PDR based on the result of primary data collection. The cities selected were Chiang Khan and Nan for Thailand and Vientiane and Luang Phrabang for Laos PDR. Data collection was done as in-depth interviews with stakeholders as well as questionnaire surveys with local population. Questionnaires include eight groups of indicators; economic aspects, agricultural situation, environmental characteristics, public health conditions, social conditions, physical conditions, architectural aspects and art and cultural aspects. Results from all cities have shown some similarities. All interviews and questionnaire surveys have shown that cultural indicators play a crucial role for sustainable cities. The second most important indicator varies following cities characteristics. The environmental indicator ranks second for Nan and Luang Phrabang, while ranking third for Chiang Khan and Vientiane. Vientiane, the capital city of Lao PDR, has been faced with rapid growth; therefore the development of physical structure was considered important.

Keywords: livable cities, sustainable city, sustainable indicators, Greater Mekong Region Cities

I. Introduction

New cities have emerged all over the world and have contributed to global environmental conditions. Over the last few decades, cities have expanded into sub-urban areas at a fast rate, resulting in the development of physical structure to support growth. A proper development must balance social, economic, and environmental needs. Local government should offer investors security, infrastructure, and efficiency, and should also put the needs of its citizens at the forefront of all its planning activities. However, it is estimated that 95% of new cities will be located in developing countries (The Cities Alliance, 2007). It is unlikely that their local governments can appropriately implement urban planning and management. Consequently, the expansion of cities has devastating results on the urban economy, the environment, and society. Poorly managed urban settlements will be unable to keep pace with urban expansion bringing with them poor health, poverty, social instability, and economic inefficiency.

However, there is no single formula for managing the change that can be applied to all cities. Cities are affected by many factors: location, climate, and natural features, for instance. Experiences from cities are essential for the formulation of development policies; therefore, the assessment of development status is crucial. Many forms of assessment, auditing and indicator systems for guiding and better evaluating the effect of city development, are now available. However, as cities have specific characteristics, the utility of each evaluation tool may not be fully applicable.

This article aims to develop and discuss sets of indicators used in measuring factors contributing to livable city characteristics for countries in the GMS. Sets of indicators were developed and tested with two countries in this region: Thailand and Lao PDR. Data collected were seen as mechanisms for citizen participation in local governments and to be used in city planning. As cities in the region share certain characteristics, the results of this study can be applied to other cities as well.

II. Data Collection and Analysis

2.1 City selection

Countries in the Greater Mekong Sub-Region include Cambodia, Lao PDR, Myanmar, Vietnam, Thailand, and Yunnan Province in the People's Republic of China (Figure 1). For the first phase, data collections were done in Thailand and Lao PDR. Two cities were chosen for each country based on the result of primary data collection. The cities selected were Chiang Khan and Nan for Thailand and Vientiane and Luang Phrabang for Laos PDR. All cities selected are growing rapidly with a strong relationship to local culture. Once the cities were selected, stakeholder meetings were organized to identify the factors that local people believe have an impact on their livelihood. Basic information for each city was collected from secondary sources.



Figure 1 Map of GMS countries.

Source: <http://mekongtourism.org/website/about-mtco/what-is-the-gms/gms-map/>

2.2 Development of new indicators: SWOT analysis and stakeholder consultation methods

During a stakeholder consultation meeting, the project team compiled data on two aspects: SWOT data and opinions based on the question “What is a sustainable city?”, then, established a list of factors mentioned by each stakeholder to be used in indicator development. Stakeholders included in this study were local citizens, government offices, and Non-Governmental Organizations in the area. After stakeholder consultations, Strength, Weakness, Opportunity, and Threat of each area were identified. In addition, factors that stakeholders considered important for sustainable living were identified and grouped. In general, there are three main categories of factors: human wellbeing, environmental wellbeing, and economic wellbeing. These three major factors were further broken down into 8 aspects of indicators (Figure 2). In total, there were 96 indicators used in this study.

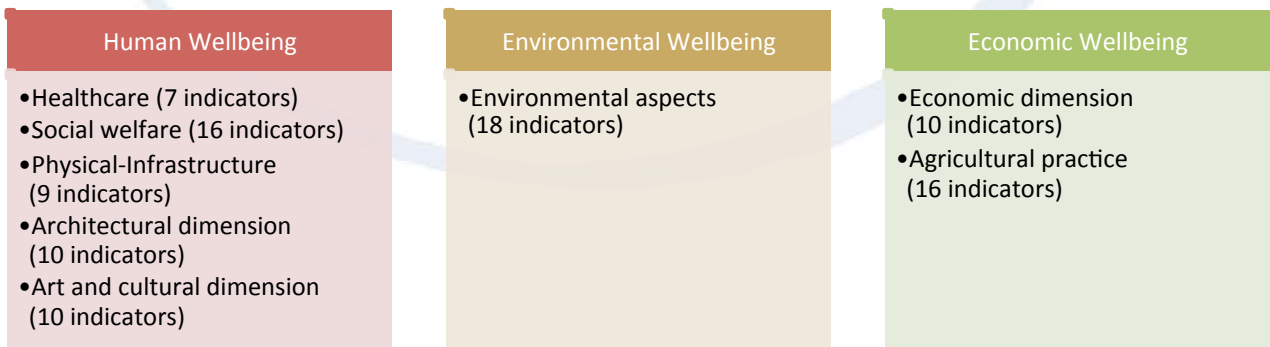


Figure 2 Eight groups of indicators developed for sustainable city evaluation.

2.3 Data collection and analysis

For each city, data collections were done with in-depth interviews with stakeholders as well as questionnaire surveys with local population. In each city, the city area was divided into 16 grids and 400 questionnaires were distributed within these grids. Questionnaires include eight groups of indicators that will contribute to the quality of life of people in the city. Results from both SWOT analysis and questionnaire surveys were used in city planning.

III. Result and Discussion

General information related to socio-economic conditions of each city were compiled in order to understand the situation in the study area. Basic information is shown in Table 1. Cities like Vientiane, where population density is high, focus more on the physical environment (ranked no. 2 in terms of importance for sustainable city).

Table 1 General Socio-economic data for study area.

General Information	Thailand		Laos	
	Loei (Chiang Khan)	Nan	Vientiane	Luang Phrabang
1. Area (km ²)	11,424.6	11,472.1	3,920	818
2. Population (2010)	607,100	458,000	524,100	364,800
3. Population density (person/km ²)	53.1	39.9	133.7	21.6
4. Population growth rate (%)	1.2	0.9	3.0	3.1
5. Population in rural area (%)	83.0	86.4	36.9	89.1
7. Minority ethnic population (%)	0.5	11.5	7.4	71.4
8. Labor force participation rate (%)	71.0	N/A	59.6	69.6
9. Unemployment rate (%)	4.7	N/A	7.2	1.7
10. GDP of country (\$)	6,000		1,471	
11. GDP per capita (\$)	2,073	2,232	N/A	N/A
12. Poverty rate (%)	36.8	19.3	13.5	40.8
13. Access to clean water (%)	97.4	71.9	89.0	37.0
14. Access to electricity (%)	87.0	90.3	100	19.0

SWOT Analysis

After consultation with stakeholders, a SWOT matrix was drafted (Figure 3). Information from SWOT analysis was used to develop a TWOS matrix or management strategies for cities (Table 2).

Questionnaire Survey

Questionnaire survey results from all cities show some similarities (Table 3). All interviews and questionnaire surveys show that cultural indicator plays a crucial role for a livable city (Figure 4). The second most important indicator varies following cities characteristics. The environmental indicator (Figure 5) ranks second for Nan and Luang Phrabang, while ranking third for Chiang Khan and Vientiane. Vientiane is the capital city of Lao PDR and has been faced with rapid growth. Therefore, the development of physical structure was considered. It should be noted that, due to the increasing number of tourists in all four cities, the local people admitted that tourism activities have impacts on their livelihood and the surrounding environment. Local government should take this into their action plan and manage the tourism industry in a sustainable manner.

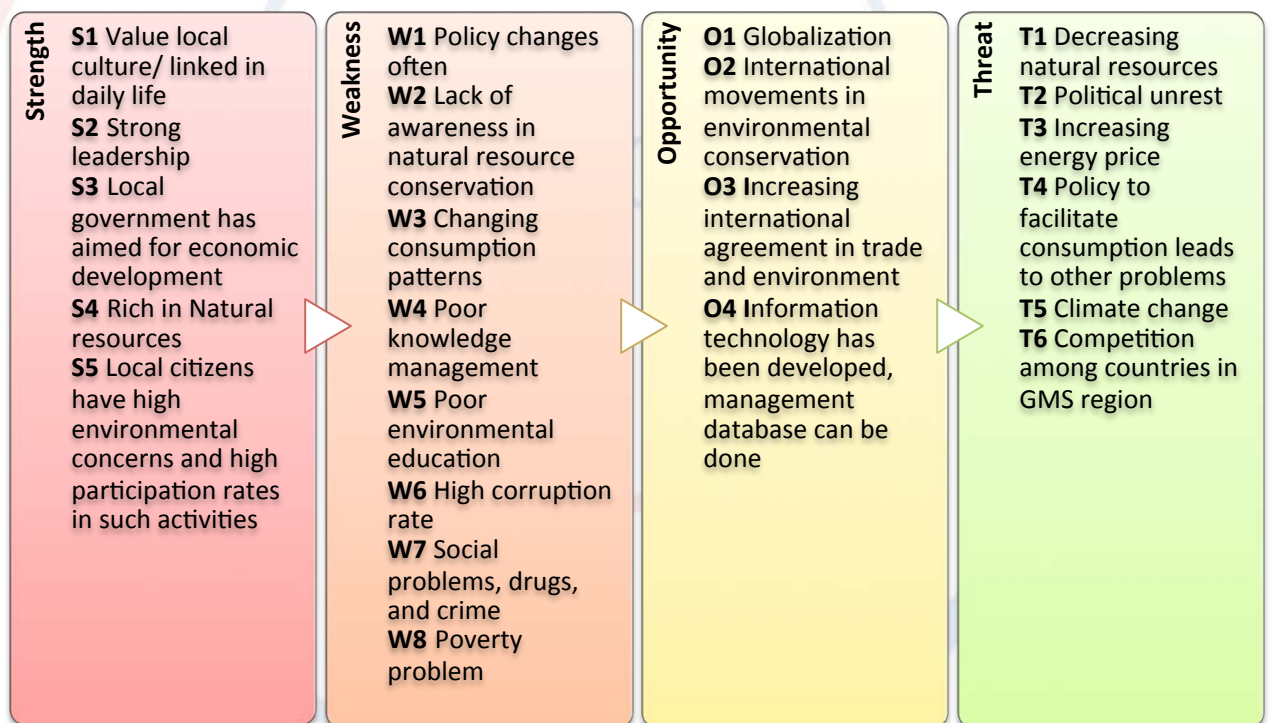


Figure 3 Results from SWOT analysis.

Table 2 TWOS matrix to develop strategic action plan for cities.

TOWS Matrix		External			
		Opportunities		Threats	
Internal	Strengths	S-O(maxi-maxi) Strategies		S-T(maxi-mini) Strategies	
		SO1	Support Eco-tourism in the area and conserve the traditional culture of each ethnic group.	ST1	Support the customary laws in the area also improve and implement the wildlife management
		SO2	Support indigenous knowledge on handicraft to create one village one product or one district one product	ST2	Promote and educate local people about the benefits of ecotourism as well teach people about environmental protection
	SO3	Promote the use of traditional knowledge in production process and use information technology in public relations	ST3	Ensure successful policy implementation and good governance	
	Weaknesses	W-O(mini-maxi) Strategies		W-T(mini-mini) Strategies	
		WO 1	Use information technology in city management to reduce cost and increase effectiveness, good governance should be practiced	WT1	Prepare environmental protection plan
WO 2		Improve education and public health services in the city	WT2	Poverty reduction via policy on sustainable consumption	

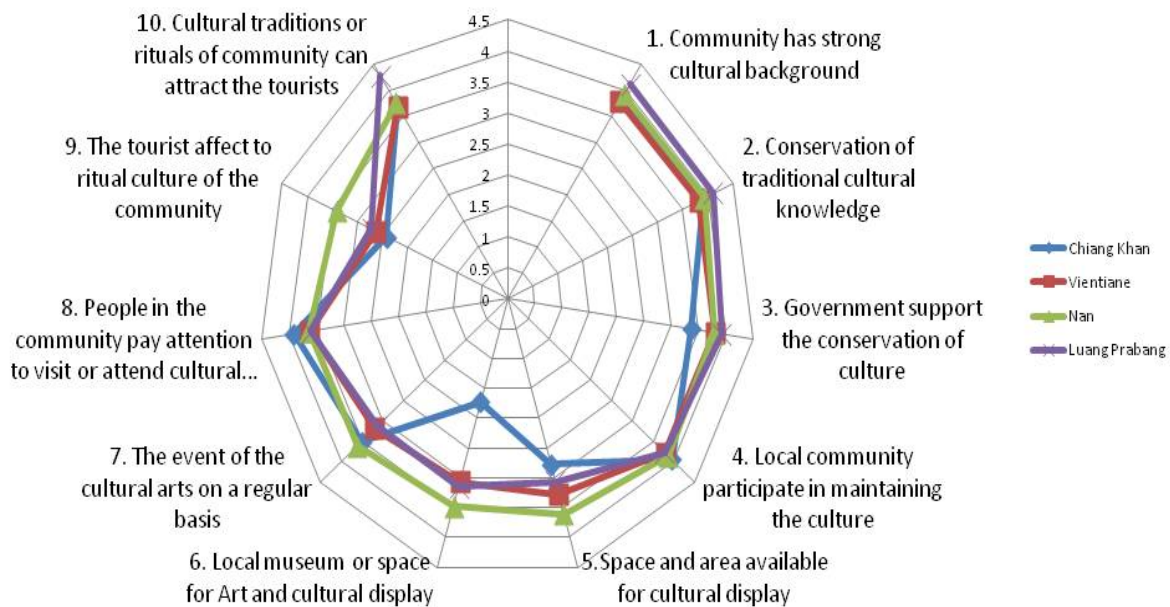


Figure 4 Indicators of cultural aspects that contribute to a sustainable city.

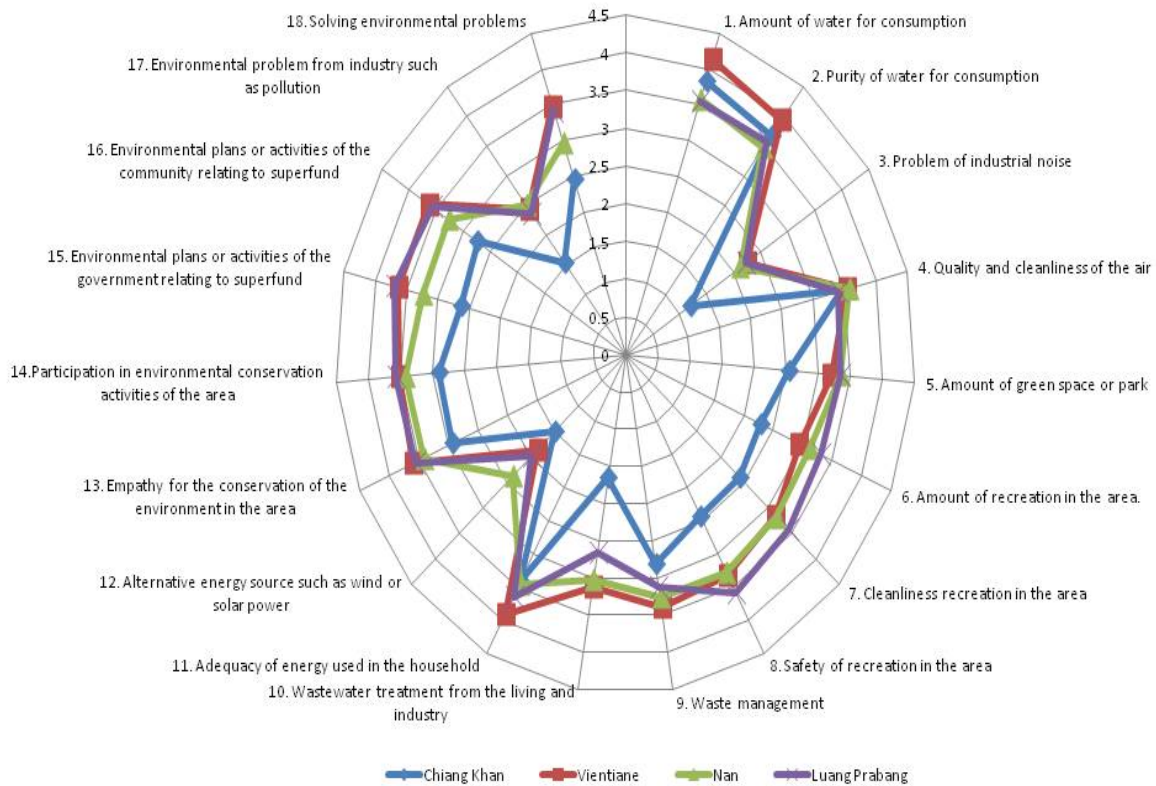


Figure 5 Indicators of environmental aspects that contribute to a sustainable city

With the factors that are considered important in ensuring desirable quality of life, the national and local government can, plan the direction of development. Cities with similar characteristics can also use the information for their localities, for sustainable development of the city.

IV. Conclusion

Data from both SWOT and questionnaires surveys were adopted by local governments to further develop participatory action plans of the cities. Factors affecting the quality of life and the sustainability of the cities are the same in studied cities. However, cities have their own characteristics and the planning for future development needs to take these characteristics into consideration. In order for sustainable development to occur, national policy as well as local policy should be consistent.

Table 3 Overall score from each city.

Indicator groups	Thailand		Laos	
	Chiang Khan	Nan	Vientiane	Laung Phrabang
Economic indicator	3.48	3.31	3.75	3.64
Healthcare indicator	3.26	3.45	3.78	3.55
Social welfare indicator	3.59 ⁽²⁾	3.48 ⁽³⁾	3.67	3.67
Physical-Infrastructure indicator	3.37	3.38	3.86 ⁽²⁾	3.55
Environmental indicator	3.51 ⁽³⁾	3.60 ⁽²⁾	3.84 ⁽³⁾	3.74 ⁽²⁾
Agricultural practice	3.33	3.41	2.90	3.34
Architectural dimension	3.35	3.29	3.43	3.71 ⁽³⁾
Art and cultural indicator	3.68 ⁽¹⁾	3.74 ⁽¹⁾	3.91 ⁽¹⁾	4.10 ⁽¹⁾

V. References

Health Unlimited 2009. Health Unlimited's programmes in Laos. Available from: <http://www.healthunlimited.org/Programmes/Asia/Laos>. Date accessed: 3 November 2010.

Hortle 2007. CMRC Technical Paper No. 16, October 2007. Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin. Mekong River Commission, Fisheries Programme, Vientiane, Lao PDR.

Messerli P., Heinimann A., Epprecht M., Spuhavat P., Chantalanouvong T., and Minot N. 2008. Socio-economic Atlas of the Lao PDR. Department of Statistics Ministry of Planning and Investment, GOL; Swiss National Center of Competence in Research North-South Switzerland; Center for Development and Environment, University of Bern; and Lao National Mekong Committee Secretariat, Water Resources and Environmental Administration.

MRC 2010. An assessment of environmental impacts of tourism in the Lower Mekong Basin. MRC Technical Paper No. 2x.

A study of feasibility to utilize lignocellulosic biomass as materials for biodiesel production

Patchanee Yasurin^{*1}, Treuktongjai Saenghiruna^{*1}, Jirapa Phetsomb^{*2}, Malinee Sriariyanun^{*3}

^{*1}Assumption University, Thailand ^{*2}Maharakham University, Thailand ^{*3}King Mongkut's University of Technology, Thailand

0305

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Lignocellulosic biomass is a renewable, inexpensive, and abundant resource with high potential for biofuel production to implement the sustainable energy world. The bottleneck of biofuel production is the recalcitrance of lignocellulosic biomass to fermentable sugars. Searching for a novel cellulase, a biocatalyst is one of major challenges to promote biofuel production with economic and environmental friendly. Natural microorganism is the great source of cellulase production. Therefore the objective of this research is to identify thermophilic, rapid, efficient cellulose-degrading bacteria from organic fertilizer, rice field, activated sludge, and rain forest in Thailand. More than 300 isolates were screened at 45°C on carboxy-methyl-cellulose (CMC)-containing media to observe the cellulase activity. Using standard filter paper assay, only 9 isolates (S3-10, S3-20, L2-S1, L2-S2, S3-7, L3-S1, L11-S2, L11-S3, and L11-S4) showed high total cellulase activity among other isolates. All isolates then were cultured in media containing 4 different carbon sources; CMC, filter paper, untreated rice straw, nutrient broth (NB), to see effect of substrates on cellulase production. It showed that L2-S2 in Dubois salts media with rice straw could induce high total cellulase activity to 25.57 $\mu\text{mole/mg-protein}$ while L11-S3 in NB could induce the highest total cellulase activity to 27.92 $\mu\text{mole/mg-protein}$. Therefore untreated rice straw and NB represented as an effective inducer for cellulase production. A portion of the 16srDNA genes of cellulase positive isolates were amplified and sequenced, then BLASTed to determine species. The results showed that most of isolates are *Bacillus* sp.

Introduction

The continuous growing of industry worldwide, including Thailand, leads to the increasing of energy demand to support their production lines and processes. Natural petroleum is the main resource to generate energy. However the price is increasing, while the accumulated crude oil supply is decreasing. To increase the national security in energy situation issue, Thai Government launched the policy to promote the research and production of biofuel by using as the alternative option of petroleum fuels. By year 2021, the production of biofuel is planned to 39.97 million liters per day, as year 2012 only 2.7 million liters per day was produced. (Source: Energy in Thailand: Facts&Figures 2012 Report, Department of Alternative Energy Development and Efficiency, Ministry of Energy).

Each year Thailand has agricultural waste more than 55 million per year. These agricultural wastes are abundant and inexpensive source of lignocellulosic biomass for conversion to biofuel. Lignocellulosic biomass is comprised of mainly cellulose (the most abundant organic polymer in the world), a homologous polymer of glucose molecules connected by β -1,4 linkages [1]. It also contains hemicellulose (a heterologous polymer of 5- and 6-carbon sugars) and even less so lignin (a complex aromatic polymer) [1]. Plant cell wall is composed of lignocellulose biomass, though with different proportion up to plant species [2]. For example, rice straw has 69.2% cellulose, 4.9% lignin, 10.2% hemicellulose [3].

Cellulase enzyme plays key importance rule in conversion of lignocellulosic biomass into fermentable sugar for biofuel production. Cellulase enzyme complex comprises of three classes of soluble extracellular enzymes: 1,4- β -endoglucanase, 1,4- β -exoglucanase, and β -glucosidase (β -D-glucoside glucohydrolase or cellobiase) [4]. Endoglucanase is responsible for random cleavage of β -1, 4-glycosidic bonds along a cellulose chain [4]. Exoglucanase is necessary for cleavage of the nonreducing end of a cellulose chain and splitting of the elementary fibrils from the crystalline cellulose, and β -1, 4-glucosidase hydrolyses cellobiose and water-soluble cellodextrin to glucose [4]. To complete cellulose hydrolysis, the synergy of these three enzymes is needed. In nature, cellulose biomass is hydrolyzed and degraded by microorganisms that produce many types of cellulolytic enzymes. Synergic multienzyme systems are also expected in bacterial cellulase complexes [5]. Cellulolytic bacteria include aerobes such as *Pseudomonas* and *Actinomyces*, facultative anaerobes such as *Bacillus* and *Cellulomonas*, and strict anaerobes such as *Clostridium* [5]. A variety of *Bacillus* species secrete cellulases, including strains of *B. cereus* [6], *B. subtilis* [7]. Therefore this research was aimed to identify thermophilic, rapid, efficient cellulose-degrading bacteria from organic fertilizer, rice field, activated sludge, and rain forest in Thailand

Materials and Methods

Materials and chemicals

The organic fertilizer was obtained from rainforest park at Assumption University, Bangkok, Thailand. The activated sludge was obtained from waste water treatment system at King Mongkut's University of Technology, North Bangkok, Thailand. The soil from rice field and rain forest was obtained from Maharakham province, Thailand.

The growth media used in the experiments include the R2A agar (0.5g yeast extract, 0.5g protease peptone, 0.5g casamino acids, 0.5g glucose, 0.5g soluble starch, 0.3g dipotassium phosphate, 0.5g magnesium sulfate·7H₂O, 0.3g sodium pyruvate, 15.0g agar), the carboxymethyl cellulose (CMC) agar (0.5g CMC, 0.1g NaNO₃, 0.1g K₂HPO₄, 0.1g KCl, 0.05g MgSO₄, 0.05g yeast extract, 1.5g agar, per 100 ml ddH₂O) and the Dubois salts media (K₂PO₄ 1g, KCl 0.5 g, MgSO₄ 0.5g, NaNO₃ 0.5g, FeSO₄ 0.01 g, pH 7.4) [1]. The other chemicals used in this study were purchased from Ajax (Bangkok, Thailand)

Isolation of microorganisms using R2A

The 1 g of each sample was suspended in 20 ml of sterile 0.1% peptone by vortexing for 2 min on maximum speed. Following, a 10X serial dilution of the suspension was made in peptone. Then, 1 ml of each dilution in the series was spread onto R2A agar using the standard spread plate technique. All plates were incubated at 45°C as the thermophilic screening. The microorganisms were isolated at 24 h. and then they were incubated for an additional 48 and 72 h to allow growth of slower growing microorganisms for further sampling [1]. From the growth observed over 24, 48 and 72 h, various colonies were selected based on their morphology, size and color [1]. The colonies selected were then streaked out on separate R2A plates to ensure purity. Colonies were further subcultured on R2A if more purification was required [1]. The plates were then photographed and described for a database (data not shown).

Screening for cellulase activity

Isolates were grown in 10 ml of NB broth at 45°C for 48 hrs. Then 5µl of each broth culture were singly dropped onto a carboxymethyl cellulose (CMC) agar and then was incubated at 45 °C for 48 h. To investigate the cellulase activity, the plates was flooded with 0.1 % Congo red solution for 15 min and washed with 0.1 M NaCl [8]. To indicate the cellulase activity of the organisms, diameter of the clear zone around colonies on CMC agar was measured. The cellulase activity screening was repeated five times to check the stability of cellulase activity.

Total cellulase activity on different carbon source

The 9 selected isolates, which shown the highest and stable cellulase activity, were choose for total cellulase activity. The total cellulase activity was performed by transferring 100 µl of an overnight culture to 20 ml of different four medias as the following; CMC media, Dubois salts media with filter paper, Dubois salts media with rice straw, and Nutrient broth (NB) to investigate the effect of carbon source on cellulase production and activity at 45 °C for 24 h. The total cellulase activity was performed by using standard filter paper assay. Protein determination was done by using Bio-Rad protein assay. The specific activity of cellulase was calculated.

16S rDNA amplification and isolates identification

The genomic DNA of 9 selected isolates was isolated by using Genomic DNA Extraction Kit from RBCbioscience, Gibthai Co., Ltd., Thailand. The genomic DNA was used as a template in a PCR reaction to amplify a region of the 16S rDNA. The Universal primers (27F (forward) : 5'AGAGTTTGATCMTGGCTCAG 3' and 1429R (reverse) : 5' GGTTACCTTGTTACGACTT 3') were used. The PCR products were sent for sequencing.

The sequencing results were individually aligned online into the nucleotide blast tool through the NCBI database (<http://blast.ncbi.nlm.nih.gov>) to identify the possible genera of the isolates.

Results and Discussion

Isolation and Screening

Cellulolytic bacteria were screened using R2A media from various sources; organic fertilizer, activated sludge, soil from rice field and rain forest at Thailand at 45°C. A totally 330 isolates were selected and screened for cellulase activity on CMC agar by using congo red method to check clear zone as cellulase activity. After first round cellulase activity screening, only 29 isolates showed high positive cellulase activity at 45°C, 48 h. Most of isolates' cellulase activity were dramatically decrease after first round cellulase activity assay, as show in figure 1. In order to check stability of isolates' cellulase activity, it is necessary to repeat isolates' cellulase activity assay for 5 more times.

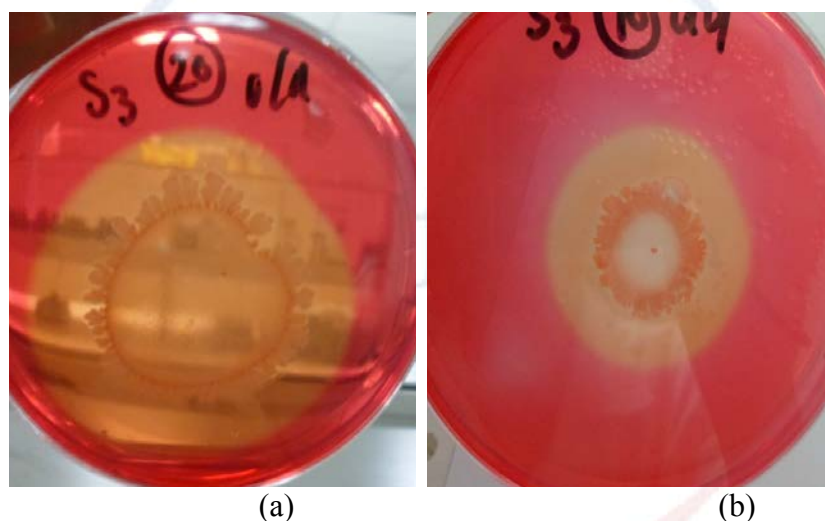


Figure1: Cellulase activity assay showed the clear zone on CMC media at 45°C, 48 h. after congo red flooding indicated cellulase activity positive. The cellulase activity was decrease after first round assay. (a) showed the first round cellulase activity assay (b) showed the second round cellulase activity assay.

After 5 times cellulase activity assay, only 9 isolates showed high and stable cellulase activity as the following; S3-10 and S3-20 from organic fertilizer in rainforest park at Assumption University, Bangkok, Thailand, L2-S1 and L2-S2 from soil in rice field at Mahasarakham province, Thailand, S3-7 from soil in rain forest at Mahasarakham province, Thailand, L3-S1, L11-S2, L11-S3, and L11-S4 from activated sludge in waste water treatment system at King Mongkut's University of Technology, North Bangkok, Thailand. The results showed that clear zone and hydrolytic capacity (HC) value ranged between 45.0 to 32.0 mm and 5.3 to 8.7 for all 9 isolates as showed in table 1.

Table1: The cellulase activity as clear zone on CMC agar and hydrolytic capacity (HC) value at 45°C, 48 hrs.

Source	Isolates	Average Clear Zone (mm)	Average HC value
Organic fertilizer in rainforest park at Assumption University, Bangkok, Thailand	S3-10	32	5.6
	S3-20	40	7.6
Soil in rice field at Mahasarakham province, Thailand	L2-S1	42	8.7
	L2-S2	38	5.3
Soil in rain forest at Mahasarakham province, Thailand	S3-7	45	6.5
Activated sludge in waste water treatment system at King Mongkut's University of Technology	L3-S1	42	6.9
	L11-S2	39	7.4
	L11-S3	34	8.1
	L11-S4	44	6.5

Total cellulase activity on different carbon source

The 9 selected isolates, which shown the highest and stable cellulase activity, were chosen for total cellulase activity. The total cellulase activity was performed by transferring 100 µl of an overnight culture to 20 ml of different four medias as the following; CMC media, Dubois salts media with filter paper, Dubois salts media with rice straw, and Nutrient broth (NB) to investigate the effect of carbon source inducer on cellulase production and activity at 45 °C for 24 h. The total cellulase activity was determined by standard filter paper method. The totally cellulase activity of all 9 isolates was showed in table 2. The L11-S3 in NB could induce the highest total cellulase activity, 27.92 umole/mg-protein while the L2-S2 in Dubois salts media with rice straw could induce high total cellulase activity, 25.57 umole/mg-protein. It is interesting that the L2-S2 was isolated from soil in rice field at Mahasarakham province, Thailand and showed high total cellulase activity as using rice straw as carbon source inducer. This indicated that habit of microorganism has impact on cellulase expression. The cellulase isolated from the *Bacillus* sp. was highly active at 50°C (24 U/mg protein) and highly stable at this temperature for at least 30 min of enzyme denaturation [10]. Glucose and milled filter paper inhibited the growth and cellulase production of *B. brevis* VS-1 [11]. Cellulose, cellobiose and lactose are effective only at high concentrations [11]. Milled filter paper inhibits cellulase due to its adsorption to the substrate [11]. Cellulase biosynthesis is regulated by a complex interaction of catabolite repression, induction and enzyme inhibition [12]. In addition, the production of extracellular endoglucanases is cAMP dependent and therefore is subject to catabolite repression by glucose accumulation [13]. Cellulose has been reported as the best inducer for the complete cellulase complex [13].

Table 2: Total cellulase activity on different carbon source as inducer

Isolates	Total cellulase Specific activity ($\mu\text{mole}/\text{mg protein}$)			
	CMC media	Dubois salts media with filter paper	Dubois salts media with rice straw	Nutrient broth
S3-10	4.90	1.16	1.92	0.82
S3-20	10.34	19.00	1.64	0.77
L2-S1	0.19	6.37	0.19	2.52
L2-S2	2.76	7.41	25.57	1.15
S3-7	2.67	1.31	1.81	1.14
L3-S1	2.93	2.06	2.80	3.03
L11-S2	2.05	1.55	1.64	2.95
L11-S3	17.99	11.14	3.10	27.92
L11-S4	2.05	3.04	1.46	5.36

16S rDNA sequencing

The sequencing results were successfully obtained for all 9 difference 16S rDNA PCR products. The sequencing results were individually aligned online into the nucleotide blast tool through the NCBI database (<http://blast.ncbi.nlm.nih.gov>) to identify the possible genera of the isolates base on homology. From BLAST search results, genera of all 9 isolates were determined based on 92-99% homology. The BLAST results are shown in table 3. The majority of sequencing belong to *Bacillus* sp.

Table 3: The BLAST results

Isolated	Strain	E Value	Present Homology
S3-10	<i>Bacillus subtilis</i> strain W48	0	99%
S3-20	<i>Bacillus licheniformis</i> strain B3-15	0	97%
L2-S1	<i>Bacillus methylotrophicus</i> strain ALK069	0	99%
L2-S2	<i>Bacillus</i> sp. JS3	0	93%
S3-7	<i>Bacillus safensis</i> strain PDRV	0	96%
L3-S1	<i>Bacillus pumilus</i> strain SEMP7	0	99%
L11-S2	<i>Bacillus safensis</i> strain PDRV	0	99%
L11-S3	<i>Pseudomonas brenneri</i> strain GGRJ16	0	92%
L11-S4	<i>Bacillus methylotrophicus</i> strain Ns2-16	0	92%

The 99% homology sequencing BLAST results shown to belong to the genus *Bacillus*; S3-10 is *B. subtilis* strain W48, L2-S1 is *B. methylotrophicus* strain ALK069, L3-S1 is *B. pumilus* strain SEMP7, and L11-S2 *B. safensis* strain PDRV. *B. subtilis* YJ1 was cultivated in the medium and only produced the Endo- β -1,4-glucanase at 37°C for 36 hrs. [9]. However, the activities of other 2 enzymes, Avicelase and β -glucosidase were very low during cultivation [9].

Over - production of CMCCase from *Bacillus* sp. can be achieved by physical, chemical methods of mutagenesis and through recombinant DNA technology. This kind of study also helps to produce CMCCase in commercial scale utilizing local agro-wastes in solid state culture [10].

Conclusion

From the results obtained in this study, L2-S2; *Bacillus* sp. JS3, the novel thermophile cellulase producing bacteria which rice straw is an inducer for its production was isolated. Further study is to characterize the cellulase proteins, optimize the growth condition.

Acknowledgment

The authors would like to thank King Mongkut's University of Technology, North Bangkok (Research University Grant No. KMUTNB-GOV-56-10) for financial support of this work.

1. Maki L.M., Broere M., Leung T.K., and Qin W. Characterization of some efficient cellulase producing bacteria isolated from paper mill sludges and organic fertilizers, *Int J Biochem Mol Biol.* 2011. 2(2): 146–154
2. Chandel, A. and O. Singh, Weedy lignocellulosic feedstock and microbial metabolic engineering: advancing the generation of 'Biofuel'. *Appl Microbiol Biotechnol.*, 2011. 89(5): 1289-303.
3. Zhu, S., et al., Pretreatment by microwave/alkali of rice straw and its enzymatic hydrolysis. *Process Biochemistry*, 2005. 40(9): 3082-3086.
4. Gupta P., Samant K., and Sahu A. Isolation of Cellulose-Degrading Bacteria and Determination of Their Cellulolytic Potential, *Int J Microbiol.* 2012; 2012
5. Kim Y-K., Lee S-C., Cho Y-Y., Oh H-J., and Ko Y. H. Isolation of Cellulolytic *Bacillus subtilis* Strains from Agricultural Environments, *ISRN Microbiology*, 2012; 2012 doi:10.5402/2012/650563
6. Thayer D. W., and David C. A., Growth of seeded cellulolytic enrichment cultures on mesquite wood, *Appl Environ Microbiol.* 1978. 36(2):291-6
7. Robson L. M., and Chambliss G. H., Characterization of the cellulolytic activity of a *Bacillus* isolate, *Appl Environ Microbiol*, 1984. 47(5): 1039–1046
8. Sethi S., Datta A., Gupta B. L., and Gupta S. Optimization of Cellulase Production from Bacteria Isolated from Soil, *ISRN Microbiology*, 2013 <http://dx.doi.org/10.5402/2013/985685>
9. Yin L-J., Lin H-H., and Xiao Z-R. Purification and Characterization of A cellulase from *Bacillus subtilis* YJ1. *Journal of Marine Science and Technology*, 2010. 18(3):466-471
10. Vihayarafhavan P., and Prahash V.S.G., Purification and Characterization of Carboxymethyl Cellulase from *Bacillus* sp. Isolated from a Paddy Field. *Polish Journal of Microbiology*, 2012. 61(1):51–55

11. Singh V. K., and Kumar A., Production and purification of an extracellular cellulase from *Bacillus brevis* VS-1. *Biochem Mol Biol Int*, 1998. 45(3):443-52
12. Stewart B.J., and Leatherwood J.M., Derepressed synthesis of cellulase by *Cellulomonas*, *J. Bacteriology*, 1976. 128(2): 609–615
13. Mandal M., Panish, F.W. and Reese, E.T (1962). Sophorose as an inducer of cellulase in *Trichoderma reesei*, *J Bacteriol*, 1962. 83:400-408

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is enclosed within a circular graphic composed of two overlapping, thick, brush-stroke-like lines. The outer line is a light blue color, and the inner line is a light red color. The lines are slightly offset from each other, creating a sense of depth and movement.

*Assessment for Sustainable Solid Waste Management in Nakhon Ratchasima City
Municipality, Thailand*

Siriporn Boonpa, Alice Sharp

Sirindhorn International Institute of Technology Thammasat University, Thailand

0333

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Rapid increase in volume and types of solid waste generation due to economic growth, urbanization, and industrialization has become a problem in developing countries including Thailand. Urban cities in Thailand such as Nakhon Ratchasima City Municipality (NRCM) have put sustainable waste management among their top priorities. One way to solve this problem is to convert waste to energy. Municipal Solid Waste (MSW), as a source of fuel, decreases need for landfill volume, thus freeing sites for other more useful purposes; it also contributes to a decrease in fuel demand, thereby protecting the environment. Despite the fact that integrated waste management has been used widely in the country, there is room for improvement of the system being used to increase effectiveness of the system. At the NRCM, mixed MSW is being converted to renewable energy such as Refuse Derived Fuel (RDF) and biogas production. However, a large amount of MSW is still being disposed of in landfill. This study focuses on an assessment of waste management process at NRCM to determine its efficiency, environmental impacts, and impact mitigation measures in all the stages of waste management system. Data compiled for analysis include waste generation and separation at source, characterization of waste feedstock, and material flow through the integrated system being employed at the NRCM. Problems encountered in each step were identified. In addition, this study proposes improvement measures for waste management services to maximize resource recovery and resource utilization.

Keywords: Municipal Solid Waste, Integrated solid waste management system, system efficiency, waste to energy

1. Introduction

Environmental concerns on municipal solid waste management (MSWM) have become a global challenge because of increasing population, which results in increasing amounts of MSW.

Siriporn Boonpa is with the Department of Common and Graduate Studies, Sirindhorn International Institute of Technology, Thammasat University, PO Box 22 TU-Rangsit Post Office, Pathum Thani, 12121, Thailand. e-mail: boonpa.srp@gmail.com

Alice Sharp is with the School of Bio-Chemical Engineering and Technology, Sirindhorn International Institute of Technology, Thammasat University, PO Box 22 TU-Rangsit Post Office, Pathum Thani, 12121, Thailand. (Corresponding author phone: 66-2-986-9009 Ext. 1805; Fax:66-2-986-9112~3; e-mail: alice@siit.tu.ac.th)

In developing Asian countries including Thailand, this factor is further exacerbated by inadequate financial resources, and inadequate management and technical skills within municipalities and government authorities. Thailand is a country located at the center of the Indochina peninsula in Southeast Asia. The country is divided into 78 provinces, in 5 regions. Total land area is 513,120 square kilometers. Thailand has gross domestic product (GDP) growth of 6.4% [1] and a population of 67 million people [2]. The country has relied on agricultural and industrial exports and tourism. The average amount of waste generation per capita is 0.63 kg/capita/day with slight differences among localities: 1.5 kg/capita/day in Bangkok, 1.0 kg/capita/day in municipalities and Pattaya city, and 0.4 kg/capita/day outside municipality areas [3]. Waste generation per capita is the highest in the Asia Pacific Region [4]. Wastes normally contain a high organic fraction. This has potential for energy production. However, these wastes are being dumped into landfills and they release pollutants and greenhouse gases into the environment.

In addition to MSW problem, the country is also experiencing rapid economic growth which leads to increasing demand for energy. This may result in the energy insecurity that has become an emerging issue in Thailand. MSW can be used as a source of renewable energy. In MSWM, there are several technological methods to manage solid waste before final dispose into landfill. These methods manage solid waste in a sustainable way and can recover energy from waste materials. For example, incineration produces energy; composting of organic wastes produces fertilizer; anaerobic digestion produces energy (biogas); recyclable materials are recovered through recycling activities. The above methods together reduce the final quantity of waste into a manageable amount of environmental friendly product.

Technologies that can convert waste to energy in Thailand consist of 5 main types: incineration, refuse derived fuel (RDF), anaerobic digestion, pyrolysis, and landfill gas recovery. For this study, NRCM integrated waste management facilities are selected to study the waste management process. The efficiency, environmental impacts, and impact mitigation measures in all stages of waste management system are determined.

2. MSW characteristics and composition in NRCM

Nakhon Ratchasima City Municipality (NRCM) is located at Muang district, Nakhon Ratchasima province in the northeastern region of Thailand that is 250 km away from Bangkok. The area of jurisdiction is 37.50 square kilometers and located at 150 – 300 meters above sea level.

This section describes the results of the MSW characterization study carried out by the standard method [5-9]. Initially, MSW properties such as density, moisture content, dry matter, volatile

solid, ash/non-volatile solid, and heating value are described, for Nakhon Ratchasima City Municipality.

Density of MSW

The density of MSW was 0.384 Kg/L or ton/m³ on average. The density of MSW result will be used to predict the environmental problems due to limited landfill space and odor.

Characterization of MSW

The composition of MSW is shown in Fig.1. According to the result, organic waste was the largest portion of MSW, which contributes to 40% of total waste generated. The second and third largest components were soft plastics (23%) and paper (14%).

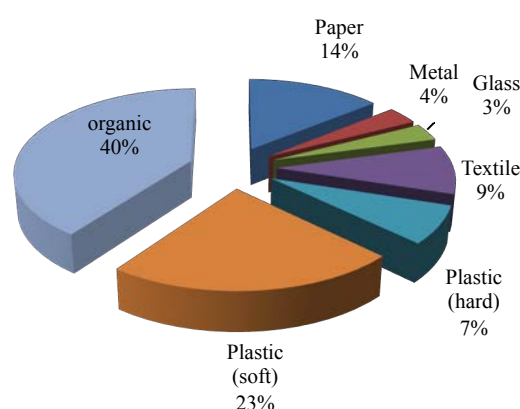


Fig. 1 Characterization of MSW at NRCM, Thailand.

Moisture content and dry matter of MSW

Moisture content and dry matter of MSW results are given in Table 1. The highest moisture content was observed for organic waste at 70.93%, while paper at 20.69% and plastic (soft) at 6.84% waste were the second and third levels of moisture. The compositions of metal and plastic (hard) waste had almost equal levels of moisture. The above information indicates the benefit of RDF product from plastic (hard) and plastic (soft) in managing waste at NRCM due to their moisture content low level. Furthermore, paper can be used for RDF production after decreasing its moisture content.

Volatile and ash/non-volatile solid of MSW

Volatile solids in most samples were found to vary from 87 to 99% of the total solid. Glass and metal waste contributed volatile solids of 0.8 and 11%, respectively, as shown in Table 1. According to the German fuel standard, volatile matter is approximately 50-80% by weight [10]. From these results, plastic (hard), plastic (soft), textile, paper, and organic wastes can be used as raw material for production of RDF and RDF can be used as energy source.

Heating value of MSW

Heating values of oven dried components of MSW were obtained the tests carried out according to the Bomb calories methods [7] and the results are given in Table 1. The highest heating value was observed for plastic (soft), while paper waste recorded the lowest levels of heating value due to it containing high moisture content.

Table 1 Compositions and characteristics of MSW in NRCM (2013).

Compositions	Contribution (%)	Moisture content (%)	Dry matter (%)	Volatile solid (%)	Ash/non-volatile solid (%)	Heating value (GJ/ton)
Paper	14	20.69	79.31	89.90	10.10	13.99
Metal	4	5.84	94.16	11.62	88.38	-
Glass	3	1.59	98.41	0.83	99.17	-
Textile	9	2.53	97.47	92.47	7.53	15.79
Plastic (soft)	23	6.84	93.16	99.96	0.04	36.86
Plastic (hard)	7	5.72	94.28	99.56	0.44	22.01
Organic	40	70.93	29.07	87.64	12.36	18.96
Hazardous	0	-	-	-	-	-
Other	0	-	-	-	-	-

3. Review and discussion of MSW management process in NRCM

Mass balance

The mass balance of the SW management process at NRCM is shown in Fig.2. Waste coming to the NRCM dumping site was estimated from the data obtained from the Development of Environment and Energy Foundation (DEE) [11]. The total solid waste generation integrated waste treatment facility of 392 ton is sent to NRCM on a daily basis: 48.98% of MSW was sent to landfill, while 51.02% was sent to a waste treatment facility. The estimated amounts of waste coming to the waste treatment facility are 87.61% as MSW, 1.54% as organic waste separated at source, 8.81% as market waste, and 2.04% as night soil. The majority of MSW was large size material that include recyclable waste (0.32%, 2,000 baht/ton), RDF1 (12.62%, 900 baht/ton), and others (87.06%) while small size material were mixture of organic and fiber waste. Only the organic portion was sent to be mixed with organic waste, market waste, and night soil in order to produce biogas by anaerobic digestion. Another material of MSW was metal waste which accounted for less than 1% with a sale price of 5,000 baht/ton.

Analysis of process

The analysis of MSW management process in NRCM is described in Table 2 in terms of strength, weakness, and solution of each process: collection, landfill, and waste treatment facility. The NRCM waste management process is shown in Fig.3.

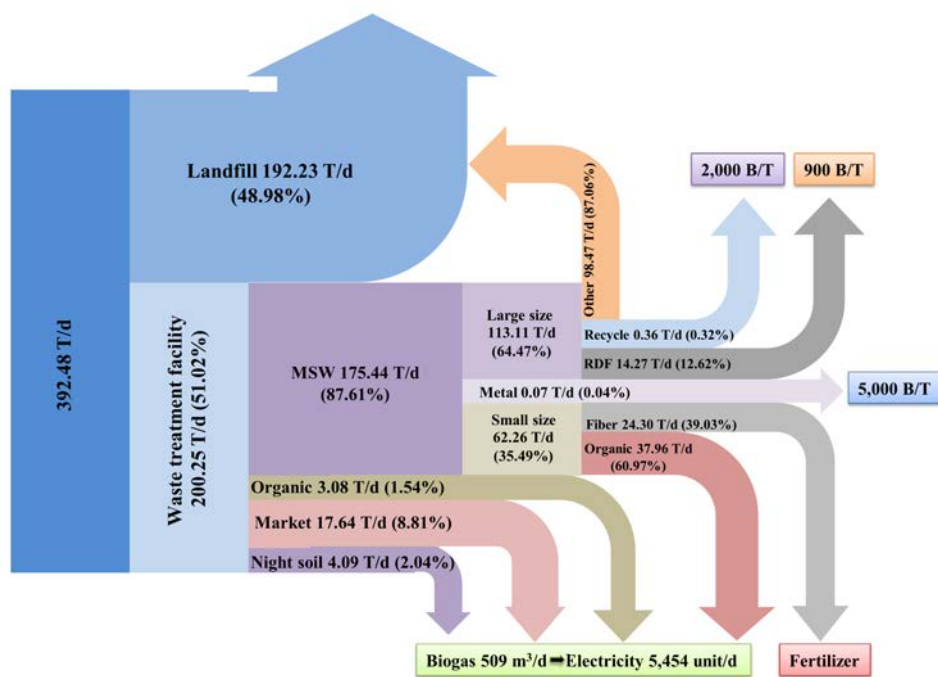


Fig. 2 Total waste flow within NRCM based on data from DEE foundation.

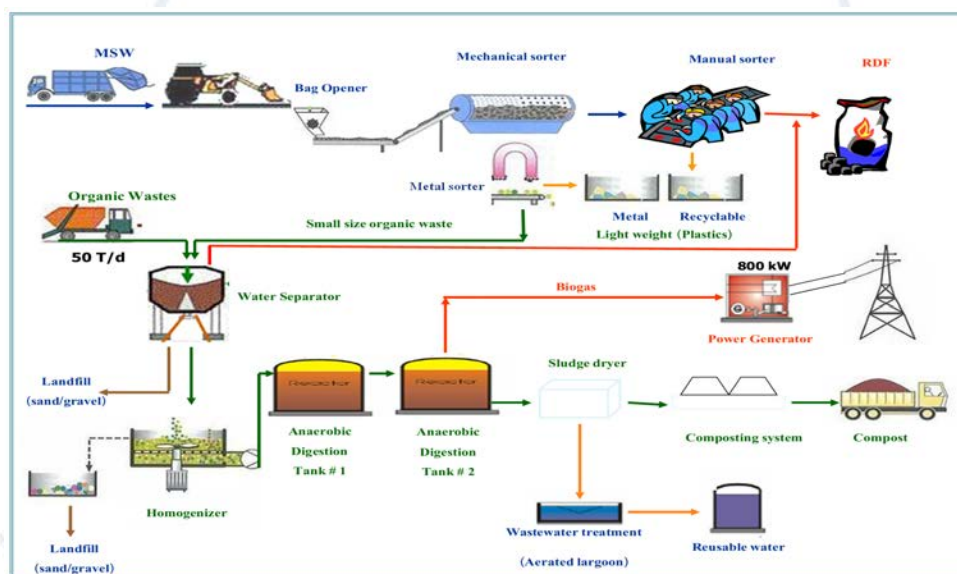


Fig. 3 NRCM waste treatment facility system [11].

Table 2 Analysis of MSW management process in NRCM.

Process	Strength	Weakness	Solution
Collection	<ul style="list-style-type: none"> • Solid waste can be collected daily <ul style="list-style-type: none"> • Door to Door Collection • Curb-side collection • Waste Station • Collection rate is 72%. 	<ul style="list-style-type: none"> • Collection rate is less than 100% • Wastes are disposed as mixed MSW <ul style="list-style-type: none"> • Difficult to manage 	<ul style="list-style-type: none"> • Introduced a public participation program in <ul style="list-style-type: none"> • Solid waste management • Source separation
Sorting			
- bag opening	<ul style="list-style-type: none"> • For effective waste separation • Constant material flow • Increase the values of waste • Use for alternative energy source (RDF) 	<ul style="list-style-type: none"> • Cost of waste management is increased • Maintenance of equipment is frequently required • Effectiveness is low/large amount of waste to landfill 	<ul style="list-style-type: none"> • Machine required skillful personnel in operation and maintenance • Always cleaning, inspecting and maintaining the machine
- mechanical sorting			
- metal sorting		<ul style="list-style-type: none"> • Collecting and sorting by labor at the facilities • It can be seen that the methods are not only ineffective but also not sanitary 	<ul style="list-style-type: none"> • Annual health check for labor • Labor should be trained to sort waste • Incentive system
- manual sorting			
Treatment technologies			
- Refuse derived fuel (RDF)	<ul style="list-style-type: none"> • Can divert most combustible waste from landfill • Alternative energy source 	<ul style="list-style-type: none"> • Waste separation system must be required • No trading market • Electricity cost • Maintenance of equipment is frequently required 	<ul style="list-style-type: none"> • Encourage the use of RDF as alternative energy source in industry • Machine required skillful personnel in operation and maintenance • Produce RDF1, RDF2, RDF3
- Anaerobic Digestion (AD)	<ul style="list-style-type: none"> • Can divert most organic and biodegradable waste from landfill • Biogas recovery • Useable compost 	<ul style="list-style-type: none"> • High-tech system that requires skilled technical operators • Methane gas that is explosive • Disease generated from solid wastes fermentation and odor • Annual system shut down needed for discharging 	<ul style="list-style-type: none"> • Odor control at the organic waste separation plant prior to composting • Install automatic scum discharging part with peristaltic pump
Final disposal	<ul style="list-style-type: none"> • The landfill is located within a military area <ul style="list-style-type: none"> • It can be extended • No public opposition 	<ul style="list-style-type: none"> • Lack of control of environmental impact <ul style="list-style-type: none"> • No collection of emitted gases • Landfill GHG gas and odor 	<ul style="list-style-type: none"> • Construction of gas collection and ventilation • Leachate treatment system

4. Conclusion

It can be seen clearly that appropriate management of solid waste in NRCM is required in order to reduce the quantity of waste in an environmentally and economically sustainable way. With increasing environmental concerns, the NRCM integrated MSW management system has the potential to maximize the utilization of waste materials (metals and recyclable plastic) and alternative energy sources (RDF and biogas).

In NRCM, the compositions of waste are mainly organic waste, plastic (soft), paper, textile, plastic (hard), metal, and glass. As a result, the waste in NRCM is very suitable for an integrated MSW management with suitable technologies for reducing the disposal cost. For NRCM waste, most combustible waste will be RDF, while most organic and biodegradable products contribute biogas by anaerobic digestion.

However, the current situation in NRCM is that wastes are disposed of as mixed MSW. Contamination of each component makes it difficult to use valuable materials within. Communities that effectively separate waste can reduce the quantity of waste to be disposed of drastically. Effective separation of waste starts with education programs for local citizens with well-designed waste containers provided. Information gathered from all sources show that in order to have successful implementation of MSW management, there are weaknesses and solutions that NRCM should consider. If these weaknesses are not solved, the NRCM integrated MSW management system is unlikely to succeed.

5. Acknowledgment

The authors would like to thank the Development of Environment and Energy Foundation (DEE) for raw data provided in Fig. 2 of this paper. We would like to express thanks to The Bangchak Graduate Scholarship Program for their scholarship which has enabled us to carry out this research.

6. References

1. Wikipedia, t.f.e. *Economy of Thailand*. 2012; Available from: http://en.wikipedia.org/wiki/Economy_of_Thailand.
2. Indexmundi. *Thailand Demographics Profile 2012*. 2012; Available from: http://www.indexmundi.com/thailand/demographics_profile.html.
3. Sharp, A., and Sang-Arun, J. , *A Guide for Sustainable Urban Organic Waste Management in Thailand: Combining Food, Energy, and Climate Co-Benefits*, 2012.
4. Troschinetz, A.M. and J.R. Mihelcic, *Sustainable recycling of municipal solid waste in developing countries*. Waste Management, 2009. **29**(2): p. 915-923.
5. E830-87, A., *Standard Test Method for Ash in the Analysis Sample of Refuse Derived Fuel* 2004.
6. D5231-92, A., *Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste*, 2003.
7. E711-87, A., *Standard Test Method for Gross Calorific Value of Refuse Derived Fuel by the Bomb Calorimeter* 2004.
8. E790-87, A., *Standard Test Method for Residual Moisture in a Refuse Derived Fuel Analysis Sample*,

2004.

9. E897-88, A., *Standard Test Method for Volatile Matter in the Analysis Sample of Refuse Derived Fuel* 2004.
10. Kara, M., *Environmental and economic advantages associated with the use of RDF in cement kilns*. Resources, Conservation and Recycling, 2012. **68**(0): p. 21-28.
11. DEE, *Feasibility Study of Municipal Solid Wastes for Electricity Generation*, 2007. p. 13-15.



*A Study in Information Usage Behavior of Students in
Rajabhat Rajanagarindra University*

Waraporn Sinthaworn

Rajabhat Rajanagarindra University, Thailand

0356

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

The study had following objectives as: (1) to study information usage behavior of students in Rajabhat Rajanagarindra University, (2) to study about problems in information usage and (3) to study about requirements of the students in information usage. Sample comprised of 300 students. Data were collected by questionnaires analyzed by percentage, mean and SD. The results were: 1) most of the samples used Internet at their place. The most usage time was between 16:31 – 24:00. Most of samples used internet more than four hours/day. Most of samples had never used internet via mobile phone, never played online game and never utilized e-learning. 2) The facilities that were used to search for information were the Main Library, Bangkla Internet center, and Bangkla Library. The most used information source was WWW, second in rank was books and journals. On the other hand, the three least used information source were encyclopedia, personal source and database. 3) The samples utilized data for their assignments and daily life. The most used applications were search engine, communication programs, and e-mail service, respectively, however, they rarely used Internet to buy goods or services. In addition, the problems in using information were inadequate facilities, especially number of computers, and capacity of the computers. The other problems were computer software and service time. Moreover, the samples needed more computers (in more capacity) and more service time.

Keywords: Information Usage Behavior, Information Source

Introduction

In the era of learning society, knowledge emerges for all time and people need to adapt to live in a quality and balance life. In education, it needs to adapt ideas, formulate and develop method according to the need of learners and intention of Education Act 1999, which has the final goal for continuous human development and encourage applying technology to the education system.

Information system is sets of data, which is synthesized from raw data and can be utilized in planning, development, controlling and decision-making. Reliable information leads to efficient decision. In addition, reliable Information system can lead to learning society too.

As the result of advance of information technology, the information sources have been increased and become diversity one. An obtaining of excess and unnecessary information, which is not useful for decision-making, also becomes a serious problem as it causes confusion in the information selection. Thus, the information literacy is an essential basic element which enables students to employ self-learning and also cultivates a research habit to students. The students are able to apply the using of information knowledge in professional practicing. The resource-based learning is a concept, which gives an importance on a learning of information process through both the information sources and the subject matter. The students are able to search, select, and use the knowledge from the various information sources, able to learn the information process, and able to gain the knowledge through problem solving and decision-making based on the using of information (National Forum on Information Literacy, 1998).

So, this study was conducted to gather information about students' information system using behavior at Rajabhat Rajanagarindra University and used result as guideline to develop the university's information system and encourage the students to utilize information system properly.

Materials and Methods

Population and sample

Population for this study was 3,011 students in Rajabhat Rajanagarindra University, which included every years and both full-time and part-time student. Sample was 300 students, which selected by simple random sampling.

Variables

Independent variables were consisted of, i.e., gender, age, year of study, faculty, student status, and basic computer knowledge.

Dependent variables are using information system behavior, problem in using information system, and requirement in using information system.

Methods

Researcher studied documents and research, both inside the organization and other sources to develop tool for collecting data. Developed tool was questionnaire about behaviors and opinion in using information system of the students. Then the data were collected in 2009 academic year, which data of full-time students were collected on weekdays and weekends for part-time students. The data were analyzed by percentage, average and standard deviation via computer program. Finally, analyzed data were summarized and discussed to report the result.

Result

Two hundred eighty five out of three hundred sets of questionnaires were returned, which were equivalent to 95%. Data were analyzed and yielded result as shown in following tables:

Table 1: Frequency and Percentage by genders

Genders	Frequency	Percentage
Male	109	38.24
Female	176	61.76
Total	285	100.00

From table 1, it was found that from 285 returned questionnaires, the sample comprised of 109 males (38.24%) and 176 females (61.67%).

Table 2: Frequency and Percentage by genre of students

Genre	Frequency	Percentage
Full-time	150	52.63
Part-time	135	47.37
Total	285	100.00

From the table 2, it was shown that most of the samples were full-time students (52.63%) and the remaining were part-time students (47.37%).

Table 3: Frequency and Percentage by computer knowledge of students.

Computer knowledge level	Frequency	Percentage
High	63	22.11
Moderate	166	58.25
Low	51	17.89
Unspecified	5	1.75
Total	285	100.00

Results from Table 3 showed that most of sample had moderate computer knowledge (58.25%), while the remaining had high and low knowledge with the percentage value was 22.11 and 17.89, respectively.

Table 4: Frequency and Percentage by genre of students by information system knowledge of students.

Information system knowledge level	Frequency	Percentage
High	46	16.14
Moderate	134	47.02
Low	100	35.09
Unspecified	5	1.75
Total	285	100.00

Results from table 4 demonstrated that 134 students (47.02%) had moderate knowledge about information system. The remaining students had low and high knowledge about information system where the percentage value was 35.09 and 16.14, respectively.

Table 5: Frequency and percentage by student's behavior in using information system.

Content	Frequency	Percentage
1. Place of using		
1.1 The university	93	32.63
1.2 Home or Dormitory	170	59.65
1.3 Internet Café	19	6.67
1.4 Other place	3	1.05
2. Time of usage		
2.1 0:00-9:00 A.M.	10	3.51
2.2 9:01-12:00 A.M.	21	7.37
2.3 12:01 A.M. - 1:00 P.M.	85	29.82
2.4 1:01- 4:30 P.M.	25	8.77
2.5 4:31 - 12:00 P.M.	134	47.02
2.6 Conveniently	10	3.51
3. Interval of usage		
3.1 less than a hour	21	7.37
3.2 1 – 2 hours	32	11.23
3.3 3 – 4 hours	97	34.03
3.4 More than 4 hours	135	47.37
4. Using internet via mobile phone		
4.1 Yes	41	14.39
4.2 No	244	85.61
5. Playing online-game		
5.1 Yes	130	45.61
5.2 No	155	54.39
6. Using e-learning		
6.1 Yes	31	10.88

Content	Frequency	Percentage
6.2 No	254	89.12
7. Used facilities		
7.1 Library (main campus)	111	38.95
7.2 Library (Bangkla campus)	34	11.93
7.3 Computer & Internet Center (Bangkla campus)	108	37.89
7.4 Unspecified	32	11.23
8. Most used information source		
8.1 Person	1	.35
8.2 Book	80	28.07
8.3 Journal	5	1.75
8.4 Thesis	3	1.05
8.5 Encyclopedia	-	-
8.6 Data base	1	.35
8.7 World Wide Web	195	68.43
9. Least used information source		
9.1 Person	34	11.93
9.2 Book	8	2.81
9.3 Journal	10	3.51
9.4 Thesis	13	4.56
9.5 Encyclopedia	185	64.91
9.6 Data base	30	10.53
9.7 World Wide Web	5	1.75
10. Information sources used in doing assignment		
10.1 Internet	210	73.68
10.2 Library	69	24.22
10.3 Bookstore	5	1.75
10.4 Unspecified	1	.35
11. Information sources used in daily life		
11.1 Internet	221	77.54
11.2 Library	10	3.51
11.3 Bookstore	53	18.60
11.4 Unspecified	1	.35

Results in Table 5 showed that most students used Internet from their places (59.65%), whereas the second rank was from the university (32.63%). The time that most spent on using Internet was between 4.31 P.M. to 12.00 P.M. (47.02%) whereas the second rank of most used was between 12.00 A.M. to 1 P.M. (29.82%). It was found that the length of time required for using Internet, where most of them used

internet more than four hours a day (47.37%) and the second rank of time used was three to four hours a day (34.03%).

In addition, the result yielded that most of sample (85.61%) never used Internet via mobile phone, never played online game (54.39%), and never used e-learning (89.12%).

In the case of facilities in the university, it was shown that the most frequent use was the facility at library of the main campus (38.95%), while the second and third rank of most frequent use were Computer & Internet Center at Bangkla campus (37.89%), and library at Bangkla campus (11.93%), respectively.

According to information sources, it was found that WWW was the highest one that was used (68.43%), while the second and third high rank that had been used were book (28.07%), and journal (1.75%), respectively.

On the other hand, the lowest rank of sources that had been used was encyclopedia (64.91%), person (11.93%) and database (10.53%).

Finally, the source of information that was used to do assignments and daily life was Internet.

Table 6: mean, SD and scale of students' internet activities

	Activities	\bar{X}	SD.	Quality
1.	E-mail	4.32	.62	Often
2.	On-line games	2.21	.66	few
3.	Chat programs (such as MSN, Yahoo, ICQ, Skype)	4.45	.57	Often
4.	Social networks	4.01	.78	Often
5.	Download (music, movie, program)	3.32	.88	Moderate
6.	Upload (photo, video)	3.11	.78	Moderate
7.	On-line shopping	1.25	.65	rarely
8.	Entertainment news	4.06	.76	Often
9.	General news	4.11	.66	Often
10.	Search engine	4.86	.89	Always
11.	Watch video and listen music on-line	3.87	.58	Often
12.	Check study result	4.04	.64	Often
13.	University news and information	3.89	.77	Often

Results from the table 6 showed that the most often an activity was using search engine with the mean value was 4.86, while the second rank of an activity was chat program (4.45), and the third rank of an activity was e-mail. On the other hand, the activity that was rarely happened was on-line shopping (1.25).

Summary

General information

It was found that 285 returned questionnaires; the samples were 109 males (38.4%) and 176 females (61.76%). One hundred and fifty were full-time student (52.6%) and 135 were part-time (47.37%), most of sample have moderate knowledge about computer and information system.

Behavior in using information system

Most of sample used Internet at home or dormitory (59.65%) and second to the most use was at the university (32.63). The time interval of most usage was between 4.31 P.M. to 12.00 P.M. (47.02%), and second to the most use was between 12:00 A.M. to 1:00 P.M. (29.28%). It was found that the estimated time, which required for using Internet was over four hours/day (47.37%) for the most frequent use, while second rank to the most frequent use was three to four hours/day (34.03%). Most of samples (85.61%) never used Internet via mobile phone, whereas 54.39% never played on-line games and 85.61% never used e-learning system. The university's facilities that most frequently used by sample were the library (main campus), computer and Internet center (Bangkla campus), and library (Bangkla campus), respectively.

WWW appeared to be the most frequently used information source (68.43%), while the second rank of the most frequently used was books (28.07 %), and the third rank of the most frequently used was journal (1.75 %). The lower frequently used information source was encyclopedia (64.91%), person (11.93%), and database (10.53%), respectively. Internet was the most frequently used information source for doing assignment and daily life. The most frequent activity related to the use of WWW was used as search engine (mean = 4.86), chat program and e-mail with mean value was 4.45 and 4.32, respectively. In another way, the rarely occurred activity was on-line shopping, which the mean value was 1.25.

Problems in using information system could be listed as follows:

1. Inadequate facilities
2. Insufficient number of computers
3. Capacity of computer and virus infection
4. Service time is too short
5. Problem in information acquiring.

Requirement in using the university information system could be listed as follows:

1. Increase more computers.
2. Increase capacity of the computers.
3. Extend service time.
4. Increase capacity of system.

Discussion

Most of samples have moderate knowledge about computer and information system. It means that the university should develop students in computer literacy and using information system. Short training programs or workshops may be suitable for serving the purposes.

About students' behavior in using information system, the result yields that they has used information both at home and at university. So, they can use it anywhere and anytime, but the university should provide more facilities to increase opportunities for students to access information system. Most of them have been using Internet more than four hours/day. It may convey that students lack of skill in searching information or the computer lacks of capabilities (or both), so, the university should improve the computer capabilities to match to enormous knowledge sources in the present time.

WWW is much more used than book, which can imply that it is more convenient in searching and recording retrieved information. In addition, it can conclude that library service time is insufficient, especially for part-time students who come to campus only on weekend. Then, the university should arrange training course to increase student's skill to use information system more efficiently. The most frequently used application is search engines, which reflect that it is the most convenient tool for searching information. In case of communication applications, chat program and e-mail are still popular among the students because they can use them to contact with both friend and teacher, and they are convenient, economic, and fast way to send various type of information.

In the aspect of problems, facilities, number of computers, capacities of computers, virus infection, service time, and information accession are addressed problems. The university needs to improve facilities according to the problems.

References

- Breivik, P.S. and Gee E.G. (1989). **Information Literacy: Revolution in The Literacy**. New York: American Council on Education and Macmillan.
- Bundit A. (2007). **A proposed instructional web-based model with resource-based learning process for developing analytical thinking and information utilization for problem solving of undergraduate students, Walailak University**. Doctoral Dissertation, Ph.D. (Educational Technology and Communications). Bangkok : Chulalongkorn University.
- National Forum on Information Literacy. (1998) **American Library Association Presidential Committee on Information Literacy**[online] . Available from:
<http://www.infolit.org/documents/89Report.html>[2006 , February 21]
- Rattanapian V. (2005). **Instruction to Web-Based Instruction**. Bangkok : Chulalongkorn University.

Ratana-Ubol A. et al. (2006). **The Development of model in developing information literacy for Thai society.** Bangkok : Chulalongkorn University.



*Firm level motivations and barriers for initiating sustainability transitions in the
Norwegian energy system*

Tyson Weaver*¹*²

*¹Sogn and Fjordane University College, *²Norwegian University of Science and
Technology, Norway

0369

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Given the urgency of realizing a transition to more sustainable energy systems, it is crucial to gain more knowledge about the role of incumbents and the dynamics of regimes. Over the past decade many energy system incumbents have found themselves responding to exogenous challenges in their core domestic markets and many have strategically reoriented themselves towards new 'green' opportunities. By investigating diversification strategies of traditional energy companies and their associated suppliers in terms of both products and markets, this paper contributes to an enhanced understanding of agency and dynamics of regimes and the role of spatiality in transitions. Our analytical framework is multi-disciplinary in drawing on insights from transition studies, evolutionary-relational economic geography, and strategic management. Utilizing survey data from 250 strategically sampled firms, our findings suggest that skill relatedness triumphs spatial proximity in diversification strategies, but that this also depends on the nature of the incumbent's product. However, recently two key industry developments have taken place that changes the trajectory of these firms being firmly rooted in sustainability transitions. Whilst the discovery of new fields on the Norwegian Continental Shelf has revived the O&G industry, the implementation of a 'Green certificate scheme' has created new opportunities in the domestic electricity sector. We conclude that our case incumbents continually demonstrate reactive strategies, thus undermining proactive sustainability transitions. Until global market opportunities in new renewable energy technologies can demonstrate sustained market stability and growth as traditional industry we posit that such incumbents will remain on beaten tracks.

1. Contextures of Sustainability Transitions

It is well understood that humankind is set upon an unsustainable trajectory. In attempts to understand how we can begin to make a shift towards a more sustainable path, academics have begun devising several emerging theories of sustainability transitions. The transfer of resources from non-sustainable to sustainable sectors, a process that Cooke (2012) has defined as transversality, is crucial to succeeding the grand energy system transition. This restructuring of societal production and consumption patterns will not occur overnight, and thus transitions are understood to be long-term processes spanning multiple decades (Konrad et al., 2008, Farla et al., 2012). As a point of departure we find it prudent to share Jørgensen's belief that sustainability should be considered as a journey, rather than a destination. What is the role of dominant firms in this journey? Do they take a proactive or reactive stance? What are their motivations for pursuing sustainability? What barriers stand in their way? These questions have been posed before, yet there is much work to be done to complete our understanding.

According to Moors et al. (2004) transitions are regarded as large societal transformation processes which are not deterministic or predetermined, and involve the emergence and diffusion of new technologies into user domains with societal embedding. With the pursuit of sustainability at the focal point, understanding how processes unfold that engage transitions is of importance to scholars and other stakeholders alike. Much focus has been placed upon framing sustainability transitions in a larger systems perspective which has shed light on the bigger picture but according to Farla et al. (2012) these insights may have overshot more actor oriented analyses. In light of much work that has been done in the technological innovations systems and strategic management frameworks, we have begun to understand how niche innovations have the capability to disrupt the existing regime and force prevailing actors to respond to such niche innovations. A prevailing *a priori* assumption in the strategic niche management and technological innovation systems literature is that incumbents resist changes within the regime, are focused upon pursuing their *status quo* through the control of resources, and most importantly, take a reactionary stance towards green innovations that guide the regime towards sustainability transitions (Jacobsson and Lauber, 2006). Whilst there is antecedent evidence to support this claim, we believe one in the same as Bob Dylan in that the 'times are a changin'. Whilst new entrants may at times be credited for the creation of niche green innovations that promote the sustainability agenda, we argue that it is the incumbents who embrace these that realize the rollout from niches to full scale market economies with these innovations.

It has been well versed that disruptions to the regime can come from innovations or landscape forces, but what is overlooked is the transformation from inside the regime itself. We argue that the role of transversality at the incumbent level of the regime is constrained by the firms' dynamic capabilities and motivationally impinged upon their future strategic orientations. The article is structured as follows. First we discuss the role of incumbents in regimes, followed by linking extant grounded theories in strategic management to discourse in sustainability transitions. We follow with presenting the research backdrop and questions for empirical investigation. Section 4 outlines our methodological approach, with ensuing results presented in section 5. We

conclude with some theoretical implications for sustainability transitions and propositions for further research.

1.1. Incumbents and the triple P

A key node in sustainability transitions theory is the role of firms. The success of sustainability oriented transition management depends greatly on interactions, performance (Morioka et al., 2006), and intentions of the stakeholders involved. In the case of actors within the energy regime, one of the largest challenges to achieving sustainability transitions is surmounting the path dependence and lock-in conundrum. This entrapment in existing systems may be difficult to dislodge (STRN, 2010), but we must be mindful that transitions unfold over longitudinal time scales and thus it is most interesting to gain more insight into the timing of actor engagements that disrupt, or perhaps intervene upon, existing path dependencies.

It has been commonly argued that niche actors create protected spaces in a technological regime, and incumbents are forced to respond to such new innovations (Hockerts and Wüstenhagen, 2010, Farla et al., 2012). We have thus set forth an empirical analysis of the energy regime in Norway in attempts to uncover several key facets of how sustainability transitions unfold at the regime level. Contrary to Penna and Geels assessment (2012), we posit that a number of incumbent actors proactively engage into the green innovation agenda on their own volition.

1.2. On the need for the inclusion of complementing theories

It has been stated there are many theoretical advancement opportunities in sustainability transitions theory through the inclusion and incorporation other existing and established theoretical knowledge bases (Markard et al., 2012). Amongst these vast opportunities, we have chosen to incorporate doctrines rooted in strategic management studies into our theoretical framework.

One of the key theoretical challenges in sustainability transitions is the appropriate construct of its conceptualization when so many factors are at play. Jørgensen (2012) proclaimed one and the same highlighting the need 'to combine an analytical understanding of... path dependent dynamics of dominant societal configurations...with a process oriented understanding of situated actor's possibilities of engaging in transitional processes.' This vulnerability creates opportunities for sustainability transitions to come under stark criticism from distinct academic disciplines. Ranging from policy to society to industry regimes which all take a stake and play a role in transitions, proponents of the multilevel perspective have worked feverishly to address this theoretical demurring (Geels, 2011, Smith et al., 2010). In line with Markard et al. (2012), we believe that sustainability transitions can benefit greatly from the inclusion of existing theories that can ultimately both critique and broaden existing theoretical knowledge of the field.

2. Theories on strategic orientations of the firm

Strategic orientation is a concept widely used in the research field of strategic management to reflect future directions of the firm as devised in a strategic corporate plan. It involves the conceptualization of how a firm will position itself moving

forward with the creation of a plan, and the managerial actions to allocate of resources to implement that plan. Strategic orientations may entail a variety of options for the firm including internationalization, diversification, and innovation activities. The underlying rationale for incorporating the following theoretical contributions from management science and their connection to the role that incumbents play in sustainability transitions is the simple question: how do firms explore to create new value?

2.1. Market and product mixes

According to industry life cycle theory firms must seek new ways to create value to survive the long haul. A firm eventually finds itself seeking to take existing products or services into new markets or develop new ones for their existing market. This has traditionally been conceived to occur at the maturity or decline stages of the model. Firms therefore either look for new ways of consolidating or increasing their domestic market shares (Gallego et al., 2009) through incremental product and service innovations, or seek market expansion abroad. Managerial perceptions of stimuli, their attitudes towards risk, and an understanding of the firms resource base create the foundation for which strategic orientation decisions of the firm are made. Firm level positioning and their resource base within a given industry will play a major role in their capability to engage into new activities. Scholars have thoroughly investigated the identification and significance of firm resources with attention being paid to tacit knowledge, network capabilities, financial wherewithal, and innovative capabilities.

The focus of our work is then upon diversification in strategic reorientation. Diversification in strategic management has taken a wide form of constructs over its theoretical evolution, but we choose to focus on product and market level diversification based upon Ansoff's seminal work (1957) reflected in Figure 1. It is well established that diversification basically occurs along the two axes of market and technology, and often in 'proximity' to skills/technological relatedness to the 'base position' of a given firm (Neffke and Henning, 2012). Theory suggests that a key element in firms' diversification strategies is to leverage existing resources by slowly shifting product and market penetration matrixes further out along both axes.

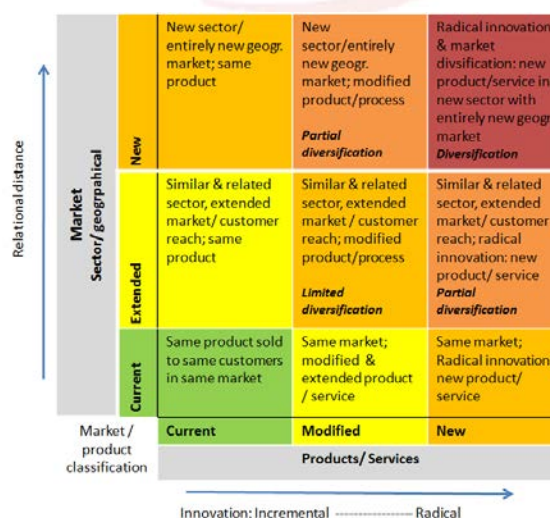


Figure 1 Product and market diversification mix; modified from (Ansoff, 1957)

2.2. The corporation as an entrepreneur?

The recent academic definition of entrepreneurship goes far beyond its historical connotation of small startups. Entrepreneurship embodies risk taking, proactivity, innovativeness, and strategic response to a recognized need through coordinated economic activity. Given that corporations are nothing more than a collection of individuals, they possess the same capability to demonstrate these characteristics as a single individual. Therefore the notion of entrepreneurship has been extended beyond its neoclassical meaning to include all collections of individuals that exhibit such behavior, including corporations. These newly defined boundaries have given rise to the growing body of literature on corporate entrepreneurship. It reflects how established corporations can act entrepreneurially by venturing into new business areas to identify and explore the potential of new business opportunities, even at times when no existing market for the product exists (Frederiksen and Davies, 2008). Thus firms that engage in diversification by extending their activities into areas marginally related to their current domains of competence exhibit characteristics of corporate entrepreneurship (Burgelman, 1983).

Corporate environmental strategies began to take shape in accordance with greater demand for corporate social responsibility throughout the 1990s, resulting in a strand of entrepreneurship literature based around these principles. Sustainability transitions and sustainable entrepreneurship share close linkages. According to Hockerts and Wüstenhagen (2010), sustainable entrepreneurship is the 'discovery and exploitation of economic opportunities...that initiate the transformation of a sector towards an environmentally and socially more sustainable state' (p.482). An alliance that the sustainable entrepreneurship research stream shares with sustainability transitions is the notion that new entrants disrupt stability in the regime, forcing incumbent firms to respond to new green niche innovations. Hockerts and Wüstenhagen's conceptual work offered us a significant takeaway: when incumbents positively respond to market introductions from new entrants, incumbents propel transitions. They deem incumbents engaged in these gradual transformations 'greening goliaths,' as strategic reorientation repositions incumbents along new lines towards sustainability paths.

2.3. To track on beaten paths or forge new?

The concept of organizational learning through exploration versus exploitation was championed by March (1991) which implied that firms choose between two trajectories to renew knowledge based assets of the firm. Exploitation emphasizes refining the firms knowledge base through incremental steps with high degrees of control, certainty and risk minimization (Prange and Verdier, 2011), whereas exploration entails greater departure from the norm implying more risk of expansionary plans outside of core competencies (March, 1991, Barkema and Drogendijk, 2007) with discovery, experimentation, and innovation at its core (Prange and Verdier, 2011). According to (He and Wong, 2004, Benner and Tushman, 2003, Barkema and Drogendijk, 2007), firms operating in a technological domain seeking exploitation improve on existing components within existing product and market

domains, whereas exploration implies a shift to a different technological trajectory altogether.

2.4. Path dependence and lock in

As firms move further through industry life cycle their past histories may constrain what they can do in the future (Teece et al., 1997). These path dependencies give a firm their current stock of capabilities but also constrains future strategic options (Medcof, 2000). Path dependence is a powerful force in energy systems (Lovio et al., 2011) as much of the existing system is characterized by stability, lock-in (Verbong and Geels, 2010) and large sunk costs into the existing infrastructure. Outside of the obvious infrastructural lock-in that embodies energy systems, the related skills and belief systems associated with former legacies complicate transitions towards new systems (Verbong and Geels, 2010) or paths breaking away from the sector all together. This entrapment in existing systems may be difficult to dislodge (STRN, 2010), but it is most interesting to gain more insight into the timing of actor engagements that disrupt, or perhaps intervene upon, existing path dependencies.

The past may not only constrain and shape on-going evolution, but also constitutes the platform for which diversification processes unfold, implicating an enabling view on path dependence (Martin and Sunley, 2006). In line with Dewald and Truffer (2012) we argue that cross-sectorial resource transfer will depend on firms' historic capabilities and will be impinged upon their strategic intentions to pursue new product and market opportunities.

3. Motivation for this contribution

We find it timely to research diversification and path creation within the energy system due to the fact many energy systems throughout the world are undergoing transformation along political, technical, and socio-economic lines. Therefore the underlying tenant to this research stream is the need to understand processes that firms in a given regime endure, and more specifically for our work, the effects of being exposed to new stimuli that act as triggering factors which forces firms to search for new paths in either proactive or reactionary stances.

3.1. Research setting

Norway is an energy nation. As a country it is a major global producer and exporter of natural gas and oil (gas: 4th, 3rd; oil: 15th, 7th respectively). The extraction of fossil fuels on the Norwegian continental shelf currently generate tax revenues amounting to 23% of GDP, and represent about half of total exports, making the petroleum sector Norway's largest industry (OED, 2013). Figure 2 reflects the Norway's drastic increase and imminent decline of petroleum extraction. Like many other countries globally, available reserves are on the decline as peak oil and peak gas have already occurred in the early 2000's (based upon known reserves).

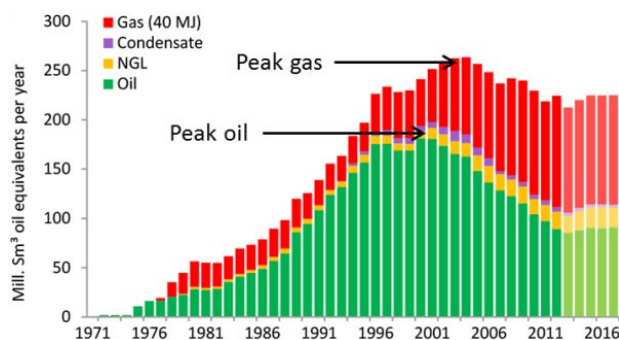


Figure 2 Norwegian peak oil and gas (OED, 2013)

The country has amongst the highest percentage of renewable energy in its electricity supply globally (over 97%), provided namely through hydropower that was primarily built out during the water wave of the 50's-80's. The global rise of environmental and social concerns that plagued the hydropower industry throughout the 1990's and 2000's drastically slowed down new development of this clean energy resource. Of Norway's total domestic hydropower resource base of 217 TWh, 60% has been built out, 25% is protected, leaving 15% available for further development for future generations to meet future energy needs (NVE, 2011).

With the EU renewable energy directive, Norway has also committed to increasing its share of primary renewable energy consumption from the 2005 baseline year of 60,1% to 67,5% in 2020. The strategic plan of implementation has resulted in a joint subsidy support mechanism for renewable energy in the power sector with Sweden, with both countries jointly responsible for adding 26,4 TWh of new clean power to the common grid. Interestingly enough, the estimated production trajectory of renewable energy share of electricity for Norway was cited at 113,6% in 2020, reflecting large renewable energy export plans with the surplus (MPE, 2012).

Given this background context of a nation that has built strong industrial foundations around these two core industries in which limited opportunities existed for both more fossil extraction and hydropower development in the mid to late 2000's, we find it most interesting and timely to empirically investigate if and how sustainability transitions are unfolding. What will the Norwegian energy system transformation look like? Will the oil and gas sector strategically reorient itself from grey to green? Given the favorable existing high penetration of renewables in the power sector, what technologies will be utilized in expanding production?

3.2. Research question

In light of the aforementioned literature review, we propose the following research question:

What are firm level motivations and barriers for pursuing diversification within the energy regime?

That transitions unfold over long time scales, we find it prudent to investigate why firms are interested in pursuing the ‘green agenda,’ and equally importantly, what barriers stand in the way of doing so. Understanding that motivations and barriers come from both inside the regime and the external landscape, we developed two frameworks that reflect both internal and external motivations and barriers as depicted in Figures 3 and 4. Furthermore we developed our framework to test whether firms in the energy system are more proactive or reactive, based upon their motivations for engaging into new activities that promote sustainability transitions.

	Proactive	Reactive
Endogenous	-HR strategy (attract / hold talent) -Reuse competence and resources in new area	-Reduce dependence on main activity -Low returns on main activity
Exogenous	-More attractive business opportunities -Positioning for future	-Stagnation in main activity (sector) -Following customers /competition

Figure 3 Motivational framework for pursuing diversification within the energy system

Endogenous	-Lack of internal knowledge resources -Access to competent talent -Lack of financial capacity
Exogenous	-Unclear politics -Uncertain subsidies-tax mechanisms -Access to new resource areas

Figure 4 Barriers framework for pursuing diversification within the energy system

4. Methodological structure

Our research design for answering the aforementioned research questions consisted of an industry wide web based survey throughout the energy sector in Norway. Our strategic sample and respondent list was collected and compiled through industry representative organizations, consisting of 783 firms in total. We grouped our respondents into three primary classifications as reflected in Figure 5: energy producers, product suppliers, and service suppliers. Our belief is that incumbents within these classifications play different roles in the shaping of the industry, and our goal was to capture these regime dynamics.

In line with Cooke’s (2011) notion of transversality, our methodological approach to track diversification has been tailored to fit the sustainability transitions framework as we sought to underpin transfer of resources between non-sustainable sectors (oil and gas) to sustainable ones (renewable energies). Diversification options were thus limited to renewable energies, as opposed to a variety of industries outside the energy sector for which we could not make the clear argument and distinction of resource transfer leading to sustainability transitions.

4.1. Research model

Figure 5 reflects our methodological approach in a research model. We sought to capture a current picture of incumbents’ current situation, i.e. what their business

dynamic is. This involved a number of descriptive elements about their firm and current activities, in addition to managerial perceptions about former and future market developments. This structure sought to underpin product and market level diversification as laid forth in Figure 1.

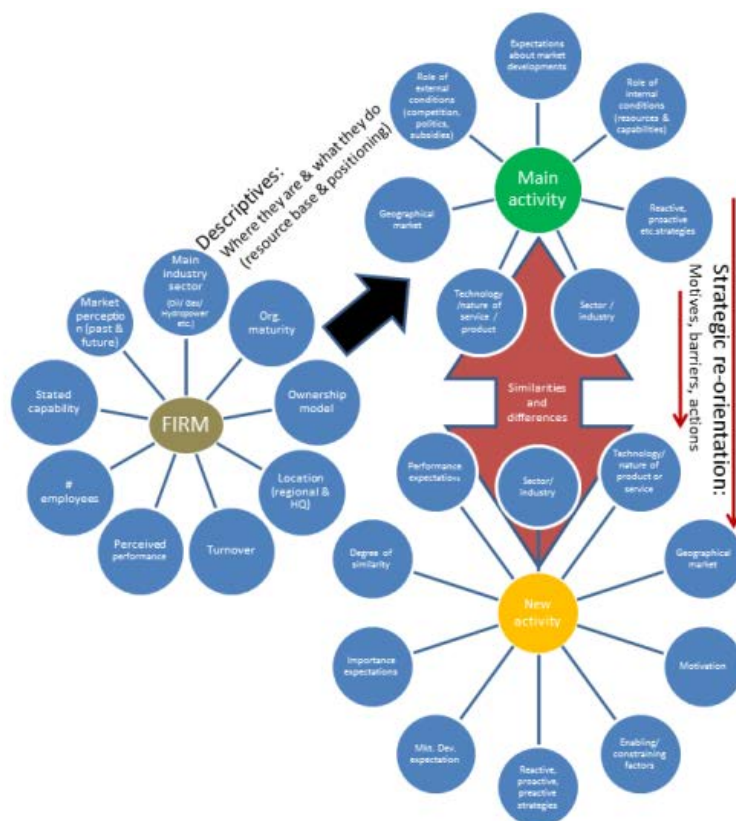


Figure 5: Research model for strategic reorientation in transversality

4.2. Measures and analysis

Key measures utilized a seven point Likerts scale, indicating degrees of assessment with the variables presented. Survey results are presented as descriptive statistics below.

5. Results

The survey produced 220 responses, a response rate of 28%. Individuals with senior leadership roles make up 55% of total respondents. Figure 6 shows the industry composition of each according to the firms' stated primary activity. Figure 7 breaks down the activities of the incumbents in both regimes.

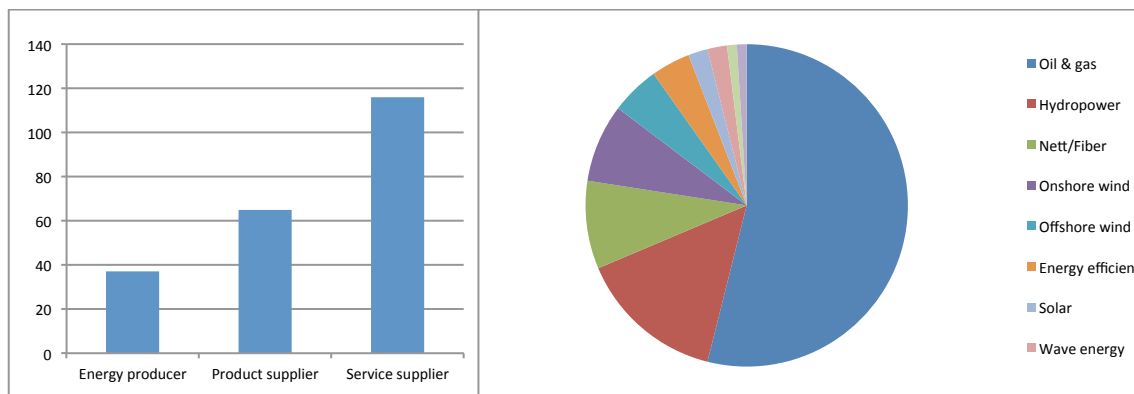


Figure 6 Activities of the respondents

Figure 7 Composition of the respondents' main sectors

Following our framework in Figure 3, motivational results for pursuing transversality within the energy system are presented in Figure 8.

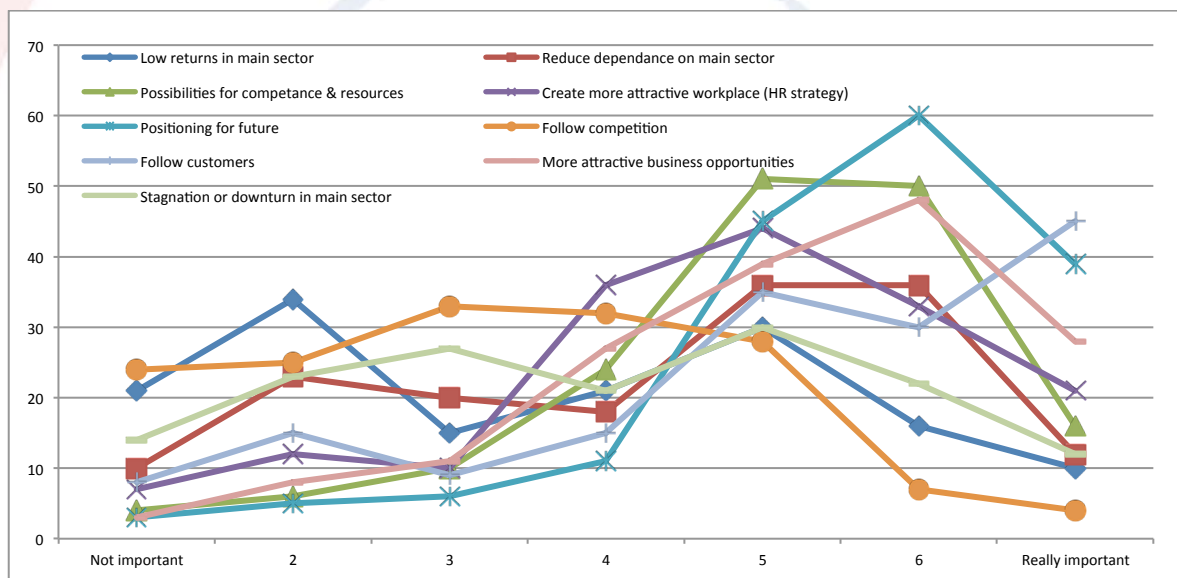


Figure 8 Motivations for pursuing sustainability transitions

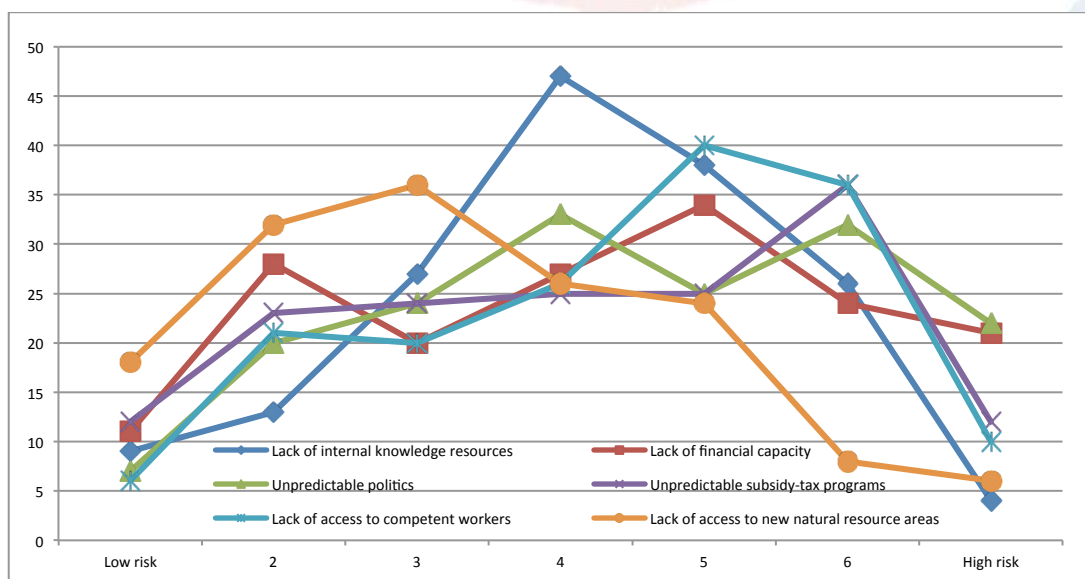


Figure 9 Barriers to pursuing sustainability transitions

6. Theoretical implications for Sustainability Transitions

Industry plays a critical role in sustainability transitions as the link between technology and society (Morioka et al., 2006). In addressing the compound problems of lock-in and path dependence within (energy) regimes, it is well understood that ‘uncertainties about future market and regulations hinder the commitment of firms to the development (or implementation) of sustainable technologies...because of market uncertainties and fear of cannibalising their existing products’ (Geels et al., 2008). This antecedent conclusion offers us several takeaways when analysing incumbents within their prospective regimes. First, a strong market demand for new green innovations must exist for incumbents to pursue them. Second, the policy and regulation of their existing business line and the technological maturity of the new innovation being pursued must align in a way that allows firms to envisage a promising economic future in the new green innovation while simultaneously suppressing the outlook for their existing (unsustainable) business activity. Thus regulation plays a key role in advancing transitions by creating frameworks that offer a roadmap towards sustainability, and thus a way to begin the transition out of path dependency and lock-in of existing systems. Given that all firms pursuing multiple paths face internal competition for resources, the allocation of such resources between new and old activities characterizes the managerial challenge of pursuing sustainability transitions.

iafor

References:

- ANSOFF, H. I. 1957. Strategies for diversification. *Harvard Business Review*, 35, 113-124.
- BARKEMA, H. G. & DROGENDIJK, R. 2007. Internationalising in small, incremental or larger steps? *Journal of International Business Studies*, 38, 1132-1148.
- BENNER, M. J. & TUSHMAN, M. L. 2003. Exploitation, exploration, and process management: The productivity dilemma revisited. *The Academy of Management Review*, 238-256.
- BURGELMAN, R. A. 1983. Corporate entrepreneurship and strategic management: Insights from a process study. *Management science*, 29, 1349-1364.
- COOKE, P. 2011. Transversality and regional innovation platforms. In: COOKE, P., ASHEIM, B. T., BOSCHMA, R., MARTIN, R., SCHWARTZ, D. & TÖDTLING, F. (eds.) *Handbook of Regional Innovation and Growth*. Cheltenham: Edward Elgar.
- COOKE, P. 2012. Transversality and Transition: Green Innovation and New Regional Path Creation. *European Planning Studies*, 20, 817-834.
- DEWALD, U. & TRUFFER, B. 2012. The Local Sources of Market Formation: Explaining Regional Growth Differentials in German Photovoltaic Markets. *European Planning Studies*, 20, 397-420.
- FARLA, J., MARKARD, J., RAVEN, R. & COENEN, L. 2012. Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change*, 79, 991-998.
- FREDERIKSEN, L. & DAVIES, A. 2008. Vanguard and ventures: Projects as vehicles for corporate entrepreneurship. *International Journal of Project Management*, 26, 487-496.
- GALLEGO, M. Á., HIDALGO, E. R., ACEDO, F. J., CASILLAS, J. C. & MORENO, A. M. 2009. The relationship between timing of entry into a foreign market, entry mode decision and market selection. *Time & Society*, 18, 306-331.
- GEELS, F. W. 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, 1, 24-40.
- GEELS, F. W., HEKKERT, M. P. & JACOBSSON, S. 2008. The dynamics of sustainable innovation journeys. *Technology Analysis & Strategic Management*, 20, 521-536.
- HE, Z.-L. & WONG, P.-K. 2004. Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organization science*, 15, 481-494.
- HOCKERTS, K. & WÜSTENHAGEN, R. 2010. Greening Goliaths versus emerging Davids — Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. *Journal of Business Venturing*, 25, 481-492.
- JACOBSSON, S. & LAUBER, V. 2006. The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. *Energy Policy*, 34, 256-276.
- JØRGENSEN, U. 2012. Mapping and navigating transitions—The multi-level perspective compared with arenas of development. *Research Policy*, 41, 996-1010.

- KONRAD, K., TRUFFER, B. & VOß, J.-P. 2008. Multi-regime dynamics in the analysis of sectoral transformation potentials: evidence from German utility sectors. *Journal of Cleaner Production*, 16, 1190-1202.
- LOVIO, R., MICKWITZ, P. & HEISKANEN, E. 2011. Path dependence, path creation and creative destruction in the evolution of energy systems. In: WÜSTENHAGEN, R. & WUEBKER, R. (eds.) *Handbook of Research on Energy Entrepreneurship*. Cheltenham: Edward Elgar.
- MARCH, J. G. 1991. Exploration and exploitation in organizational learning. *Organization science*, 2, 71-87.
- MARKARD, J., RAVEN, R. & TRUFFER, B. 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41, 955-967.
- MARTIN, R. & SUNLEY, P. 2006. Path dependence and regional economic evolution. *Journal of Economic Geography*, 6, 395-437.
- MEDCOF, J. W. 2000. The resource-based view and transnational technology strategy. *The Journal of High Technology Management Research*, 11, 59-74.
- MOORS, E., RIP, A. & WISKERKE, J. S. 2004. The dynamics of innovation: a multilevel co-evolutionary perspective. *Seeds of Transition: essays on novelty production, niches and regimes in agriculture*. Assen: Van Gorcum, 31-56.
- MORIOKA, T., SAITO, O. & YABAR, H. 2006. The pathway to a sustainable industrial society—initiative of the Research Institute for Sustainability Science (RISS) at Osaka University. *Sustainability Science*, 1, 65-82.
- MPE 2012. National Renewable Energy Action Plan under Directive 2009/28/EC. Norwegian Ministry of Petroleum and Energy.
- NEFFKE, F. & HENNING, M. 2012. Skill relatedness and firm diversification. *Strategic Management Journal*, n/a-n/a.
- NVE 2011. Energy Status Norwegian Water and Energy Directorate.
- OED 2013. Facts 2013. Norwegian Petroleum Directorate.
- PENNA, C. C. R. & GEELS, F. W. 2012. Multi-dimensional struggles in the greening of industry: A dialectic issue lifecycle model and case study. *Technological Forecasting and Social Change*, 79, 999-1020.
- PRANGE, C. & VERDIER, S. 2011. Dynamic capabilities, internationalization processes and performance. *Journal of World Business*, 46, 126-133.
- SMITH, A., VOß, J.-P. & GRIN, J. 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, 39, 435-448.
- STRN 2010. A mission statement and research agenda for the Sustainability Transitions Research Network.
- TEECE, D. J., PISANO, G. & SHUEN, A. 1997. Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, 18, 509-533.
- VERBONG, G. P. J. & GEELS, F. W. 2010. Exploring sustainability transitions in the electricity sector with socio-technical pathways. *Technological Forecasting and Social Change*, 77, 1214-1221.

Social Green as a Strategy to Design Sustainable City in Developing Countries A case study of Surabaya

Citra Hennida

Universitas Airlangga, Indonesia

0428

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Designing city with minimum ecological foot print is necessary. However, most cities in developing countries have lack ability to design it. Lack of budget, lack of technology, urbanization, rapid population and economic competitive pressure has created slum and waste (Zarsky & Tay, 2000). Article argues that environment policy should meet five criteria. It should have cheap and easy technology implementation, local government regulations that resemble international environment commitment, budget sustainability, law enforcement and community involvement. Moreover, the initiative should be bottom up; decentralization and community based. Each city has unique problem and solution, so it should be not centralized. Local government has authority to design the program. Community based means that local government should encourage community to design the program. All program and design should be from community since the main problems are on budget sustainability and changing habit. Clapp and Dauvergne (2005) call it social green. In order to support the argument, article takes Surabaya as an example. Surabaya is a pilot project for solid waste management in Indonesia. Solid waste management in Surabaya is initiated by private companies and local communities. The program has not only succeeded reducing municipal waste, but also generates income for households as they turn waste into organic fertilizer. Furthermore, it creates city farming. People start to cultivate veggies and fruits and use their homemade fertilizer.

Keywords: sustainable city, social green, solid waste management, city farming, Surabaya

Introduction

Waste management is a problem in most cities in developing countries, so does in Surabaya. Surabaya is the second largest city in Indonesia. Its inhabitants are over three million and its produces 2,390 ton waste a day (Hartono, 2007). However, in 2007, Surabaya been selected as pilot project on reducing and composting organic waste in Indonesia (Tejo, 2007). Surabaya has succeeded implementing community based waste management. The project is adopted in Medan, Palembang, Jakarta, Bandung, Semarang, Jogjakarta, Jombang, Denpasar, Makasar, Balikpapan and Tarakan (IGES, 2009).

Despite the fact that Surabaya has reduced its organic waste, it does not mean that the government successfully overcome all problems. Every year there is waste related problem such as floods and dengue fever. It means that the management is not comprehensive. The development and implementation of environmental policy, program and practice is partial. Lack of budget, lack of technology, inefficient policy and economic competitive pressure are some problems relate to environment management (Zarsky & Tay, 2000).

Clapp and Dauvergne (2005) explained that there are four views on environment. First view is market liberal. Market liberal believes that economic growth and high per capita incomes are essential for the maintenance of sustainable development. It stresses on scientific achievements, human progress, and human ability to reverse and repair environmental problem. Second view is institutionalism. Institutionalism stresses the need of strong institutions and norms to protect the environment. The principle of sustainable development should be internalized into the decision making process of state bureaucracies, corporations and international organizations. Third view is bio environmentalism. Bio environmentalism emphasizes that mindset changing and law enforcement is good for environment protection. Fourth view is social green. It suggests community based program in order to overcome environmental problems. It also proposes that understanding global context with local perspective.

Using those views, article argues that environment policy should meet five criteria which are technology implementation, international environment commitment in which sustainability internalized through local government regulations, budget sustainability, law enforcement and community involvement. In order to support the argument, I analyse municipal solid waste (domestic waste) management in Surabaya.

Municipal solid waste problems in Surabaya

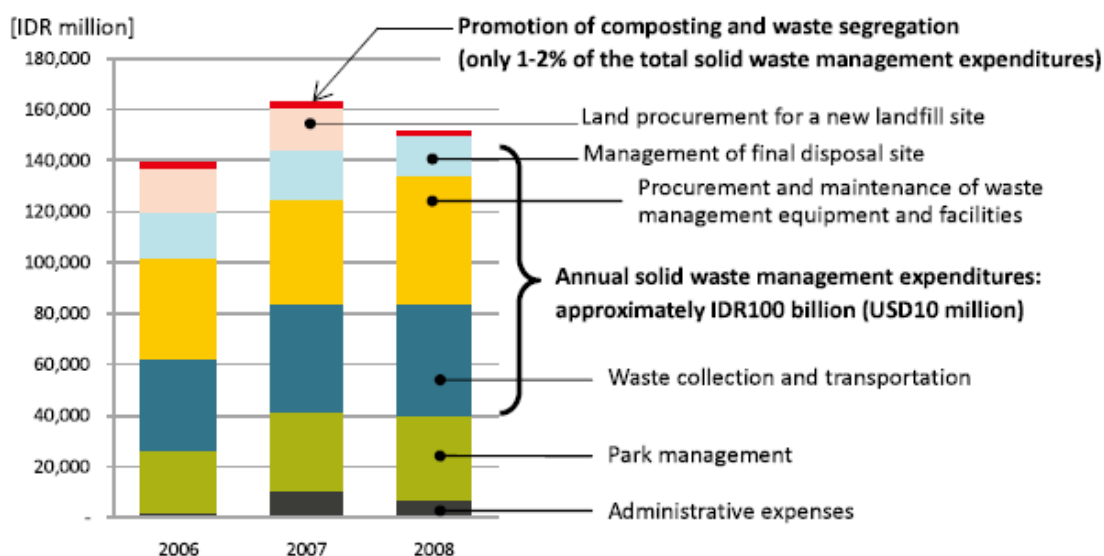
Based on 2005 data, Surabaya produces 2,390 ton waste per day in which 61.92% goes to final disposal site (TPA), 5.02% burns at temporary disposal sites (TPS), 22.26% manages independently and 10.70% disposes everywhere, for instance rivers, streets and backyards (Hartono, 2007).¹ There are six waste management problems in

¹ Surabaya is divided into 31 districts in which 163 sub districts on it. Each sub district consists of several neighbourhood units, which consists of 200 to 300 households. In Surabaya, domestic waste is transported on two stages. First stage is the transportation from producers to TPS. Producers are responsible for the transportation budget. It organizes at neighbourhood unit (RT) where each

Surabaya. Firstly, it has problem with waste production source. It is differentiated into four sources: residential, commercial, institutional and municipal services. Meanwhile, 55% of waste is organic and most of it comes from residential. In order to overcome the problem, municipal government implemented a home based composting system. The system has implemented since 2005. Based on the City Development Planning Department (BAPPEKO) data, organic waste was reduced from 1,500 ton a day in 2005 to 1,150 ton a day in 2008. The program also changes community habit in which 80% of domestic waste had been sorted and composted before it was dumped at TPS (Tejo, 2007).

Secondly, Surabaya has problem with budget allocation. In 2002, budget for the Department of Cleansing and Landscaping was only 6% from the total municipal budget (Silas, 2002). On the other hand, the department has responsible for the whole municipal waste management ensuring that the city is neat, clean and free from any impact incurred by waste (see Figure 1). As the result, there is gap between expense and revenue for daily operational. Moreover, Surabaya needs another TPA as it has one TPA with limited capacity (see Table 1). The government plans to built incinerator at TPA, but it costs a half of total municipal budget (APBD) (Mada, 2010).

Figure 1. Annual expenditure of the Department of Cleansing and Landscaping, Surabaya, 2006-2008²



Thirdly, it has problem with technology. Surabaya is not equipped by enough waste supporting appliances and technology. This condition is not only endangering the environment but also not sustainable. Most people treat waste with end of pipe approach in which waste are dumped, collected and then disposed. They also use open

household contributes some money for garbage collection. It costs about three until five thousand rupiah per month (US\$ 0.50). Collected money is used to pay the salary of garbage collector. Second stage is the transportation from TPS to TPA. At this stage the municipal government is responsible for the budget and for the waste management.

² Maeda(a), p. 8.

garbage bins in their house. In addition, there are many residents' sites and commercial sites that not equipped with different bins. For the transportation, local government is using open dump trucks transporting from TPS to TPA. While transporting from houses to TPS is using open carts. Wastes are exposed to air and pollute the environment. Last is lack of technology at TPA. Surabaya is using semi sanitary landfill in which often not covered with soil. It is not only endangering public health but also creating pollution such as groundwater contamination and methane gas migration which cause fires. Here are details of waste supporting appliances that Surabaya has.

Table 1. Waste supporting appliances

Facilities	Unit	Capacity
Final disposal site	1	16 hectares
Temporary disposal site	159	
Trucks with different type	108	6 m ³ to 14 m ³
Bulldozer, excavator, loader	13	
Mini incinerator	10	
Communal composting centre	14*	
Takakura basket	19.200*	

*data in 2009

Fourthly, it has problem with city planning. Landfill is situated near to residential areas and the capacity is limited. Surabaya had two landfills, which were Keputih, situated in East Surabaya and Benowo, situated in West Surabaya. However, Keputih was closed in 2001 because of residents' resistance. Keputih caused fires, odours and groundwater pollution. Additionally, TPA Benowo is situated near fishponds, and soil deposit is limited. As sanitary landfill system needs soil for covering, soil is brought from outside Benowo which is far. As a result, landfill area is often not covered with soil. As Benowo site is far, the transporting frequency is also limited.

Fifthly, it has problem with political commitment. Mayor changing has its contribution to the waste management policy in Surabaya (Silas, 2002). Municipal solid waste management is less important than other issues among the majority of policy makers. Lack of political commitment impacted on regulations making and enforcement. Environmental legislations at national and municipal level are not sufficient. There is no national policy for waste management, not until 2007. There is a waste management act no 18/2008 that precisely regulate waste management system. The act contains several points. First, there is public participation and involvement. Second, there is exact differentiation on the role description at government level. Third, there is scheme for compensation and sanction. Fourth, there is regulation on cooperation between local governments, and local governments and private sector (Sidik, 2008). The new legislation acquires several consequences to local government to formulate local regulations, provide accurate baseline data, build environmental friendly landfill, set target on waste reduction, expand cleaning area, choose proper waste technology and open public and private participation (Sidik, 2008). However, as decentralization in 2001, local government and municipal government have a limited budget for the implementation. Poor waste appliances and facilities are some result for the poor political commitment.

Sixthly, it has problem with community involvement. Even though participation at residents' site is high, participation at the commercial and public sites is low. Demographic composition of Surabaya residents is also an obstacle. Home based composting system is targeting housewives. As many women are career women, the practice depends to household assistants who are migrants. They are not permanent residents and their movement to other cities or areas is high.

Establishing an effective municipal solid waste management in Surabaya

Establishing an effective municipal solid waste management in Surabaya is not easy. In order to establish an effective municipal solid waste management in Surabaya, policy should meet five criteria which are technology implementation, international environment commitment in which sustainability internalized through local government regulations, law enforcement, budget sustainability and community involvement.

Firstly, as waste is unavoidable, implementing precise technology is needed. Regarding the technology, municipal government focuses on source reduction. Source reduction is important as TPA capacity is limited and municipal government has minimum budget to expand or create a new TPA. Reduction on sources could minimize the budget for establishing a new TPA and budget for the management itself. For instance, municipal government, in 2008, spent US\$ 10 million a year for solid waste management alone (see Figure 2).

After the research on 2002, it was identified that organic waste is the main source (see Figure 1). Households as a source is also the majority³ Therefore, Surabaya is targeting on households and organic waste reduction under the program community based waste management which was initiated in 2004. Technology that supporting the program is *Takakura*, a home based composting technology. *Takakura* basket is part of Surabaya Kitakyushu partnership on waste management. With this program, Surabaya has reduced its waste 18.6% (1,480 tons in 2007) from 2,610 tons in 2001.⁴

However, TPA technology should be developed so does other waste appliances like dump truck. Sanitary landfill is also not sufficient due to pollution. TPA should be sustainable. Singapore practice is an example. Table 3 describes disposal method that can be chosen.

³ Hartono, et.al

⁴ UN Habitat, *Best practices database in improving the living environment*, 2008, viewed 10 may 2013, < <http://www.unhabitat.org/bestpractices/2008/mainview.asp?BPID=1903>>

Table 3. Disposal Methods for Municipal Solid Waste in Selected ASEAN Countries

Country	Disposal Methods (%)				
	Composting	Open dumping	Landfilling	Incineration	Others
Indonesia	15	60	10	2	13
Malaysia	10		30	5	5
Myanmar	5	80	10	-	5
Philippines	10	75	10	-	5
Singapore	-	-	30 *(10 in 2002)	70 *(90 in 2002)	-
Thailand	10 **(0 in 2001)	65 **(67 in 2001)	5 **(32 in 2001)	5 **(1 in 2001)	15 **(0 in 2001)
Vietnam	10	70	-	-	20

Source: ENV 1997

*Communication with National Environment Agency officials

**Draft Annual Report, the State of Pollution, Thailand B. E.2544 (2001), Pollution Control Department 2002

Secondly, waste management policy should be sustainable. It means that it gives environmental, social and economic benefits to city and its inhabitants.⁵ Sustainability is an ambiguous definition.⁶ However, sustainability stresses that it can be achieved through local initiatives with global significance.⁷ Sustainability, however, should be internalized into local regulations. UNEP recommends that national government should develop legislation and policies that promotes environment protection and establish agency or department for the implementation and research. Those should be integrated with international commitment that has been adopted like Agenda 21.⁸ At

⁵ There are three pillars of sustainability: economic, social and environment.

⁶ J. Dryzek, *The politics of the earth: environmental discourses*, Oxford University Press, Oxford, 1997, p. 124.

⁷ P. Newman and J. Kenworthy, 'Sustainability and cities: summary and conclusions', in A.R. Cuthbert (ed), *Designing cities: critical readings in urban design*, Blackwell Publishing, Oxford, 2003 p. 235; Dryzek, p. 129.

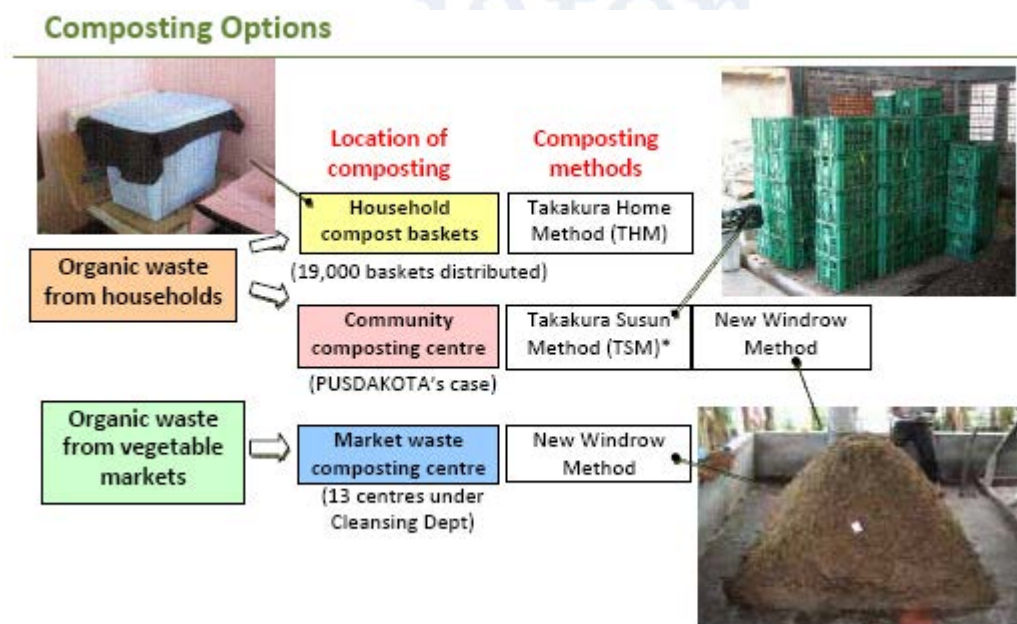
⁸ There are three principles of waste development within the context of sustainability based on Agenda 21. First, accumulation of waste should not disturb material and nutrient cycles. Second, waste disposal should be limited to a level not exceeding the environmental carrying capacity to absorb pollution. Third, recycling and composting system should be developed. Thus, this agenda identified into four programs: waste minimization; maximizing the concept of waste reuse, recycling and composting; extending waste service coverage; and promoting environmentally sound waste

regional level, beside the other two at national level, province government regulate solid waste management practice and encourage research and development of pilot project in their region. At municipal level, municipal government is responsible for the implementation of municipal solid waste management programs and facilities.⁹

In this part, neither local nor municipal government has solid waste legislation. At the national level, there is UU 18/2008 which explicitly stated that solid waste management in Indonesia projected to fulfil sustainability.¹⁰ The new legislation also changes the paradigm from end of pipe practice to 3Rs (reduce, reuse and recycle) practice.¹¹

Surabaya is a step ahead. Nevertheless, implementing 3R is difficult as it relates to changing habit. Surabaya implemented ‘reduce’ practice first before ‘reuse’ and ‘recycle’ practice. Reducing through composting system has been initiated since 2004. As composting is part of Indonesia culture, the implementation is much easier. People used to have *jumblangan*, a hole that dig in their backyard, to put their organic waste. *Jumblangan* was traditional composting method. Due to limited land, especially in big cities, *jumblangan* is no longer used. *Takakura* offer the same result, and as it is a basket, this method is more compact and suitable for land limited house. Composting is applied at households and vegetable markets such as Keputran (see Figure 3).

Figure 3. Type of composting options in Surabaya



disposal and treatment. See

<<http://www.un.org/esa/agenda21/natlinfo/country/indonesia/natur.htm#waste>>

⁹ UNEP, *Integrated waste management scoreboard: a tool to measure performance in municipal solid waste management*, United Nations Environment Programme, 2005, pp. 9-10, viewed 11 May 2013, <http://www.unep.or.jp/letc/Publications/spc/IWM_scoreboard-binder.pdf>

¹⁰ Article 3 and 6.

¹¹ Sidik.

Thirdly, law enforcement is needed in order to establish an effective solid waste management. There are regulations with certain fine for littering; however, there is no one fined for it.

Fourthly, solid waste management needs budget sustainability. It relates to political commitment. However, as waste not strategic issue compare to employment and education, budget allocation is tend to minimum. Moreover, during the crisis, government revenues have been allocated for other programs. For that, municipal government can do several infiltrates. First, municipal government could maximize local sources such as private companies, community and NGOs.¹² Municipal government open a wide access to community and private business. It can use CSR legislation (UU no 40/2007) in order to access private business involvement. Table 4 describes an example of business and community financial involvement. Table 3 shows that Unilever, private business, alone contributes 48% in 2005 for community based waste management program. It means that private businesses are potential asset. Moreover, Surabaya is known as city of *Budipamarinda* which stands for industries, commerce, maritime, education, garrison and tourism. Rungkut, Ngagel, Tanjung Perak and Tandes are industrial sites in Surabaya.¹³ Commerce is vast developed also. There are 24 malls in Surabaya.¹⁴ Each of which is a potential assets. Under the new environment legislation UU 18/2008, local government can make local legislation which rules that. Incentives and compensation such as green tax can be adopted. Moreover, private business and NGOs are potential for designing, monitoring and implementing environment programs and industrial regulations. Municipal government monitor their practice and develop community monitoring capacities.¹⁵ For instance is whether or not industrial and commercial sites obey waste disposal regulations. Second, municipal government could access foreign sources. Municipal government takes benefits from regionalism in Asia. Regionalism means that either capital or technology can be accessed easily.¹⁶ For instance, Japan which prioritizes on environment policy could be resource for waste technology and environment aid. Municipal government could also maximize sister city cooperation for adopting waste management. Moreover, Surabaya's composting practice is adopted in other cities in Indonesia and abroad.¹⁷ Inter city relations should be easier and fruitful.

¹² Zarsky and Tay, p. 139

¹³ H. D. Ferita, 'City report of Surabaya', paper presented at AUICK First 2006 Workshop, p. 2, viewed 15 May 2013, <<http://www.auick.org/database/training/2006-1/CR/WS2006-1CR-Surabaya.pdf>>.

¹⁴ D. A. Setiono, 'Penambahan mall masih mungkin, asal ada zoningisasi', *Berita Jatim*, 6 April 2010, viewed 10 May 2013, <http://www.beritajatim.com/detailnews.php/1/Ekonomi/2010-04-06/60742/Penambahan_Mal_Masih_Mungkin,_Asal_Ada_Zoningisasi>

¹⁵ Zarsky and Tay, pp. 139-140.

¹⁶ G. R. Heaton and B. Resosudarmo, 'Technology and environmental performance: leveraging growth and sustainability' in D.P. Angel and M. T. Rock (eds), *Asia's clean revolution: industry, growth and the environment*, Greenleaf Publishing Limited, Sheffield, 2000, p.54.

¹⁷ It has been adopted in Medan, Palembang, Jakarta, Semarang, Makassar, Balikpapan, Tarakan, Kuala Lumpur (Malaysia), Bangkok (Thailand), Cebu and Iloilo (Philippines). See IGES.

Table 4. Financial profile regarding community based waste management

YEAR	TOTAL BUDGET in USD	Surabaya City Government	Partner 1 (% of total budget) – Unilever	Partner 2 Local NGO	Partner 3 (% of total budget) – Kitakyushu City Government	Partner 4 - Media
2005	12,000 USD	42 %	48 %	Technical and administrative support (they help city government to increase people awareness (campaigns), make compost and also recycle waste.	10 %	In kind (gift for green and clean road shows), publishing information to their news paper (about green and clean and Free from Waste Movement), make banners for elucidations
2006	9,000 USD	66 %	34 %			
2007	43,000 USD	91 %	9 %			
2008	25,000 USD	100%	N/A		N/A	

Note: Other partners namely local NGOs and Media do not give direct financial contribution. As example the Media (Jawa Post, Jaktim TV and Radar) provide in-kind support such as coverage and publication of events in the media and sponsorship of awards.

Fifthly, solid waste management needs community involvement. Community involvement is needed because most of municipal wastes are from domestic waste. Domestic wastes are produced in the community, at the household level. Moreover, like have been stated in this article, main problems are on budget and habitual change. Habitual change is not top down policy, it should be bottom up because the character of the waste itself. Furthermore, Zarsky and Tay (2000) emphasize that community involvement and partnership benefit municipal government in three areas.¹⁸ First, it minimizes government budget as it bases on voluntarism and low paid community labour. Second, it helps the establishment of good governance as civic engagement is important component of good governance. Last, it minimizes public spending.

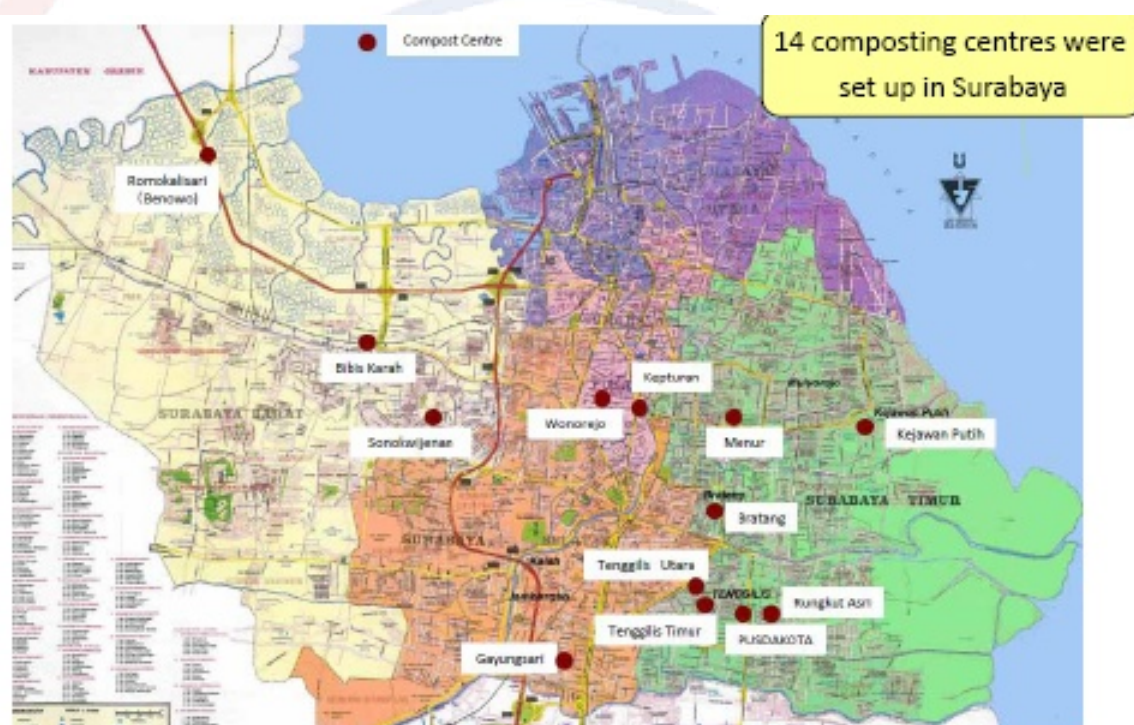
Waste management in Surabaya is based on community development. Surabaya has environmental cadre in every ten houses. Environmental cadre is also member of city women organization (PKK Kota), an organization headed by wife of city mayor. PKK Kota has strong community network. Most of kampong's administrator are PKK

¹⁸ Zarsky and Tray, p. 149.

member. For that reason, campaign of community based waste management is not so hard. Environmental cadre teaches people in their society how to sort and compost their organic waste. Furthermore, society with the support of environmental cadres and local NGO can produce goods from plastic waste like bags and sandals.

There is also TPS which functioned as waste composting study centre. Community waste station is conducted by local NGOs. In this station, people are not only learning how to sort and compost their waste but also learning how to get economic benefit from their waste. In Surabaya, composts from society are used to fertilize their plants or sell to the government. Integrated with this program, Surabaya government through Cleansing and Landscaping Department develop eleven city parks which composts come from community and vegetable markets. Composting centre, moreover, can be an answer for the need of another TPA.

Figure 4. Composting centres in Surabaya



The next question is how to engage people on this community model? Engaging and tighten commitment are not easy. People are easily to forget and ignore due to their routine. For that reason, there are five strategies that can be adopted. Surabaya people are dominated by middle class who spend their time mostly at the office. Most of households have domestic assistant or servant. They have lack education and come from surrounding regions near Surabaya. Understanding the character, applying cheap and easy technology is needed. Surabaya has started using *Takakura* in 2003, and now it has adopted nationally. In 2012, the ministry of environment distributed composting basket nationally. In some regions, the availability of composting basket does not linear with changing habit. The local government has difficulties to distribute it because community did not want it. Therefore, it needs another strategy. It should give economic benefit. The next question is after they sorting and composting their waste, so what next to do? Is there any economic benefit? The government should think about it. The next strategy is local government should encourage people to take

part for design and implementation of the policy. But first, the policy should be popular. For that reason, media coverage and fun competition are needed.

How about Surabaya? Surabaya implemented those strategies. Since 2003, the local government committed to environment. Composting basket has been introduced from 2003, long before the ministry of environment introduces the same policy. The environment project is also supported by the media. There is annual environment competition, called “Surabaya Green and Clean”. This program starts in 2005 and followed by 325 neighbourhood unit (RT/Kampung). In 2008, the program was followed by 1,797 RT.¹⁹ Surabaya has also program called “Free from Waste”. Different from “Green and Clean” which conducted on May (May is Surabaya Anniversary), “Free from Waste” is conducted on August, as part of celebrating independence. Both of them become annual program are widely covered in newspapers, radios and television. It changes kampongs in Surabaya more green and clean. Kampong which won the competition not only looks green but also has vision to sustain their environment. For instance, in kampong *Jambangan*, people plant medicine herbs and pollution absorber plant. For the fertilizer, they use their home making compost from *Takakura*. *Jambangan* is highly appreciated and won the competition in three years. *Jambangan* is also a pilot project for composting system and waste craft production. Moreover, Surabaya received some international acknowledgement such as Energy Globe Award in Austria 2005, Green Apple and Green Organization in London 2007 and UNESCAP Award 2007 for Urban Environment Improvement.²⁰

Environment competition is cheap. “Green and Clean” expenses US\$150,000-200,000 annually, compare to US\$10m for other ordinary solid waste management task. In addition, community has their own budget to run their composting system from selling fertilizer, recycling waste, and creating handicraft. In other word, social green strategy overcome problem with lack of budget. Social green strategy is also changing habit into the “greener” one. More and more neighborhood join environment competition. As the result, the growth of population and the growth of waste isn’t linear. Based on data from Surabaya government, waste production in 2005 is 1,819 m³ with total population of 2.74 million. Meanwhile, in 2011, waste production is only 1,150 m³ whereas the number of population increases to 3.02 million. See Table 5 for details.

Table 5. The growth of population and waste in Surabaya 2005-2011

	2005	2006	2007	2008	2009	2010	2011
Waste production (m ³)	1,819	1,641	1,480	1,259	1,229	1,242	1,150
Population (million)	2.74	2.78	2.82	2.90	2.93	2.92	3.02

¹⁹ Maeda(a), p.4.

²⁰ UN Habitat

Conclusion

Solid waste management in Surabaya is based on community involvement. This practice is widely adopted throughout Indonesia. Solid waste management in Surabaya focuses on source reduction at household level. The implementation of low cost technology, community involvement and municipal government support are three dominant factors that make it success.

Those are not enough; in order to make an effective solid waste management, environment policy should meet five criteria which are technology implementation, international environment commitment in which sustainability internalized through local government regulations, budget sustainability, law enforcement and community involvement. Surabaya has lack of technology especially at TPA and waste management facilities. Moreover, limited budget, lack of regulations and law enforcement are other obstacles. Furthermore, neither facilities nor standard mechanism regarding other sources such as commercial and public sites is available. Last, high dependency on community at one side is good that people are responsible on their waste, but it needs regulations in order to sustain their commitment.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is partially overlaid by a large, faint watermark of a circular graphic composed of several curved, overlapping lines in shades of blue and red.

References:

Clapp, J. and Dauvergne, P., *Paths to a green world: the political economy of the global environment*, The MIT Press, Cambridge, 2005.

Dryzek, J., *The politics of the earth: environmental discourses*, Oxford University Press, Oxford, 1997.

Ferita, H. D., 'City report of Surabaya', paper presented at AUICK First 2006 Workshop, p. 2, viewed 15 May 2013, <<http://www.auick.org/database/training/2006-1/CR/WS2006-1CR-Surabaya.pdf>>.

Hartono, B. D. et al., *Community based development towards a sustainable city*, presented at 4th Kitakyushu Initiative Network Meeting, 25 June, 2007, viewed 29 April 2013, <http://kitakyushu.iges.or.jp/docs/network_meetings/kin4/ppt/23.Hartono.pdf>

Heaton, G. R. and Resosudarmo, B., 'Technology and environmental performance: leveraging growth and sustainability' in D.P. Angel and M. T. Rock (eds), *Asia's clean revolution: industry, growth and the environment*, Greenleaf Publishing Limited, Sheffield, 2000

IGES, *Workshop-training on composting: social and economic benefits*, 2009, viewed, 9 May 2013, <<http://www.smc.gov.my/thm02.pdf>>

Mada, K. R., 'Surabaya belum terlambat mencegah sampah', *Kompas*, 3 May 2010, viewed 10 May 2013, < <http://cetak.kompas.com/read/xml/2010/05/03/16422015/surabaya.belum.terlambat.mencegah.sampah>>

Maeda (a), T., 'Reducing waste through the promotion of composting and active involvement of various stakeholders: replicating Surabaya's solid waste management model', *IGES/Kitakyushu Initiative Policy Brief*, viewed 9 May 2013, <http://www.un.org/esa/dsd/susdevtopics/sdt_pdfs/meetings2010/icm0310/1e_Toshizo_Maeda.pdf>

Maeda (b), T., 'Enhancing public awareness and stakeholder's empowerment and involvement in waste management-through a case in Surabaya, Indonesia', presented at International Consultative Meeting on Expanding waste Management Services in Developing Countries, Kitakyushu, 18 March 2010, viewed 9 May 2013, <http://www.un.org/esa/dsd/susdevtopics/sdt_pdfs/meetings2010/icm0310/1e_Toshizo_Maeda.pdf>

Newman, P. and Kenworthy, J., 'Sustainability and cities: summary and conclusions', in A.R. Cuthbert (ed), *Designing cities: critical readings in urban design*, Blackwell Publishing, Oxford, 2003

Setiono, D. A., 'Penambahan mall masih mungkin, asal ada zoningisasi', *Berita Jatim*, 6 April 2010, viewed 10 May 2013,

<http://www.beritajatim.com/detailnews.php/1/Ekonomi/2010-0406/60742/Penambahan_Mal_Masih_Mungkin,_Asal_Ada_Zoningisasi>

Sidik, U. S., *Indonesia solid waste policy and management: based on law no. 18 year 2008 regarding waste management*. viewed 29 April 2013,

<http://kitakyushu.iges.or.jp/activities/workshops_seminars/Surabaya/Session%20/MOE.pdf>

Silas, J., *Waste management problems in Surabaya: an integrated sustainable approach*, paper presented at Solid Waste Management Seminar in Kitakyushu, 20 September 2002, viewed 29 April 2013, <<http://kitakyushu.iges.or.jp/docs/sp/swm/3%20Waste%20management%20problems%20in%20Surabaya.pdf>>

Solid Waste Management Seminar, 19 – 20 September 2002, viewed 29 April 2013, <[http://kitakyushu.iges.or.jp/docs/sp/swm/3%20Surabaya%20\(Paper\).pdf](http://kitakyushu.iges.or.jp/docs/sp/swm/3%20Surabaya%20(Paper).pdf)>

Tejo, A., *Surabaya jadi pilot project pengelolaan sampah*, 23 November 2007, viewed 29 April 2013,

<<http://news.okezone.com/index.php/ReadStory/2007/11/23/1/63218>>

UNEP, *Integrated waste management scoreboard: a tool to measure performance in municipal solid waste management*, United Nations Environment Programme, 2005, viewed 11 May 2013,

<http://www.unep.or.jp/Ietc/Publications/spc/IWM_scoreboard-binder.pdf>

UN Habitat, *Best practices database in improving the living environment*, 2008, viewed 10 May 2013,

<<http://www.unhabitat.org/bestpractices/2008/mainview.asp?BPID=1903>>

Zarsky, L. and Tay, S., 'Civil society and the future of environmental governance in Asia' in D.P. Angel and M. T. Rock (eds), *Asia's clean revolution: industry, growth and the environment*, Greenleaf Publishing Limited, Sheffield, 2000.

Deteremination of Energy consumption in Pest Control Using pesticides in New Zealand

Majeed safa

Lincoln University, New Zealand

0611

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

This study examines the energy consumption of pesticide applications in New Zealand. Energy use in pest control using pesticides is investigated in the horticultural, arable, pastoral and forestry sectors, based on 30 different groups of farm products.

On average, total energy consumption in pesticide applications in New Zealand was estimated at about 2,350,757 GJ. Energy use in pesticide applications was about 160 MJ/ha. The pastoral and horticultural sectors are ranked first and second in terms of total energy usage for pesticide applications, at about 1,109,389 GJ and 704,511 GJ, respectively. The horticultural sector has the most intensive pesticide consumption at around 5,855 MJ/ha.

The total operational energy was about 20% of total energy use in pest control of which 90% was for fuel. Herbicides are applied more than other pesticides in most agricultural sectors; therefore, energy equivalent of herbicides is ranked first with 1,353,503 GJ and 58% of total energy use. Fungicides and insecticides are mostly used in the horticultural sector.

Keywords: Energy inputs, Farm Operation, Pest Control, New Zealand

Introduction

New Zealand's economy is heavily dependent on exports from agricultural production, accounting for nearly 51% of New Zealand's exports by value (Statistics New Zealand, 2008). Farms cover about 50% of New Zealand's land area (Ministry of the Environment, 2006). In general, New Zealand farmers practice a form of 'industrialized' agriculture that relies on relatively high inputs of fossil fuels, not only to power machinery and irrigation directly but also embedded in artificial fertilizers and agrichemicals from their manufacture (Wells, C., 2001, Safa, M. and Samarasinghe, S., 2011). Consequently, New Zealand is one of the countries with the highest energy input per unit weight of agricultural output in the world (Conforti, P. and Giampietro, M., 1997). In New Zealand, the agricultural sector produces about 4.6% of total GDP, while its proportion of greenhouse gas (GHG) emissions is, surprisingly, over 54% of total national emissions (Kelly, G., 2007, Energy & Environment, 2009).

New Zealand's climate is not extremely cold or hot; therefore, high energy modifications are not widely used in agriculture, such as animal housing or heating. Moreover, 99% of cows and sheep graze directly on pasture and farmers don't need to spend energy on harvesting this land. Pigs and poultry are often intensively housed, but these are relatively small sectors of New Zealand's livestock industries. Other high intensive energy use farming activities, such as greenhouses production, are not very significant.

The relative proportion of different types of production in New Zealand varies with technical and financial factors. Following increases in the prices of dairy products in 2007 and 2008, many farms were converted from arable to dairy production and some existing dairy farmers increased their stocking rates. However, the high exchange rate for the New Zealand dollar and increasing oil prices are also likely to affect farming patterns. In addition, investigation into the effects of economic changes on farm production in the short term is difficult and farmers' reactions to price changes are always slower than those in other sectors. They cannot easily change capital equipment, establish orchard trees, or change crops after sowing, and they cannot convert their farms from dairy to arable use quickly. According to Statistics New Zealand (2007), 12,279,599 ha (82%) of farm land is in pastoral farms used for livestock and dairy production. Forestry ranks second with 13% of land, and horticulture and arable farms have similar proportions at 2% of total land.

Pests destroy an estimated 37% (insects 13%, plant pathogens 12%, and weeds 12%) of all potential agricultural production every year. When the post-harvest losses are added to the pre-harvest losses, total agricultural production losses due to pests increase to 52% (Pimentel, D. and Pimentel, M., 2008). Three different methods of pest control - chemical, mechanical and biological - are usually applied to control or eliminate fungi, insects and weeds on modern farms. On small farms, organic farms, and in areas with cheap labor sources, farmers use more mechanical methods. Other pest controls methods used for specific crops or conditions include insect collectors, thermal weeding and soil disinfectors. However, most farmers choose chemical methods because they are perceived to be faster, cheaper and more effective than non-chemical methods.

The average worldwide growth in the use of agrichemicals is around 4.4% per year (Vlek, P.L.G. et al., 2004). The first recorded chemical use on farms was by the Sumerians who used sulfur compounds as insecticides, around 4500 years ago. However, chemical pest control did not become widespread until the 18th and 19th centuries. In modern farming systems most farmers choose chemical methods because they believe them to be faster, cheaper, and more effective than other pest control methods. Global pesticides use is about 3 billion kg, costing nearly 40 billion US\$ per year (Pimentel, D. and Pimentel, M., 2008). Significant challenges to plant protection by chemical pest control methods include pesticide resistance, pest resurgence, new pests and diseases, cost, and environmental and health issues.

In agriculture, a wide range of pesticides are used for a variety of purposes. Pesticides should control weeds, insects and fungi without causing serious harm to the crops (Smil, V., 2008). Their responsibilities are prevention, avoidance, monitoring, and suppression of weeds, insects, diseases and other pests. Pesticide use generally reduces crop losses. However pesticide use creates a number of adverse effects, including human and animal poisoning, cancer and other chronic health effects, reduced biological diversity, and soil and water contamination. These adverse effects should be a balanced against the benefits from pesticides. Some studies show that through appropriate management, it is possible to reduce pesticide use without reducing crop yields (Pimentel, D. and Pimentel, M., 2008).

Nevertheless, the use of pesticides is increasing rapidly in some countries. Pesticides have become a major environmental hazard, the main source of pollution in agriculture (Lal, R., 2004), and a major hazard to health in some countries.

Because of public and scientific concern about the environmental effects of agrichemical use, new components have been introduced into spray programs to reduce pesticide losses from runoff and leaching and reduce pesticide residues in crops. Research is being carried out to introduce new natural methods and to improve traditional methods. Several studies have been undertaken to improve the genetic resistance of crops to pests, encourage pests' biological enemies, employ crop rotation, combinations with conservation tillage and the use of natural forages and trees (CIGR, 1999, Lal, R., 2004, Pimentel, D. and Pimentel, M., 2008). Some government programs in Canada, Sweden, Denmark and Indonesia have reduced pesticide use in some crops by 50% to 65% with minimum impact on yields and quality (Pimentel, D. et al., 2005). There is now also high-level support for the replacement of pesticides with what is increasingly known as agroecological methods that use pesticides only as a last resort when other approaches are not sufficient. For example, the International Code of Conduct on the Distribution and Use of Pesticides (the Code), a global guidance document on pesticide management for all public and private entities associated with the distribution and use of pesticides was adopted by the FAO in 1985, has a guidance document on Pest and Pesticide Management Policy Development (2010) that promotes the adoption of integrated pest management (IPM). Its definition of IPM involves an ecosystem approach to pest management and states that "Pesticides are only used in those cases where there are no effective or economically viable alternatives" (FAO, 2010).

1. Pesticide Consumption in New Zealand

Comparing pesticide consumption in different years is not easy. Because of the wide range of companies and products, and the broad classifications of the later, together with the lack of government collection of usage figures, and the difficulty in obtaining data from the companies, comprehensive and reliable data on the use of agrichemicals in New Zealand was difficult to obtain. Also, every year new, more concentrated products are introduced that can reduce later sales volume without reducing pesticidal activity (Ministry of the Environment, 2006). The value of pesticide products, moreover, depends on several financial factors that make the analyses more difficult. Non-agricultural use is one of the major limitations in estimating usage figures. There are few records available of this kind of use in New Zealand, but it can be substantial. For example, some estimations show the annual use of glyphosate to manage roadside weeds in the Auckland region alone to be about 25,000 liters of formulated product (pers. Comm. Burton, Biothermal, 2012)¹. There is no information available on home use, but this can also be substantial, especially the use of herbicides.

Agcarm (the agrichemical industry's organization in New Zealand) provides a report from members only, which is estimated to cover about 80% of agrichemical sales (Manktelow, D. et al., 2005). Over the last ten years (2000-2010), according to FAOSTAT, the value of imported agrichemicals in New Zealand has increased by approximately 62%. Between 2000 and 2006 the value of imported herbicides, fungicides and insecticides increased 61%, 50%, and 42%, respectively (Manktelow, D. et al., 2005). Unfortunately, data for these individual categories were not available after 2006. Most herbicides are used in the pastoral and forestry sectors, and the horticulture sector accounts for the largest volume of fungicides and insecticides.

Total pesticide consumption for each farming sector depends on the total land area cropped and the sum of diseases, pests and weeds for a particular farm production system. There is no recent reliable data on the total pesticide consumption in New Zealand. It is estimated that the value of agrichemical sales in New Zealand is around \$200 million NZ\$ (too difficult to verify) (Ministry of the Environment, 2006). Compared with world standards, the pesticides market in New Zealand is very small, which reduces opportunities for establishing new products because of the high cost of development and registration relative to sales.

Over the last few years new and more effective pesticides have been introduced and the pesticide products being used have been changed considerably. For example, the quantity of biological materials sold has increased and there has been a decrease in the quantities of miticides sold (Manktelow, D. et al., 2005). The fluctuating trends of herbicide, fungicide and insecticide use during the last few years would be mostly because of major changes in the pesticide types used. Because of new pesticides and fluctuating prices of most pesticides (mostly downwards), neither the value nor the quantity are good indicators of pesticide consumption.

The wet maritime climate of New Zealand creates suitable conditions for disease development, which affects fungicide use in New Zealand. As shown in Table 1, based on pesticides loading (Manktelow, D. et al., 2005) and area of agriculture

¹ Biothermal is a roadside weed maintenance contractor in Auckland.

sectors (Statistics New Zealand, 2007), horticulture is the most intensive pesticide using sector, using 49% of total pesticides on about, 1.7% of land, and this must be taken into consideration.

Table 1 Areas and pesticide used in sector group (Manktelow, D. et al., 2005, Statistics New Zealand, 2007)

Sector group	Total New Zealand Area (ha) (2007)	Areas as % of Total	Total Tonnes (a.i./yr)	Mean Pesticide Loading (kg a.i./ha/yr) (2005)	Percentage of Total Use
Horticulture	246,748	1.7%	3,254,606	13.19	49%
Arable	318,416	2.2%	773,751	2.43	12%
Pastoral Farming	12,279,599	84%	2,087,532	0.17	32%
Forestry	1,849,897	13%	499,472	0.27	8%

Manktelow et al (2005) estimated the proportion of herbicide, insecticide and fungicide use in each agricultural sector. Table 2 shows herbicides are applied mostly on pastoral farms and the horticulture sector ranked the highest for insecticide and fungicide consumption at 88.6% and 61.9 %, respectively.

Table.2 The percentage of pesticide use by agricultural sector (Manktelow, D. et al., 2005)

Sector group	Herbicides (%)	Insecticides (%)	Fungicides (%)
Horticulture	13.2	88.6	61.9
Arable	12.3	3.5	3.7
Pastoral Farming	55.5	6.3	34.4
Forestry	19	1.8	0

2. Spraying Systems and Technologies

There are several techniques and technologies for applying pesticides on farms, including aerial spraying, air-blast spraying, boom spraying, in-furrow spraying, soil injection, dust and granular application. It appears the technology of farm spraying has not significantly changed during the last few decades. However, the new large commercial sprayers use GPS guidance to prevent overlap, misses and reduce drift (Kubik, R., 2005, Kondo, N. et al., 2011).

Spraying liquid is more common than dust and granular applications. Sprayed chemicals are mixed with water and broken down into droplets by forcing the liquid under pressure through an orifice, injecting the liquid into a fast moving air stream, or spraying the liquid off the surface of a rapidly rotating disc (Hawker, M.F.J. and Keenlyside, J.F., 1985, Culpin, C., 1986). Tank, pump, filter, spraybar (boom), nozzles and mixing devices are the most important parts of liquid sprayers. Selecting appropriate spraying size, selecting right tractor speed, spraying pressure, nozzle size, and spraying boom height can increase the efficiency of pesticide use (Bell, B.J. and Cousins, S., 1991, CIGR, 1999, Hunt, D., 2001, Bell, B.J., 2005, Kubik, R., 2005). Furthermore, the shape and size of paddocks, barriers in borders, environmental

condition, availability of clean water and fuel, and driving skill can influence field efficiency by sprayers.

Spraying techniques and technologies can be categorized based on pesticides properties, injection system, amount of liquid applied per hectare, power sources, targeted pests and targeted species. In this study, to analyze energy use in pesticide application, the applications are categorized into ground and aerial spraying.

3. Main Energy Inputs in Spraying

Studies by McChesney et al. (1982), Nguyen and Hignett (1995), Wells (2001), Barber (2004), Barber and Glenys (2005) and Saunders et al. (2006) have estimated energy consumption in different farming systems and farm productions. Most of these studies are interesting and provide useful information; however, agriculture is a complex system and it is not easy to estimate the average energy use for the whole country from a limited number of farms. Many energy studies in New Zealand use a small number of farms or do not mention the sample size. Also, some of them do not indicate the location of the farms on which they estimated energy use. Moreover, most studies only estimated energy consumption in a particular agricultural system while some compared energy use of different methods and in different countries.

Due to different farming systems, spraying techniques and agricultural products, it is very difficult to have definite energy consumption figures for pesticide applications. Main energy inputs in pesticide applications include fuel, labor, machinery and pesticides. Farmers use knapsacks (which do not consume significant amounts of fuel and machinery energy) in many greenhouses and small nurseries, but the labor costs per hectare for knapsacks are much higher than for boom sprayers. Many factors, such as environmental and soil conditions, driving skill, shape and size of paddocks also affect energy use in pesticide applications.

In terms of energy, using pesticides is much more energy intensive than mechanical pest control methods. For example, in organic farms, energy used for weed control using cultivators takes half the energy used for herbicide weed control (Pimentel, D., 2009). The energy component in agrichemicals comes mainly from its manufacture, packaging and transport (Stout, B.A., 1990, CIGR, 1999). Fuel consumption and machinery use depend on the number of applications, farm production and farming system. The number of applications would be increased in high pest or disease pressure situations. Due to large potential variations in the number of applications, finding actual use patterns is extremely difficult. For example, in the pastoral and forestry sectors, only some farms are usually sprayed and it varies with area and farming system.

3.1 Fuel

Fuel consumption in specific operations depends on soil conditions, crop type, ground speed and rolling resistance (Smil, V., 1991). Also, fuel consumption in spraying depends on the tractor, sprayer, shape and size of farm, and driver skill. The energy component in fuel comes mainly from the heat of combustion; furthermore, the energy required to drill, transport and refine the petroleum should be added to this figure (Stout, B.A., 1990).

There are several methods to estimate the fuel consumption of tractors based on the power of the tractors; nevertheless, due to the effect of parameters such as altitude above sea level, soil conditions (soil type, moisture, density and residue cover), barometric pressure, humidity and temperature on tractor power and fuel consumption, most of these methods work only in specific areas (McLaughlin, N.B. et al., 2002, Serrano, J.M. et al., 2007, Bertocco, M. et al., 2008, Safa, M. et al., 2010). Furthermore, these methods can only predict fuel usage of diesel engines under full loads, but under partial loads and conditions when engine speeds are decreased from full throttle these methods do not work (Siemens, J. and Bowers, W., 1999, Safa, M. et al., 2010).

For an accurate estimation, fuel consumption is measured before and after any farm operation by filling the fuel tank of the equipment (tractor, combine, or pump) and recording the difference in volume. After sampling several different farms and conditions, a formula was arrived at using mathematical modelling methods (Safa, M. and Tabatabaefar, A., 2002). The energy input is determined from fuel consumption per operation for one hectare times the fuel equivalent energy per litre, as shown in Equation 4-1.

$$\text{Energy (input)/hectare} = \text{Operation fuel consumption (L/ha)} \times \text{Fuel energy (MJ/L)} \quad (4-1)$$

The formula for fuel consumption depends significantly on field efficiency of farm machinery. The efficiency of tractors and self-propelled sprayers is analyzed with respect to engine, power transmission and wheel soil system (Pellizzi, G. et al., 1988, Serrano, J.M. et al., 2007, Safa, M. et al., 2010). Matching of tractor and implement, using hydraulic 3-point linkage equipment, using Power-Take-Off (PTO) equipment, selecting the right travel pattern, having large paddocks, regular servicing, adjusting tyre inflation pressure, matching engine speed and gear selection, improving traction efficiency, using turbochargers and improving farmers' awareness, are all methods that could reduce fuel usage and improve field efficiency (Barber, A., 2004, Grisso, R.D. et al., 2004, Safa, M. et al., 2010) and can reduce fuel consumption around 10% in crop production (Pimentel, D., 2009).

Diesel is the main fuel for tractors and other agricultural machinery because diesel engines are stronger, and have a higher efficiency and longer life than gasoline-powered engines (Safa, M. et al., 2010). McChesney (1981) estimated diesel consumption for spraying at approximately 3 l/ha in New Zealand. However, because of developing technology and the use of more efficient machines and methods, the current rate is much lower than his estimation. There are large differences between different estimations of diesel consumption in ground spraying: Witney (1988): 1 L/ha, Dalgaard (2001): 1.2 L/ha, CIGR (1999) 1.5 L/ha to 3 L/ha, and Wells (2001): 3 L/ha.

Estimations of fuel consumption for aerial spraying range from 0.035 L/ha in New Zealand (Barber, A., 2004) to 1.85 L/ha in southern Queensland, Australia (Ghareei Khabbaz, B., 2010). Comparing catalogs of helicopters and aircraft and data collection from contractors shows that fuel consumption for most aircraft and helicopters ranges from 58 L/h to 200 L/h, which means that due to high field capacity, fuel consumption per hectare is much lower and per hour is much higher than ground applications.

According to Saunders et al. (2006), an extra 23% of energy consumption beyond the energy contents of diesel fuel and gasoline consumed accounts for processing, refining, and transport of crude oil and final products to, and within, New Zealand. Thus the total energy consumption for diesel and gasoline were taken to be 43.6 MJ/ha and 39.9 MJ/ha, respectively.

3.2 Tractors and Field Machines

Most commercial energy in agriculture is used in agricultural machinery manufacture and operation (Stout, B.A., 1990). This energy can be categorized into energy required for manufacturing, maintenance and repair (Fluck, R.C. and Baird, C.D., 1980). Estimating the energy consumption of field machinery is much more complicated than determining energy consumption of other farm inputs (Smil, V., 2008) because of the wide range of different tractors and sprayers and also different companies use different processes for producing machinery.

To compare energy use for producing and repairing tractors and equipment, energy use per kg has usually been used. Due to different technologies and different components, weight is not a good estimation index to compare energy consumption in producing machinery. There are large differences between different estimations: 75 MJ/kg (Roller, W.L. et al., 1975), 90 MJ/kg (McChesney, I.G. et al., 1978), 80.23 MJ/kg (Hornacek, M., 1979), 27 MJ/kg (Fluck, R.C. and Baird, C.D., 1980), 85 MJ/kg (Stout, B.A., 1990), 129 MJ/kg for sprayers and 138 MJ/ha for tractors (CIGR, 1999), 132 MJ/kg for sprayers and 144 MJ/ha for tractors (Lague, C. and Khelifi, M., 2001), and 80 MJ/kg for sprayers and 160 MJ/kg for tractors (Wells, C., 2001). Comparing the above rates, it appears that improving technology does not change the energy consumption for producing agricultural machinery. CIGR (1999) considered several steps in calculating these energy coefficients: first, the energy required for producing the raw materials; second, the energy used in the manufacturing process; third, the energy consumption for transporting the machine to the consumer; and fourth, the energy used in repairs and maintenance.

To calculate the energy input of tractors and other field equipment, it was necessary to know the weight, working life span, and the average surface area on which they were used annually (Safa, M. et al., 2011). The estimated life can be taken from the ASAE Standard D497.6 (2009) and the estimated weight of different machines and equipment can be taken from companies' catalogues.

To calculate the energy used in producing and repairing agricultural machinery, the following formula was used:

$$ME = (G \times E) / (T \times Ca) \quad (4-2)$$

where ME is machine energy (MJ/ha); G is the weight of the implement (kg); E is the energy sequestered in agricultural machinery (MJ/kg); T is the economic life of the machine (h) and; Ca was effective field capacity (ha/h).

For calculation of Ca, the following equation was used:

$$Ca = (s \times w) \times FE / 10 \quad (4-3)$$

where s is ground speed (km/h); w is the width of the machine (m) and; FE is field efficiency (%), which was taken from the ASAE Standard D497.6 (2009).

3.3 Labor

Before the invention of the tractor, hand and draught domestic animals were the only choices for power generation needed for agricultural operations. Even now, human power is the main source (73%) of energy in agricultural operations in many developing countries (Stout, B.A., 1990). In the future, human labor on fully mechanized (mechatronic) farms could be reduced to almost nil. Nevertheless, some scientists believe that organic agriculture, one of the important choices for future farming, needs more manual work for harvesting and weeding (WCED, 1987, Pimentel, D. et al., 2005, Wallgren, C. and Höjer, M., 2009) and, in some crops, this could be up to 35% (WCED, 1987, Pimentel, D. et al., 2005, Wallgren, C. and Höjer, M., 2009).

Human energy is used less than other energy inputs in modern agriculture (sometimes less than 1% of all energy inputs) so it has not been calculated in many recent agricultural energy studies. The energy output for a male worker is 1.96 MJ/hr and 0.98 MJ/hr for a female worker (Singh, S. and Mittal, J., 1992, Mani, I. et al., 2007). Most physical activities in pesticide application involved driving, adjusting, and servicing tractors and sprayers, which consumed significantly less energy than physical weed control. However, estimating human energy use in operations such as tractor servicing is difficult as this also contributes to other farm products. Farmers clearly expended different amounts of energy per hour for each operation and several factors, such as gender, weight and age can influence their energy use.

3.4 Pesticides

Pesticides are the most energy intensive of all farm inputs (Stout, B.A., 1990). Most ingredients used in pesticide production come from petrochemical products such as ethylene, methane and propylene (Safa, M. et al., 2011). Energy used in formulation, packaging and transport, as well as manufacturing active ingredients, inert ingredients and adjuvants should be considered as a part of pesticide energy equivalents.

Studies such as Helsel (1992) and CIGR (1999) estimated energy use of some pesticides, but these studies did not cover all products, especially new ones. Pesticide products vary between brands and, because of patent and commercial issues, it is impossible to access the details of active ingredients, inert ingredients, and manufacturing processes. Exact documented energy consumption in manufacturing is not available and would be very difficult to estimate, especially for newer pesticides which are introduced continuously and labelled for use at very low rates. In this study, the energy coefficients for herbicides, insecticides and fungicides were taken from Saunders et al.'s (2006) report and these were 310, 315, and 210 MJ/kg, respectively.

4. Results

Herbicides are the main pesticide energy use with 1,353,502 GJ. As shown in Table 3 and Figure 1, the intensive use of pesticides in the horticultural sector affects energy

consumption as well. However, pastoral farming, because of the size and high herbicide use, has the highest proportion of total pesticide use.

The high energy intensity in the horticulture sector was expected; it is four times more than the arable sector and around 35 times more than pastoral farming per hectare. The average energy use per hectare of all pesticides was estimated at around 128 MJ/ha, which is around five times more than operational energy.

The total energy use for pesticide applications in New Zealand was estimated at around 2,350,757 GJ. As expected, pastoral farming has the highest proportion of total energy use for pesticide applications, with 1,109,389 GJ, due to the large area; and the horticultural sector ranked second due to intensive pesticide applications, with 704,511 GJ (Table 3). As Table 3 shows, horticultural and arable farming have the most intensive energy use per hectare with 2,855 and 792 MJ/ha, respectively. Average total energy use per hectare was estimated to be 160 MJ/ha. Table 3 shows that operational energy in arable and pastoral farming is higher than other sectors, at 27% and 25%, respectively. The percentage of operational energy to total energy in orchard and vegetable production is higher than for other groups but is very low in nurseries and greenhouses, which are estimated to be around 16% of the horticultural sector. The percentage of operational energy, mostly from aerial applications, of total energy use in forestry sector was estimated at only 2.5%.

As shown in Table 3, energy use in each farming sector depends on pesticide use, the area of that sector, type of pesticide application and spraying frequency. For example, fungicides and most herbicides are applied by aerial application in only some forests; therefore, the proportion of insecticide and operational applications per hectare are lower than in other sectors. Another example is the high usage of fungicides in vegetable farms, nurseries and orchards in humid areas of the North Island.

Table. 3 Total energy use (GJ) and energy use per hectare of pesticides and operational energy inputs in New Zealand

	Herbicides	Insecticides	Fungicides	Operational Energy	Total Energy (%)	Energy use per hectare (MJ/ha)
Horticulture	178662	128990	282138	114721	704511 (30%)	2855
Arable	166481	7710	11183	66946	252320 (11%)	792
Pastoral	751194	71684	5751	280759	1109389(47%)	90
Forestry	257166	0	20130	7241	284537(12%)	154
Total (%)	1353503(58%)	208384(9%)	319202(14%)	469667(20%)	2350757	160

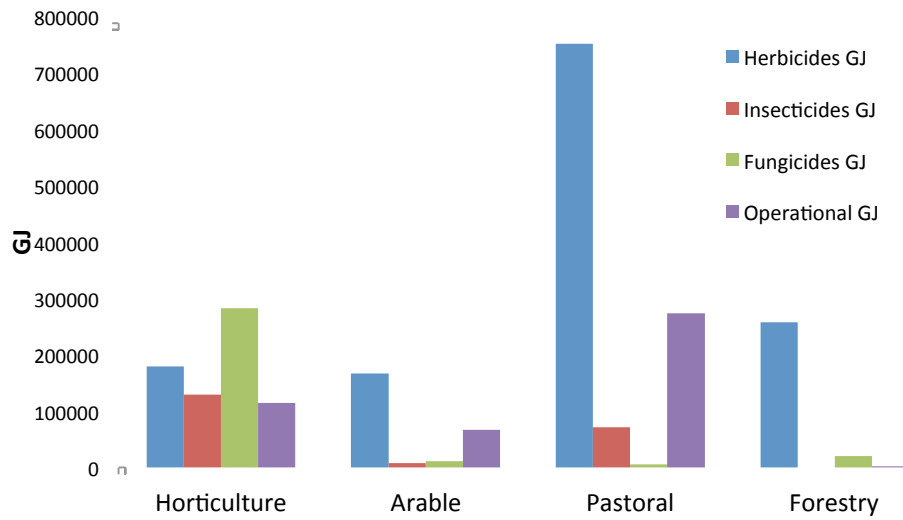


Figure. 1 Energy use (GJ) of farm inputs in agriculture sectors in New Zealand

iafor

References

- ASAE (2009). ASAE D497.6, June 2009, Agricultural Machinery Management Data. In (ed.), Vol. pp. St. Joseph, Mich.: American Society of Agricultural and Biological Engineers (ASAE),
- Barber, A. (2004). Seven Case Study Farms: Total Energy & Carbon Indicators for New Zealand Arable & Outdoor Vegetable Production. In (ed.), Vol. pp. AgriLINK New Zealand Ltd,
- Barber, A., Glenys, P. (2005). Energy Use and Efficiency Measures For the New Zealand Arable and Outdoor Vegetable Industry. In (ed.), Vol. pp. Climate Change Office and Energy Efficiency and Conservation Authority, Auckland.
- Bell, B.J. (2005). *Farm machinery*. 5th (ed.), Old Pond Publishing, Ipswich [England].
- Bell, B.J., Cousins, S. (1991). *Machinery for horticulture*. Farming Press Books, Ipswich, U.K.
- Bertocco, M., Basso, B., Sartori, L., Martin, E.C. (2008). Evaluating energy efficiency of site-specific tillage in maize in NE Italy. *Bioresource Technology*, 99(15):6957-65.
- CIGR (1999). *CIGR Handbook of Agricultural Engineering. International Commission of Agricultural Engineering*. American Society of Agricultural Engineers, St. Joseph, MI.
- Conforti, P., Giampietro, M. (1997). Fossil energy use in agriculture: an international comparison. *Agriculture, Ecosystems & Environment*, 65(3):231-43.
- Culpin, C. (1986). *Farm machinery*. 11th (ed.), Collins, London.
- Dalgaard, T., Halberg, N., Porter, J.R. (2001). A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. *Agriculture, Ecosystems & Environment*, 87(1):51-65.
- Energy & Environment (2009). New Zealand energy & environment business week. In (ed.), Vol. 6, pp. 1, Media Information, Christchurch, N.Z.
- FAO (2010). International Code of Conduct on the Distribution and Use of Pesticides, Guidance on Pest and Pesticide Management Policy Development. In (ed.), Vol. pp. Food and Agriculture Organization of the United Nations,
- Fluck, R.C., Baird, C.D. (1980). *Agricultural energetics*. AVI Pub. Co., Westport, Conn.
- Ghareei Khabbaz, B. (2010). LIFE CYCLE ENERGY USE AND GREENHOUSE GAS EMISSIONS OF AUSTRALIAN COTTON: IMPACT OF FARMING SYSTEMS[Thesis]. Type, UNIVERSITY OF SOUTHERN QUEENSLAND, Toowoomba.
- Grisso, R.D., Kocher, M.F., Vaughan, D.H. (2004). Predicting tractor fuel consumption. *Applied Engineering in Agriculture*, 20(5):553-61.
- Hawker, M.F.J., Keenlyside, J.F. (1985). *Horticultural machinery*. 3rd (ed.), Longman, London ; New York.
- Helsel, Z.R. (1992). *Energy and alternatives for fertilizer and pesticide use*.
- Hornacek, M. (1979). Energetic analysis of 14 agricultural practices. *Etude du Centre National d'Etude et d'Expérimentation de Machinisme Agricole, France*, 457
- Hunt, D. (2001). *Farm power and machinery management*. 10th (ed.), Iowa State University Press, Ames.
- Kelly, G. (2007). Renewable energy strategies in England, Australia and New Zealand. *Geoforum*, 38(2):326-38.
- Kondo, N., Monta, M., Noguchi, N. (2011). *Agricultural robots : mechanisms and practice*. English (ed.), Kyoto University Press & Trans Pacific Press, Sakyo-ku, Kyoto & Melbourne, Vic., Australia.
- Kubik, R. (2005). *How to use implements on your small-scale farm*. Motorbooks, St. Paul, MN.
- Lague, C., Khelifi, M. (2001). Energy use and time requirements for different weeding strategies in grain corn. *Canadian Biosystems Engineering*, 43
- Lal, R. (2004). Carbon emission from farm operations. *Environment International*, 30(7):981-90.
- Mani, I., Kumar, P., Panwara, S.G., Kanta, K. (2007). Variation in energy consumption in production of wheat–maize with varying altitudes in hilly regions of Himachal Pradesh, India *energy*, 32(12):2336-9.
- Manktelow, D., Stevens, P., Zabkiewicz, J., Walker, J., Gurnsey, S., Park, N. et al. (2005). Trends in Pesticide Use in New Zealand: 2004. In (ed.), Vol. pp. Ministry for the Environment, Auckland, New Zealand.
- McChesney, I.G. (1981). Field Fuel Consumption of Tractors. In *Internal Report 3, Joint Centre for Environmental Sciences, Lincoln College*. (ed.), Vol. pp. University of Canterbury,
- McChesney, I.G., Pearson, R.G., Bubb, J.W., Joint Centre for Environmental Sciences (N.Z.) (1978). *Energy use on Canterbury mixed cropping farms : a pilot survey*. Joint Centre for Environmental Sciences, Lincoln College.
- McChesney, I.G., Sharp, B.H.M., Hayward, J.A. (1982). Energy in New Zealand Agriculture: Current Use and Future Trends. *Energy in Agriculture*, 1:141-53.

- McLaughlin, N.B., Gregorich, E.G., Dwyer, L.M., Ma, B.L. (2002). Effect of organic and inorganic soil nitrogen amendments on mouldboard plow draft. *Soil and Tillage Research*, 64(3-4):211-9.
- Ministry of the Environment (2006). Study of the New Zealand Product Stewardship Scheme for Agrichemical Containers. In (ed.), Vol. pp. Ministry of the Environment, Wellington.
- Nguyen, M.L., Hignett, T.P. (1995). Energy and labour efficiency for three pairs of conventional and alternative mixed cropping (pasture-arable) farms in Canterbury, New Zealand. *Agriculture, Ecosystems and Environment*, 52:163-72.
- Pellizzi, G., Guidobono Cavalchini, A., Lazzari, M., Commission of the European Communities. (1988). *Energy savings in agricultural machinery and mechanization*. Elsevier Applied Science, London ; New York.
- Pimentel, D. (2009). Reducing Energy Inputs in the Agricultural Production System. *Monthly Review*, 61(3):92.
- Pimentel, D., Hepperly, P., Seidel, R., Hanson, J., Douds, D. (2005). Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. *Bioscience*, 55(7):573.
- Pimentel, D., Pimentel, M. (2008). *Food, energy, and society*. 3rd (ed.), CRC Press, Boca Raton, FL.
- Roller, W.L., Keener, H.M., Kline, R.D., Mederski, H.J., Curry, R.B. (1975). Grown organic matter as a fuel raw material resource. In *Report No NASA CR-2608* (ed.), Vol. pp. Ohio Agricultural Research and Development Center, Wooster.
- Safa, M., Samarasinghe, S. (2011). Determination and modelling of energy consumption in wheat production using neural networks: "A case study in Canterbury province, New Zealand". *Energy*, 36(8):5140-7.
- Safa, M., Samarasinghe, S., Mohssen, M. (2010). Determination of fuel consumption and indirect factors affecting it in wheat production in Canterbury, New Zealand. *Energy*, 35(12):5400-5.
- Safa, M., Samarasinghe, S., Mohssen, M. (2011). A field study of energy consumption in wheat production in Canterbury, New Zealand. *Energy Conversion and Management*, 52(7):2526-32.
- Safa, M., Tabatabaefar, A. (2002). Energy Consumption in Wheat Production, IACE 2002, Wuxi, China. In *IACE 2002*. (ed.), Vol. pp. Wuxi, China.
- Saunders, C., Barber, A., Taylor, G. (2006). *Food miles : comparative energy/emissions performance of New Zealand's agriculture industry*. Agribusiness & Economics Research Unit, Lincoln University, [Lincoln] N.Z.
- Serrano, J.M., Peça, J.O., Marques da Silva, J., Pinheiro, A., Carvalho, M. (2007). Tractor energy requirements in disc harrow systems. *Biosystems Engineering*, 98(3):286-96.
- Siemens, J., Bowers, W. (1999). Machinery management: how to select machinery to fit the real needs of farm managers. In *Farm Business Management (FMB) series*. (ed.), Vol. pp. John Deere Publishing, East Moline, IL.
- Singh, S., Mittal, J. (1992). *Energy in Production Agriculture*. Mittal Publishing Company, Mittal Publishing Company.
- Smil, V. (2008). *Energy in nature and society : general energetics of complex systems*. The MIT Press, Cambridge, Mass.
- Smil, V. (1991). *General energetics : energy in the biosphere and civilization*. Wiley, New York.
- Statistics New Zealand (2007). Agricultural Areas in Hectares by Farm Type (ANZSIC06). In (ed.), Vol. pp. Statistics New Zealand,
- Statistics New Zealand (2008). Agricultural Production Statistics (Final): June 2007. In (ed.), Vol. pp. Statistics New Zealand, Wellington.
- Stout, B.A. (1990). *Handbook of energy for world agriculture*. Elsevier Science Pub. Co., London; New York.
- Vlek, P.L.G., Rodríguez-Kuhl, G., Sommer, R. (2004). Energy Use and CO₂ Production in Tropical Agriculture and Means and Strategies for Reduction or Mitigation *Environment, Development and Sustainability*, 6
- Wallgren, C., Höjer, M. (2009). Eating energy--Identifying possibilities for reduced energy use in the future food supply system. *Energy Policy*, 37(12):5803-13.
- WCED (1987). Our Common Future. In *Oxford University Press, Oxford (1987)*. (ed.), Vol. pp. World Commission on Environment and Development,
- Wells, C. (2001). Total energy indicators of agricultural sustainability : dairy farming case study. In (ed.), Vol. pp. vii, 81 p., Ministry of Agriculture and Forestry, Wellington [N.Z.].
- Witney, B. (1988). *Choosing and using farm machines*. Longman Scientific & Technical ; Wiley, Harlow, Essex, England, New York.

Political Participation in Sport Development of Thailand

Saowalee Kaewchuay^{*1}, Sutus Sikaewkae^{*2} Eakrat Onnom^{*3}, Pateeeya Kitcharoen^{*1}

^{*1}Mahidol University, Thailand ^{*2}Institute of Physical Education Trang, Thailand

^{*3}Chandrakasem Rajabhat University, Thailand

0645

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Today, sport competitions have gained popularity among people in Thailand. In particular, sports like football, basketball, volleyball, futsal, or sepak takraw, they require team spirit and loyalty of the fans. It is clear that the rapid growth of sport competitions in Thailand has been caused by more involvement of politicians. Sport tournaments also boost local economy. However, the local sport teams are used as marketing tool by not only business industries but also, by the political institution. Many politicians have entered sports by running football clubs and being bosses of sports associations among other channels. They apparently want publicity rather than financial gains. Sport provides a stage for public visibility, attention, and awareness. It is interesting to unveil the politics in sport. The study therefore aims to explore the politician's involvement conditions in the local sport teams, the roles and functions of the politician, the success factors. It also aims to examine the effects of politicians participation on the development of the team. The sustainability of the involvement is also clarified. A number of local sport teams, which have played outstanding in the past few years are taken as case studies. The politicians who have involved in the local sport teams and other stakeholders such as, players, managers, and the community are interviewed. This paper presents a qualitative view on how politician identities are created through the powerful vehicle of sport and outlines the implications it has as social phenomena.

INTRODUCTION

The popularity in sports in Thailand has been increased rapidly. People all over the country pay attention to almost all kinds of competitions. Medias report sport news regularly whether they are amateur or professional competitions.

It can be seen clearly that competitions. in Thailand were supported by companies or private sections. In the recent years Thai politics have involved more in sport management the local and international levels. The politicians have turned to be owners: managers, pendants of the clubs or team members. Some take part in raising fund, team development. Such phenomenon can be seen in football, futsal at all levels. Therefore, it might be worth to examine why Thai politicians involved in sport activities more and more. Why are they interested in sport and competitions? What would effect to benefit sport players? This should be studied and understood it properly.

Researcher wisher to study factors affected to participation in sport of politicians to develop sport in all levels and to see if they were succeed. All data from the study could be used as guidelines to develop sport associations or could be used examples to the public or interested person.

OBJECTIVES OF THE RESEARCH

1. To study the participation of politicians in sport development in Thailand
2. To study factors that affected the participation of politicians to sport development in Thailand

This research is Qualitative Research, the process of research

Sampling studied in this study are politicians who play important role in sport organizations in provincial levels and professional football in Thailand on Purposive sampling for is politicians

Population limitation sample space

Populations in this research are Thai politicians who play the roles in administration in football clubs in provincial levels and professional clubs in national levels by using purposive sampling.

Limitation in factors

Variables are factor affected to the participation of politicians to develop sport of the country, Thailand.

Dependent variable is participation of politicians to development of the country.

BENEFIT EXPECTED

1. To know what factors affected to participation of politicians in developing sports of Thailand.
2. To know the participation of politicians in developing sports of Thailand.

3. Data from the research could be used as to guide for other firms such as the Ministry of sports and Tourism and Sports Authority of Thailand. Sports Authority of Thailand could use this information

Method and procedure of research

This research is qualitative research, the process of research will be as follow;

Sampling

Sampling studied in this study are politicians who play important role in sport organizations in provincial levels and professional football in Thailand on Purposive sampling for is politicians

Data Collecting

1. Collecting data and the study from documentation subjects concerning of the study, from textbook, thesis, reports, personal portfolio, magazines, articles, and documents etc. Information from websites also included
2. The in depth interns were conducted with was selected politicians by appointments. The interview tape recorded. Set the criteria for informant selection: They must be politicians at local or national level. They must be recognized as person who continually support/ promote sports in Thailand.
3. Contacted the informants and informed them, requested their participation in the research and then make individually appointments.
4. The individual interviews had been conducted for 2 months. Each interview was taken place for one-two hours.
5. During the interview, tape-recording was used with the permission of the informants. Record data was transcribed into written form and sent to the informants to check the validity.

Data Analysis

The research on role and factors affected to the participation of politicians on sport development of Thailand is Qualitative research. There theory and ideas concerned are rese framework to describe and analyzed questions and data from interviewing including analyzing conclusion from documentations, analyzing articles, report and study form literature concerned.

Definition Used in the Research

Politicians mean persons whose occupations are politically from local levels to national levels who play an important role and participate in administrating professional football club in Thailand, such as consultant and committee of management.

Participation means to take part in developing sports of Thailand of politicians by using 5th National Sports Development Plan (2555-2559); consists of

Developing sports basivally and the public means participation of politician in developing sports basically. The objectives are to grow love in sport and prepare promptness both in physically and in mind. Wishing sports to be as games and exercises as daily routine and to build positive opinions, co-operation and sportsmanship to the children, youth in and out school system. To develop the quality

of life of people by having good health from exercises with sufficient places which will have an effect no the development of economy and society of the country.

To develop sports for championship means the participation of politicians to develop sports for championship by supporting all groups of sportsmen, all levels to have chances to enter competitions in all levels and to develop abilities by focusing for championship both for national and international including to promote and develop sportsman continually and systematically and to be sufficient to needs to develop sports in all levels, from district, province, nation and international. To construct and develop stadiums, equipment and facilities for practicing and competing in all levels including to develop sports network in each level to join and administrate systematically and develop competitions for championship both national and international levels.

To develop sports for professional means the participation to develop sports for professional by supporting and developing international sports which are efficient and some Thai sports to be sustainable.

To develop all groups of sportsman and personnel concerning sports by developing sports in quality and spirit professional ethics and to support from institution to produce professional sportsmen and to support fan clubs of teams, from both in regional and central parts of Thailand. To develop management professionally by supporting to have fund and welfare for professional sportsmen to protect and keep rights or benefits. To motivate private sections to promote professional sports.

Factors affecting and sports development means courses to make politicians participate in sports development consist of 3 factors:

Outer factors mean factors affecting politicians in developing sports of the country such as policies about sports development of political party, roles and duties or occupations of politicians affecting sports development, etc.

Inner factors mean basic indicator. Factors which will indicate behavior in deciding of politicians that interest politicians to develop sports or to understand how to develop sports or to get support from persons or firms, etc.

Sports development of the country means to make sports in Thailand develop increasingly and could be competed in international levels efficiently with fame and income as well as to build Thai society and economics firmly.

Tool processing

Researchers manage to build tool to collect data as follow:

1. To study data and survey factors affected to participation of politicians to develop sports in Thailand by studying from ideas and theories concerned to use as data base. By studying from documents, text, reports, researches, thesis concerned. To use as guides to build tools to research which researchers process to build tools by interviewing by researchers. By using ideas from the study as frames of the research.

2. Build interviewing form to cover the study of factors affected to participation of politicians to develop sports in Thailand by using each are as to build questions.

Tool check up

1. Consult the consultant to check, correct and improve questions to interview properly.
2. Consult the expert to check content validity to correct and improve as consulted.
3. Correct and improve and bring to consultant of the research to check again.
4. After checked, bring the interview to process collect data in the research.

Findings

The data collected from the interview with 15 politicians who were local politician's members of parliament, senators. There was analyzed using content analysis. It was found that: Factors that affected the participation of politicians in sport development of Thailand were categorized into.

1. Inner factors

When they see the values they are motivated to support and mane efforts to improve the sports in the community

1.1 Personal Interests:

The politicians, who are involved in the sport activity in Thailand have strong in tersely and passions towards the particular sport.

1.2 Community concerns: They want to see their children, youth and general people in all walks of lives in their use sports to improve their general health, to become strong, fit and firm and spend their leisure time in playing sports and at last to be far away from drudge and narcotics which will help our society free from addiction and our country can be developed increasingly .

1.3 Political in implication .

1.4 The politicians are the sports as political tool to gain their votes and succeed their position in parliaments.

2. Outer factors.

2.1 Governments policy in sport development.

2.2 Follow the strategy to develop Sports in provincial level and local policy to promote and support sports development

2.3 Political party policy.

2.4 Trend of the people in the community and to wake and drive all parts of the country to participate in sports development more in the regions

The roles of politicians in sport development.

It was reported that politicians who were informant, took part in sport development as:

1. The committee in sports organization of the Thailand.
2. Chairman of sport organizations of the province.
3. Consultants of professional football clubs.
4. Chairman of professional football clubs.
5. Managers of professional football teams etc.

Guideline politician's participation in sports development is that most politicians have guidelines to develop sports by focusing on following the sports National Plan which are:

1. The participation in sports promoting basically and sports for public has found out that politicians participate in sports development basically and sports for public by youth and the people that would affected to development of communities, locals and societies. To participate in activities, politicians wish to make children, youth and the people turn to use their free time profitably that could reduce problems on drugs and to build better to the people. The healthy people would be able to reduce cost on treatment and to medical expenses of the country. People could live long life could help Thailand better in economics.

2. To participate in promoting and supporting sports to be competed in the international. Most politicians participate in sport development for championship by focusing in promoting and supporting tournaments and participate in competitions in all levels. Mostly with co- operation to many other firms. Such as administrators in provinces and local, tourism firms of provinces, sports centers in provinces, sports organizations, education institutions and governmental, for examples : competitions in provincial levels, such as; National Sport, Students Sports etc. To participate in such competitions; politicians wish to open good opportunities to children, youth in local levels, to show their abilities in sports and make fame to show their provinces. That could be quality in sports. That is what to be seen if those provinces have proficient or potential.

3. To participate in promoting professional sports that is most politicians participate in developing professional sports. Most politicians participate in managing professional football team of provinces by being administrators clubs such as Clubs consultant, Chairman of clubs, teams managers etc. The process in management is to participate in policy making to manage the clubs, plans on administration, personal selective to the clubs, management on command and include fund raising to process the clubs. All because most politicians focus on success of the clubs from competitions. The goals are to enter professional football league the top most of Thailand. The expected results are fame, and huge income from competitions and management etc.

In the participation of sport development, Processing in developing sports, politicians faced problems as follows

1. Rules and regulations of government do not support and facilitate the participation of politicians in all aspects.
2. Lack of good relation with the partners in the community. Therefore, the provincial collaborations can not make possible.
3. Lack of funding. The government budget on the sport development is in suffer.
4. Sport development is taken leisurely, not seriously to make the impacts.

Recommendations

1. The government should plan the policies to promote and to develop sport seriously.
2. Politicians who participate in sports development of the country must truly love sports and devote their lives for sports do not work for benefit only. They

should can continuity the importance of sports to be used to develop human competence.

3. Make partners at all the levels realized importance of sport and promote the collaboration between stakeholders.

4. Open for private sectors or governments see to get involved in sport development.

5. Appoint responsible persons to take fully responsibility for sport development.

6. Promote good relationships among local partners in the community.

7. The budget should be allocated in accordance with annual plans in sport development.

Suggestions on the next research

1. Should study roles of politicians to develop sports of the county.

2. Should study guidelines on processing to work of politicians in Thailand to develop sports of the country.

References.

Kim, H.D. (1990). **Government Policy For The Promotion Of Sport For All In South Korea**. Dissertation Abstracts International.

Pitter, R. (1993). **The State And Sport Development In Alberta: Conflict, Corporation And Change**. Dissertation Abstracts International.

"Sustainability, Environment and Tourism in Cape Coast: Searching for Synergies"

Monica Frimpong, Vida Commey, Akosua Afriyie Nkrumah

Sunyani Polytechnic, Ghana

0104

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Tourism has been an integral component of economic development strategies in developing nations since the 1960s. The industry is important in generating foreign exchange earnings, increase tax revenues, attract international investment and create new jobs. Sustainability of the environment and tourism was investigated using the tourists' attraction sites in Cape Coast (Ghana). Questionnaire was administered purposively to tourists and tour operators in Cape Coast. Data were collected on hygienic practices of the community, basic knowledge on environmental hygiene, human behaviour, social and cultural factors. Observational study was done and Management interviewed. Most communities' around attraction sites had poor disposal of household waste, inadequate domestic water supply and washroom facilities. The study revealed that although there is a little awareness on sustainability of tourism, its implementation and maintenance was not effective. To sustain tourism as a fast growing industry, conservation, protecting and proper management of attraction sites are very important. It was recommended that more educational campaigns should be organised to create enough awareness of the synergy factors, the Ministry of Tourism should enforce policies governing environmental issues, and the government should adequately resource the Tourism Industry to carry out its mandate to help alleviate the unemployment problem and accelerate the overall development of the country.

Keywords: Sanitation; Sustainability; Environment; Tourism; Health

1.0. Introduction

Tourism has been an integral component of economic development strategies in developing nations since the 1960s. The industry is important in generating foreign exchange earnings, increase tax revenues, attract international investment and create new jobs. It also serves as incentive for developing countries to promote tourism as an engine for macro-economic growth. It is the world's largest industry serving as an engine for economic development (Brohman, 1996; Ghimire, 1997; Cattarinich, 2001). While developing countries currently receive only about 30.5% of all international arrivals, this proportion has a potential to grow in the future.

In 1991 the International Tourism Industry employed 112 million people world-wide and generated over \$2.5 trillion in 1989, and also in 1996 about 593 million tourists travelled abroad (World Tourism Organisation 1997). In global terms, the expansion of international tourism continues to generate an increased demand for overseas travels, therefore countries, organisations and businesses are working tirelessly to attract this ever increasing market.

Ghana is no exception to the rapid growth and development of tourism industry. Tourism has received considerable attention in the economic development strategy of Ghana. Since 1980's tourist arrival and amounts of tourist expenditure has increased steadily while public and private sector investment in various tourism subsectors have expanded. The government of Ghana established the Ministry of Tourism in 1993 to underscore its commitment to tourism development and with assistance from the United Nation Development Programme (UNDP) and the World Tourism Organisation (WTO), a 15- years tourism development plan was prepared for the period 1996 to 2010.

Tourism is now recognised as an economic activity of global significance. It is steadily gaining grounds as an important sector for most developed and developing countries and Ghana is no exception. It is the fourth-highest foreign exchange earner for Ghana contributing 6.7% to GDP and creating large volumes of employment opportunities. The economic benefits of tourism have increased and fuelled global research on tourism development. One thing that can dent the image of tourism is bad environmental sanitation which has adverse effects on the overall development of tourism process. In a given area there are various hygienic practices of the communities, basic knowledge, skills and human behaviours as well as social and cultural factors concerning health, life-styles and environmental awareness, this include: disposal of human excreta, sewage, household waste and waste likely to contain infectious agents, water drainage, domestic water supply and housing. The study seeks to investigate the environmental sanitation, sustainability and tourism in Cape Coast.

Problem Statement

Not much research has been made in relation to the impact of sanitation and health on tourism. The few papers that have been written are on safe water and sanitation. According to WHO Ottawa charter (1986), health promotion is 'the process of enabling people to increase control over and improve their health'.

The environment in which tourism takes place is important to the tourist's experience. In the absence of an attractive environment, both natural and man-made tourism rarely succeeds. Therefore sustainability of our growing tourism depends to a large extent on sustainable harmony that should exist between tourism and the environment.

Aim and Specific Objectives

- The study seeks to investigate the synergy factors that favour sustainability of tourism in Cape Coast, Ghana To identify the environmental factors that affect tourism in Cape Coast, Ghana.
- To assess how tourism is benefiting from the environment and the environment from tourism.
- To investigate the preservation of the natural environment and the development of the sites to enhance tourism in Cape Coast.

The researchers concern is to find out how both the natural and man-made environment are adequately preserved to attract and retain tourist activities.

The impact of sanitation and health on tourism depend on four challenges.

- Preserving biodiversity and the world's forests.
- Preserving clean air water.
- Preventing and managing waste.
- Climate protection.

Some of the questions the researchers sought answers to are as follows:

Do tourism and the environment exist together in harmony? Is tourism benefiting from the environment and the environment from tourism? How is the natural environment preserved or conserved? To what extent is development done in the attraction sites?

2.0 REVIEW OF RELATED LITERATURE

Definition and concept

Tourism is a multidimensional, multifaceted activity which touches much life and many different economic activities, (Cooper et al, 1998).

Notwithstanding the difficulty in assigning a common definition, tourism has been defined by different authors to cater for particular needs and situations.

Within the published literature on tourism, the term travel and tourism are often interchanged, though they are normally meant to encompass 'the field of research on

human and business activities associated with one or more aspect of the temporary movement of persons away from their immediate home, communities and daily work environment for business, pleasure and personal reasons' (Chadwick, 1994).

The two terms tend to be used in differing contexts to mean similar things, although there is a tendency for the United States to continue to use the term 'travel' when in fact they mean tourism. Despite this inherent problem that may be a little more than exercise in semantics, it is widely acknowledged that the two terms are used in isolation or in unison to describe three concepts:

- The movement of people.
- A sector of the economy or an industry.
- A broader system of interacting relationships of people, their needs to travel outside their communities and services that attempt to respond to these needs by supplying products.

According to Page et al (2001) the concept of tourism refers to a broad national framework, which identify the essential characteristics and distinguishes tourism from the similar, often related, but different phenomena. In contrast, technical definitions have evolved through time as researchers modify and develop appropriate measures for statistical, legislative and operational reasons implying that there may be various technical definitions to meet particular purposes.

Tourism continues to have positive impact on the economies of most countries, especially the developing ones. It has become a global industry and is widely considered to be one of the fastest growing industries in the world (WTTC 1995).

Tourism ranks as the largest industry in the world in terms of employment (one out of every 16 employees worldwide) and ranks in the top two to three industries in almost every country (Mowlan and Smith, 1993). Thus the travelling and tourism industry has become a major contributor to the gross national product of many nations, with good sanitation becoming a widely recognised practice for both the public and private sector organisations. It is estimated that about 2.4 billion people will face needless disease and death by 2015 because of bad sanitation. Decaying or non-existent sewage systems and toilets fuel the spread of diseases like cholera and basic illnesses like diarrhoea, which kills a child every 21 seconds (WHO and UNICEF, 2004).

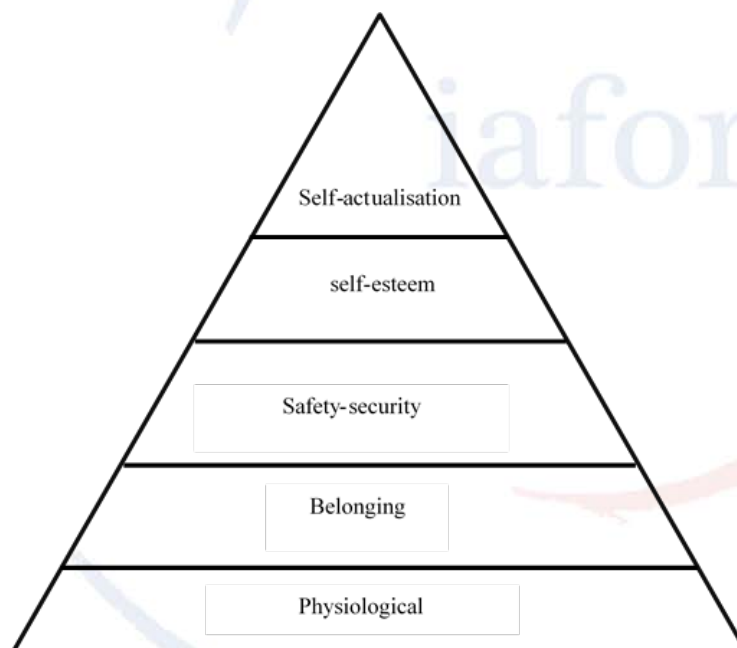
Consumer Behaviour

It is important to talk about consumer behaviour in respect of tourism. There are many influences which affect a person's decision to buy a product or service. Consumers navigate through the world of product and services adjusting their personal hierarchy stage of an attitude following a particular common experience. (Mazance et al, 1998).

The question of why people go on holiday is fundamental to the study of tourism. There has however, not been a straightforward answer to this as different writers and researchers have grappled with explanations of these questions. In view of Page et al (2001), it is argued that while it might be fair to say that, how people decide to go on holiday and what influence their decision is individual. According to Cooper et al

(1998), the demand for tourism at the individual level can be treated as a consumption process that is influenced by a number of factors, which may be a combination of needs and desires, availability of time and money, perceptions and attitude. Seaton and Bennet (1996) however, argue that understanding consumer behaviour by and large in the question as to why people travel, personal motivation is identified as one of the main factors and as such many texts associated with tourism have utilised the concept of motivation as a major influence upon consumer behaviour.

Motivation can be defined as ‘the driving force within an individual that impels his action; is the state of arousal of a drive or need which impels people to activity in pursuit of goals’. (Schiffman and Kanuk, 1978.) Once the goals have been achieved the need subsides and the individual returns to equilibrium-but only briefly because new motives arise as the last ones are satisfied. Within the theory of motivation, Maslow’s hierarchy of needs is acknowledged as the best known theory and as such several tourism researchers have applied this theory in the context of tourism motivation. Maslow argues that individual needs fall into five broad categories, as shown below:



Lower

- Physiological-hunger, thirst, rest, activity
- Safety-security, freedom from fear and anxiety
- Belonging and love-affection, giving and receiving love
- Esteem-self-esteem and esteem for other

Higher

- Self-actualisation-personal self-fulfilment. Source: Cooper et al (1998)

Maslow suggested that these five categories form a hierarchy moving with lower order physiological needs and moving through to higher order self-actualisation needs.

He argued that each of the needs expressed in a category would be satisfied before the individual sought motivation from the next category of needs. The individual may be motivated by higher order of classification until that of self-actualisation. What is worthy of mention is that, these researchers and writers that applied Maslow's theory recognise that tourists motivation changes over time and that tourists may have several motives to travel.

Cooper et al (1998) making reference to Dann (1981) on motivation in tourism pointed out that there are seven elements within the overall approach to motivation. These seven identified approaches; Dann suggests that they demonstrate a 'definitional Fuzziness' which if not clarified, may make it difficult to discover 'whether or not individual tourism researchers are studying the phenomenon'. In the same vein, quoting McIntosh, Goeldner and Ritchie (1995), these authors identified four categories of motivation;

- Physical motivators: these comprise those related to refreshment of body and mind, health purposes, sport and pleasure. This group of motivators are seen to be linked to those activities which will reduce tension.
- Cultural motivators: those identified by the desire to see and know more about other cultures, to find out about the natives of a country, their lifestyle, music, art, folklore, dance, etc.
- Status and prestige motivators: these include a desire for continuation of education (i.e. personal development, ego enhancement and sensual indulgence). Such motivators are seen to be concerned with the desire for recognition and attention from others, in others, in order to boost the personal ego. This category also includes personal development in relation to the pursuit of hobbies and education.
- Interpersonal motivators: this group includes a desire to meet new people, visit friends or relatives, and to seek new and different experiences. Travel is an escape from routine relationships with friends or neighbours or the home environment or it is used for spiritual reasons.

One interesting aspect of motivation is also the work of Stanley Plog (1974) otherwise known as Plog's tourist typologies as discussed in Page et al (2001). This study is based on US population; Plog identified two opposite types of tourists each at the end of a continuum; Allocentrics and Psychocentrics.

The allocentrics are tourists who seek adventure on their holidays and are prepared to take risks. As such this group prefer holiday in more exotic locations that are similar to their home environment. According to Plog such tourists may repeatedly return to the same destination where they have had a satisfying experience safe in the knowledge of the familiar. In between these two extremes other categories exist, such as near-allocentric, mid-centric and near-psychocentric. On these typologies, Page et al (2001) argue that while Plog's work may be simple, easy to understand and to some extent explain tourist's motivation, there are some difficulties in its application.

Social Influences

Aside personal motivation, social influences such as social class, reference groups, and family are also some of the main factors that influence consumer travel behaviour.

In the words of Seaton and Bennett (1996) 'No man is an island; people live in societies, communities and groups and the pattern of social networks through which they grow and develop influence their tastes, habits and values.'

In discussing social class, these authors emphasised that within every society, and stratified groups exist with distinctive patterns of behaviour. They made mention of the fact that many patterns of behaviour have a great impact on tourism consumption. Citing UK as an example these writers acknowledge that social class often constitute the main market for many kinds of recreational tourism including heritage and cultural tourism, wilderness tourism and long haul travel precisely because it is the middle classes who have promoted and been most influenced by concepts of elite culture.

Impact of Sanitation and Health on Tourism

As tourism continues to grow, becoming an important input to the economies of most countries of the world, so is a growing concern for and attention to tourism-related aspects of infrastructure, safety, security, health, and environmental conservation. The relation between health and tourism has long been recognised, not only as a significant driving force for travel but also in terms of potential health risks stemming from contacts by visitors, with the environment and the host population.

World Health Organization (WHO) has affirmed its leadership by establishing criteria and guidelines for drinking and for recreational water quality, for airplane catering and for publishing such classic text as "Guide to Sanitation in Tourist Establishments".

Foundations and NGO's such as the West African Water Institute, UNICEF, Water Aid, World Vision International, (Ghana), among others are providing increasing access to safe water and good sanitation in Ghana and other West

African Countries, by drilling wells, construction of household and public latrines; improving on the existing water and sanitation problems.

The Conrad N. Hilton Foundation is the chief architect of West Africa Water Initiative; (WAWI 2008) instituted a six to seven year plan targeting increased access to safe water in Ghana, Mali and Niger. WAWI also aimed at reducing, if not eliminating, the incidence of blinding trachoma and guinea worm infestation in these three countries; thus, contributing to fulfilling the Millennium Development Goals on Water and Sanitation in Africa. By 2008 WAWI experts were to provide a minimum of 825 wet wells equipped with hand pumps, reaching more than half a million people; 100 alternative water systems; 9,000 household and public latrines; and construct maintenance and repair technical resource centres in addition to training thousands of adults, children and teachers in improved hygiene and sanitation practices, while increasing skills of community members on development techniques together with water and sanitation management practices. As much as these help to improve the community it encourages tourists who would visit these communities.

Although these publications are normally general in their contents, and often times based on perceptions or projections rather than concrete facts, these publications respond to most of the concerns potential travellers have. A recent version of the book published in Canada under the title “Don’t Drink the Water” describes a long list of potential risks and suggests ways and means to avoid exposure to these risk.

Tourists can feel the health impacts very early in their journey, at the onset of jet lag or sea-sickness. Although they pose no major health risks, these two problems can cause considerable distress, mainly in elderly people and those with pre-existing health conditions.

Most attention is normally placed on the occurrence of diarrhoea caused by parasites, bacteria or virus in some of the contaminated water they drink, and food they consume. Most of the travellers are not exposed to these microorganisms in their environment of origin, making them prime victims in some of the tourist places. Such diarrhoea rarely requires intensive or extensive medical care. Escherichia coli, shigella and salmonella are among the most frequent agents of diarrhoea in tourists. These microorganisms are also present in swimming pools and coastal waters where they are sometimes related to gastrointestinal, respiratory and skin infections.

The consumption of contaminated seafood has also been shown to be associated with the occurrence of Hepatitis A, since shellfish and very specifically the bivalves concentrate the microorganisms, exposing consumers

to high doses of infectious agent. In some instances, the consumption of seafood, specifically carnivorous fish, has been linked to Ciguatera, which is an intoxication of tourists due to the presence of high concentration of Ciguatoxins produced by algae.

Outbreaks of Legionnaires disease have gained significant visibility in recent years. This is a respiratory disease caused by a bacterium called *Legionella pneumophila* associated with the water and the air conditioning systems in hotels and other closed environments.

There are many more potential biological health risks to which unprotected non-immune tourists may be exposed. Some of the more frequently identified agents are entamoeba, vibrio cholera, giardia, helminths and the virus which cause gastroenteropathies. All of these are associated with unsanitary diseases transmitted by vectors like mosquitoes, ticks, lice, fleas and mites. Malaria, dengue, yellow fever and Lyme disease are among the vector-transmitted diseases sometimes diagnosed among tourists. Most of the above health problems can be adequately controlled through the applications of well-known procedures for food handling and environmental sanitation. As a general statement, it could be said that a clean environment is a seal of quality for tourists, since it indicates the concern local authorities have with environmental health matters. It is legitimate to say that the environment is a major determining factor for tourists' health and that an adequately maintained environment not only attracts tourists, but it is also a very effective measure to protect their health. Investment in the environment is, therefore, cost-effective input to tourism. The appearance of the virus responsible for human immune deficiency virus (HIV) and the epidemic of acquired immunodeficiency syndrome (AIDS) brought about a very special chapter in the health aspect of travelling and tourism. Sexually transmitted diseases, on the rise in the world, require an urgent change in behaviour vis-a-vis occasional sexual contacts which are greatly responsible for the spread of HIV and the continuous growth in the number of AIDS cases.

From the above, it is evident that responsibility for tourists' health lies not only with local authorities but also with prospective tourists who must have a proactive position on this issue. Since tourism-related diseases are not equally distributed in all places, it is very important to seek as much information about the travel destination as possible. This attitude will provide an adequate basis for observing immunization requirements and recommendations. While yellow fever is the only disease for which some countries require presentation of an International Certificate of Immunization, there are several additional vaccines available to tourists. Among the frequently recommended ones for travellers are the vaccines for Typhoid, Hepatitis B, poliomyelitis and rabies.

While recognizing the potential health risks involved in travelling and tourism, there are plenty of ways to reduce or eliminate such risks. This requires concerned effort by local authorities and by potential travellers. Health education and health promotion, including environmental health are fundamental to bringing about appropriate attitudes and behaviour. Environmental sanitation and preventive medical measures should always be employed by authorities and by travellers.

Impact of Tourism on the Health of Hosts

The bibliographic search by the International Institute of Tourism Studies in 1992 identified among the 147 citation collected, 36 dealing with the impact of tourism on the health of residents. Most of these documents and publications written in the last 10 years, indicates a new trend in looking at the health impacts of tourism on host countries. Sexually transmitted diseases and environmental degradation brought about by tourism seem to be among the main concerns within this context. Some of the texts also deal with aspects of drug addiction and the import of cultural values from other countries. Beneficial changes including earning foreign currencies, development of labour markets and improvement of local infrastructure, such as provision of health and environmental services are also recognized.

There is little doubt that promiscuous behaviour has contributed significantly to the import and spread of Acquired Immune Deficiency Syndrome (AIDS) and other sexually transmitted diseases. Initially strongly linked to homosexuality, in the last 10 years the transmission has been more and more through heterosexual contacts, some tourists tend to have behaviours more relaxed than those they have at home. This is one of the major reasons for alcohol overuse, use of drugs, promiscuous sexual behaviour and neglect of protective habits

Most of these problems must be dealt with through health promotion and methodologies and strategies. This should be accepted by promoters of tourism and by host authorities. Tourist health promotion ought to become an integral component of tourist promotion. Although there are several successful cases in this regard, it is far from becoming a standard procedure. It is also urgent that health professionals become advocates and agent for the promotion of tourist's health.

In the Americas Region, there is a very special situation related to the potential health impacts on host communities. A very strong region-wide campaign for the eradication of immune-preventable diseases has produced important results. Since September 1994, the American Region has been declared free of the transmission of the wild virus causing poliomyelitis. In other regions of the world, this exceptional result has yet not been achieved. This poses a potential

possibility of re-introducing the disease in this region. Health authorities are maintaining strong monitoring mechanisms in all countries of the region.

Along the same line, after a strong vaccination campaign, the Caribbean region has not reported any cases of measles. This probably means that these countries are very close to eradicate this disease. A similar effort is now being carried out by the entire local communities in Ghana sponsored by UNICEF, Ministry of health, Ghana. Here also is a risk that measles could be re-introduced from a country in which measles is still prevalent.

3.0 METHODOLOGY

Questionnaire were designed and administered to 400 tourists, tour operators and members of the Cape Coast community. Tourist sites selected were the Cape Coast Castle, Kakum National Park and Hans Cottage.

Interview guide was designed for the management of the sites and observational study was done to confirm data received. Purposive sampling was the technique used as the people in and around the tourist sites were the people that could give the information needed to the researchers. Initially respondents were reluctant to release information but researchers assured them that data is strictly for academic work and may rather help their work to improve.

Out of the 400 questionnaire administered, 75% were retrieved and used. The analysis of the data was done by the Statistical Package for Social Sciences version 16.

3.1 Geographical location of Cape Coast (Ghana)

Ghana is located on the west coast of Africa, and it approximately 750 north of the equator on the Gulf of Guinea, between latitudes 4 and 11.5 degree Celsius north and longitude 3.11 West and 1.11 East.

3.2 Composition of land

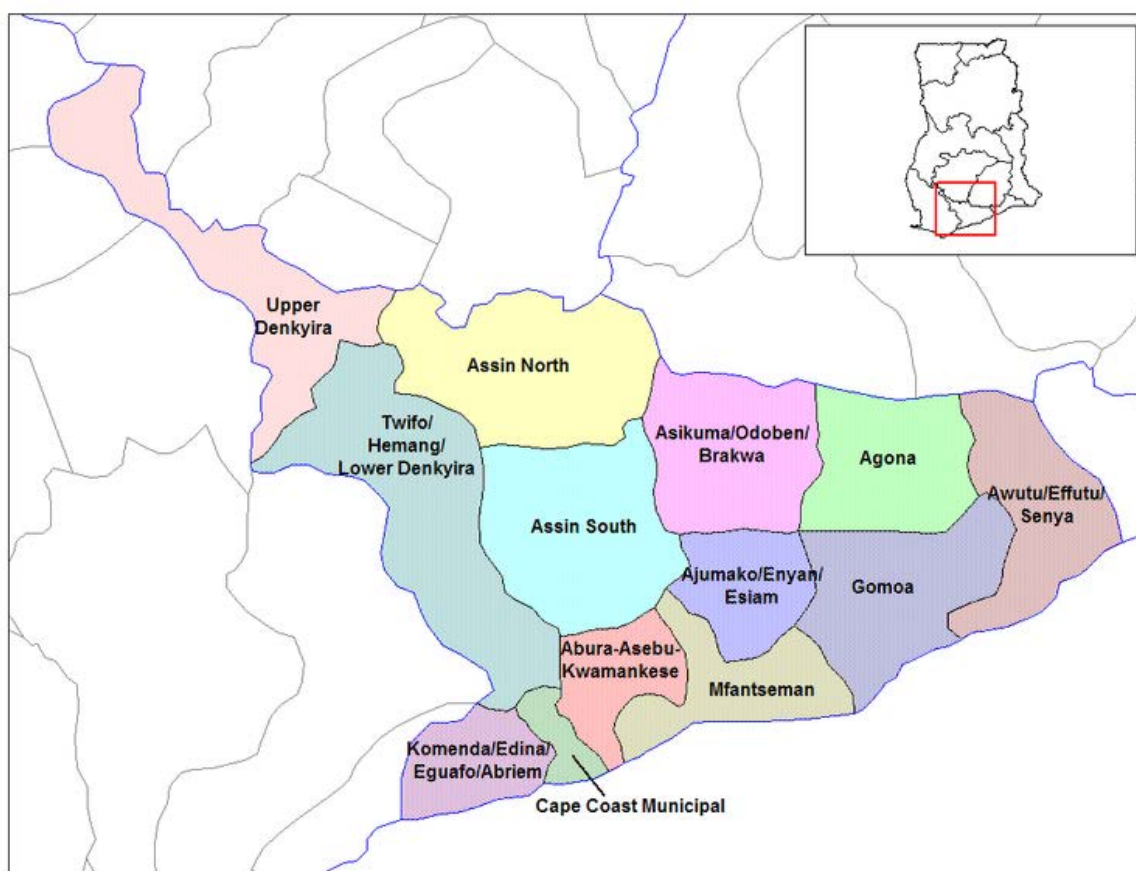
Ghana has a total land area of 238,537 km² (92,100 sq. miles) stretching 672 km north to south and 357 km east to west. Out of a total land area of 23 million hectares, 13 million hectares (57 %) is suitable for agriculture production, and 5.3 million. Cape Coast is the capital of central region of Ghana.

FIGURE 1 GHANA TRAVEL MAP



Source: http://en.wikipedia.org/wiki/File:Ghana_regions_named.png

FIGURE 1 Cape Coast travel map



3.3 Climatic condition

The climatic condition in Ghana is tropical with moderate temperature which mostly ranges between 21 and 32 (70 f, 90 f), in most part of the year with constant breezes and warm clear sunshine. There are two seasons the rainy and the dry season, the rainy season is of two forms with first commencing from March to July with second from September to October which has a short dry season after the end of the rainy season from mid-October to March. However the hottest months are February and March, just before the main rainy season while the coolest months are between June and August.

3.4 Population

According to the 2000 population and housing census, Ghana's population is about 18,912,079 and its growth is estimated at 2.7% annually. However, the population estimate for the mid-year 2010 is 23,951,519. About 2 million of the population live in the Accra Metropolitan Area with about 800,000 in the Kumasi Metropolitan Area. Most of the population is concentrated in the southern part of the country due to employment opportunities and

development relative to that of the northern part of the country. Below is the country's population data by region, sex and capital (administrative towns).

SOURCE: GHANA STATISTICAL SERVICE, (ESTIMATES: 2010 POPULATION AND HOUSING CENSUS; www.statsghana.gov.gh.)

REGION	POPULATION	MALE	FEMALE	CAPITAL
Western	2,558,113	1,267,483	1,290,630	Takoradi
Central	1,864,104	923,614	940,490	Cape Coast
Greater Accra	4,358,263	2,156,407	2,198,856	Accra
Volta	1,878,316	930,658	947,658	Ho
Eastern	2,297,565	1,138,386	1,159,179	Koforidua
Ashanti	4,839,100	2,397,652	2,441,448	Kumasi
Brong Ahafo	2,257,304	1,118,438	1,138,866	Sunyani
Northern	2,259,671	1,119,614	1,140,057	Tamale
Upper East	1,001,926	496,426	505,500	Bolgatanga
Upper West	637,157	315,694	312,463	Wa
TOTAL	23,951,519 (100%)	11,867,372 (49.6%)	12,084,147 (50%)	

4.0 FINDINGS AND DISCUSSION

4.1. Demographic information

Sex				
	Frequency	Percent	Valid Percent	Cumulative Percent
Male	175	66.7	66.7	66.7
Female	125	33.3	33.3	100.0
Total	300	100.0	100.	
Age				
21-25	92	41.3	41.3	41.3
26-30	63	22.0	22.0	63.3
31-35	55	16.7	16.7	80.0
36-40	45	10.0	10.0	90.0
41-45	45	10.0	10.0	100.0
Total	300	100.0	100.0	
Marital Status				
Single	115	52.0	52.0	52.0
Married	92	36.0	36.0	88.0
Divorced	47	6.7	6.7	94.7
Separated	46	5.3	5.3	100.0
Total	300	100.0	100.0	

From table 1, more males between ages 21-25 represent the high sampled unit in the research. 52% of the sample size are singles, followed by 32% who are married, 6.7% divorced and 5.6% separated indicating that the single youth patronize the sites more than the other groups.

Those who have tertiary education recorded the highest frequency with 108 respondents representing 47.3% followed by those with post-secondary education- 32.7%. Those who have secondary education had 12% and primary education group represented the lower unit with 8.0%.

This shows that the elite patronize tourism more than those with lower educational background. Eighty-eight (88) of the respondents representing 44% live in the Cape Coast community with the rest spreading across the country. Thirty-four (34) respondents representing 8.7% were foreigners.

4.2 Sanitation issues

		Frequency	Percent	Valid Percent	Cumulative
Keeping the environment clean					
		213	92.0	92.0	92.0
	Null	87	8.0	8.0	100.0
	Total	300	100.0	100.0	
Improvement of sanitation as a result of tourism					
	Yes	144	46.0	46.0	
	No	156	54.0	54.0	100.0
	Total	300	100.0	100.0	
Groups that care of sanitation in the community					
	Yes	188	75.3	75.3	76.7
	No	112	23.3	23.3	100.0
	Total	300	100.0	100.0	
Do tourists pollute the environment when they come around?					
	Yes	179	69.3	69.3	69.3
	No	121	30.7	30.7	100.0
	Total	300	100.0	100.0	

Two hundred and thirteen (213) respondents representing 92% were able to define sanitation. This indicates that people know what sanitation is, however putting it into practice is the problem.

One hundred and fifty six respondents (54%) indicated that tourism activities have affected the personal hygiene of the people of Cape Coast. This was confirmed by the interview results that surrounding areas of the castle are much neater than before.

One hundred and fifty-six (156) respondents representing 54% agreed that tourism has affected the personal hygiene of the people. The reason given was that law re-enforcement bodies such as sanitary inspectors and 'zoomlion' are now seeing to the environmental cleanliness of the community because of tourism.

They further explained that people living around the sites tend to be neater than those living far away from the sites. This could be due to frequent visits of sanitary or health inspectors and the work done by the zoomlion workers.

4.3 Benefits of tourism to cape coast

When asked about the benefits of tourism to the Cape Coast, some of the responses were improvement in sanitation, job opportunities and revenue for the development of the sites. For example there are over hundred people working in the castle, some as tourists' guides, administrators, and shop assistants.

4.4 Management

Interview and observation made showed that regulatory requirement for sanitation and health are in place but inadequate, for example considering the number of people who visit the sites at a time more bins for refuse should be provided, more toilet facilities, better drainage system

Generally Cape Coast have water supply problem but the sites apart from being connected with the main water supply by Ghana water and sewage, they also have cisterns that store portable water underground for usage.

5.0 Conclusion

To continue tourism as a fast growing industry, conservation and protecting, proper management of the attractions are important to sustain the tourism industry. The turning around of the tourism industry is really becoming the main stay for most economies. In terms of job creation, the economy must fully exploit the potentials especially for the hospitality industry and the growth of the hotel industry and to do this the synergy factors of promoting tourism must fully come into play. It is recommended that more educational campaign should be organised to create awareness of the synergy factors that promote tourism and the benefits of tourism and why it should be sustained. Also the ministry of tourism and the government should be reminded of how tourism can curb our unemployment problem

RECOMMENDATION

It is recommended that more educational campaign should be organised to create awareness of the synergy factors that promote tourism, its benefits and why it should be sustained.

Also the Ministry of Tourism and the government should enforce the policies that govern environmental issues and as a matter of urgency resource the tourism industry to be able to carry out its mandate as this in the long run will help alleviate the unemployment problem.

References

Adejuwon, F. (2001) Tourism in Africa: what are the realities in the developing countries. A paper presented at The third Tourism Summit at Geneva, Switzerland. UN Conference on International Travel and Tourism, Rome, Italy, 1963. Pan American Health Organization. Proceeding of the Regional Conference on Environmental Health and Sustainable Tourism Development. Washington: PAHO; 1994 Salvato, J. A Guide to Sanitation in Tourist Establishments. Geneva: WHO; 1976 Bayley, J. Guide to Health and Salubrity in Air Transport. Geneva: WHO; 1978 World Health Organization. Vaccination Requirements and Health Advise. Geneva: WHO; 1990 (Published as part of the 'International Travel and Health Series'.)

Brohman, J. 1996: New directions in tourism for Third World development. *Annals of Tourism Research* 23(1), 48-78.

Bell, J (1999) Doing your Research Project: A guide for First-Time Researchers in Education and Social Sciences. Third edition Buckingham Open University press.

Bukart, A and Medlik, R (1981) Tourism, past present and future, second edition, London: Heineman.

Cattarinich, X.2001: Pro-Poor Tourism initiatives in developing countries: Analysis of secondary case studies.

Canadian Public Health Association/Canadian Society for International Health. Don't Drink the water, keystone, J S editor: Ottawa, Canadian, CAHA/CSIH 1994

Cooper, C. P. Fletcher, DG and Wanhill, S (1998) Tourism: Principles and Practice: Harlow: Addison Wesley Longman.

Chadwick, R (1994) 'Concept, definitions and measures used in travel and tourism research', in J. R Brent Ritchie and C. Goeldner (Eds) *Travel, Tourism and Hospitality Research: A Handbook for Managers and Researchers*, second edition Wiley.

Ghana Tourist Board (2003) Statistical Handbook on Tourism, Accra, Ghana: Ghana Tourist Board.

Mowlana, H. and Smith, G. (1993): Tourism in Global Context: The Case of Frequent Traveller Programs. Journal of Travel Research winters 20-27.

Page, S.J. Brunt, P., Busby and Connel, J (2001) Tourism: A Modern Synthesis, London: Thomson.

World Tourism Organization (WTO) Yearbook of Tourism Statistics Volume 1 fiftieth edition. Madrid: WTO

WHO and UNICEF (2004) Meeting the MDG drinking water and sanitation target: A mid-term assessment of progress, 2004, WHO/UNICEF JMP for Water Supply and Sanitation, The World Health Organization, Geneva, Switzerland.

World Travel and Tourism Council (1995) The WTTC Report: Travel and Tourism in the World Economy. Brussels: World Travel Tourism Council Yu, Y and Dean A,

UNDP/WTO (1995) National Integrated Tourism Development Programme (Tourism Development Plan for Ghana 1996-2010, Ghana/92/013), Accra Ghana: Ministry of Tourism

Development of a Sustainability Indicators Framework

Yih Tng Chong, Kwong Meng Teo, Eng Seng Chia

National University of Singapore, Singapore

0366

The Asian Conference on Sustainability, Energy and the Environment 2013

Official Conference Proceedings 2013

Abstract

The recent Rio 2012 United Nations Conference on Sustainable Development highlighted that there is currently no universally accepted set of indicators to measure sustainable development. Besides discouraging cooperation and learning between cities and nations, this situation increases the possibility of some essential indicators being missed by a practitioner. While some have opined that it should be possible to identify a core set of indicators common to all localities while addressing global sustainability concerns, others argued that the different concerns across time and space means that a common set of indicators does not exist. In this paper, we propose a sustainability indicators framework to advance this status quo. We identified several desirable attributes of a framework, including comprehensiveness, explanatory value and ability to capture the local contexts of different cities / nations. We further demonstrate the practicality of this framework through re-organizing the existing list of indicators published by the United Nations Commission on Sustainable Development.

Keywords: indicator, index, sustainable development, sustainability, basic human need, theoretical framework

1.0 Problem Introduction

The recent Rio 2012 United Nations Conference on Sustainable Development highlighted that *'currently there is no single, universally accepted definition or assessment metrics for sustainable development'* (UNCSD, 2012). There has been no commonly applied conceptual framework for sustainable development, which would have served to further develop a shared terminology, improve comparability of indicators, and possibly also increase international cooperation (Gasparatos et al., 2008; Lyytimäki & Rosenström, 2008).

There are several known difficulties that have prevented the emergence of a common framework or assessment metrics. Firstly, the scope and definition of 'sustainable development' have been vague (Manderson, 2006). Secondly, while sustainable development is commonly accepted to mean 'meeting the needs of the present generation without compromising the ability of future generations to meet their own needs' (Brundtland Report, 1987), the 'needs' to be met have not been well-defined. A key challenge is that 'needs' differ from generation to generation and from culture to culture, i.e. time- and locality-dependent (Redclift 2005).

Consequent to the differences in local contexts (Mitchell, 1996) and perspectives of stakeholders (Giannetti et al., 2009), a large number of different indicators have been developed by different organizations, cities and countries. From this perspective, to aim at a universal conceptual framework for sustainable development indicators seems to be an extreme challenge (Lyytimäki & Rosenström, 2008). Mitchell (1996) however opined that it should still be possible to identify a core set of sustainable development indicators common to all localities.

Against this background, this study aims to contribute towards the development of a common framework for sustainability indicators. Such a framework should support assessment, decision-making, communication, cooperation and calibration of policies towards goal of sustainability. To fulfill this objective, a sustainability indicators framework should possess the following attributes:

- Summarizing – a framework should be structured to allow for key indicators (i.e. key performance indicators or KPIs) to indicate whether something has gone wrong in an overall sense.
- Explanatory – readings of (un)sustainability at the summarizing level (KPIs) should be explained by further indicators, hence providing guidance on areas of weaknesses. These explanatory indicators should therefore capture understandings behind issues and challenges. A framework should cover such explanatory indicators.
- Advance alerts – a framework should help identify indicators that provide advance warnings to enable preemptive and pro-active recovery actions.
- Universality and adaptability – a framework should be universal to enable applications across time and space. This requires the framework to be adaptable to different locality and temporal contexts.
- Comprehensiveness, coverage & clarity – a framework should be comprehensive to cover all areas of sustainability and can be communicated in a clear manner.

2.0 A Basic Human Needs Theoretical Approach

This research adopted a *theoretical basic needs* approach to develop a framework for sustainability indicators. A theoretical approach is to assess a subject of interest using a set of indicators from a theoretical point of view, and there has been recognition that indices require theoretical support to be valid (Lawn, 2003). In general, currently available frameworks or indicator sets with relevance to sustainable development are not theoretically grounded in the concept of sustainable development.

In this work, theories of basic human needs were applied in the development of a sustainability indicator framework, due to the emphasis of 'human needs' as a single most important underlying factor in the discourse of sustainability. For example, Parris & Kates (2003) in their extensive research noted that the wide range of goals and targets are converging on a minimal definition of sustainable development that includes meeting human needs, while preserving life support system. In the Principle 1 of the Rio Declaration on Environment and Development, it is stated that "Human beings are the center of concern for sustainable development..." (United Nations, 1992). The human-centered perspective has also been reflected in the well-referenced definition of sustainable development given by the Brundtland Commission (1987), since it focuses on the *needs* of the present and future generation.

Three theories of human needs, as briefly introduced below, were investigated and applied in this study.

- Maslow (1970) formulated a theory of human motivation, with multiple levels of basic human needs. In his theory, there are five levels in the basic need hierarchy, namely physiological, safety, love and belonging, esteem, and lastly self-actualization (see Figure 1). When all needs are unsatisfied, human is said to focus and be dominated by the first level of needs. When needs of a level are satisfied, other higher order needs emerge.

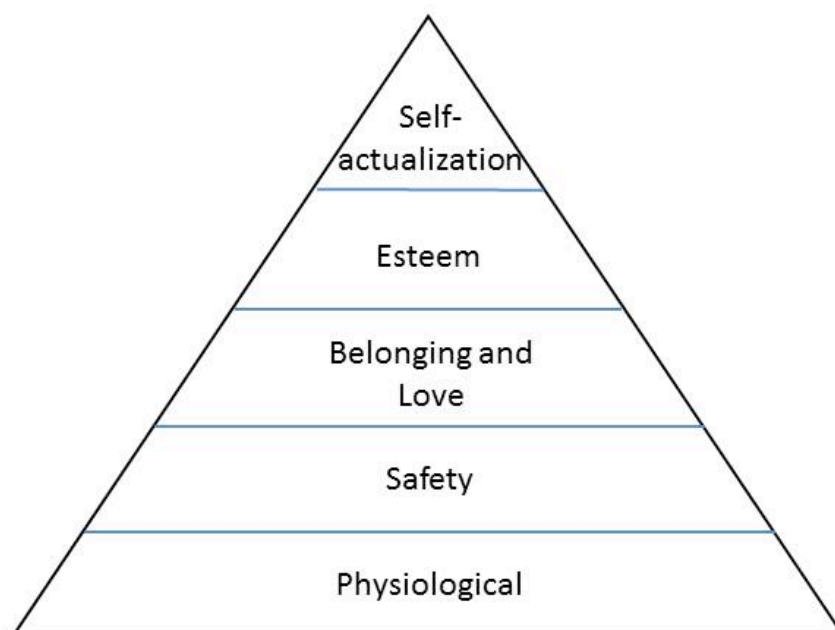


Figure 1 Maslow Hierarchy of Basic Needs

- Doyal and Gough (1991) identified a conceptual space of universal human needs. Eleven categories of ‘universal satisfier characteristics’ or ‘intermediate needs’ were identified as the followings: adequate nutritional food and water; adequate protective housing; non-hazardous work; non-hazardous physical environments; appropriate health care; security in childhood; significant primary relationships; physical security; economic security; safe birth control and childbearing; appropriate basic and cross-cultural education.
- Corning (2000) proposed the operationalization of the basic needs concept via a biological approach, grounded in the empirical problem of biological survival and reproduction for human species. As shown in Figure 2, Corning postulated fourteen domains of primary needs.

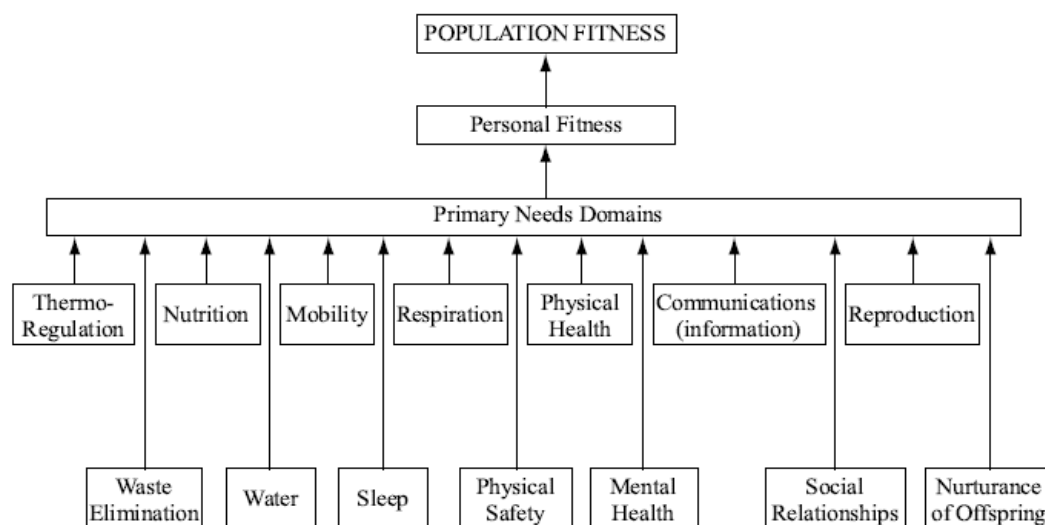


Figure 2 Primary needs domains (Corning, 2000)

The first two theories introduced above were selected in this study as they are two of the most well-cited and accepted theories of human needs. The third was included as it offers a different perspective – a biological one.

3.0 A Proposed Sustainability Indicators Framework

The framework for sustainability indicators that has been developed can be described starting from a general perspective, in a top-down approach. The proposed framework is as shown in Figure 3.

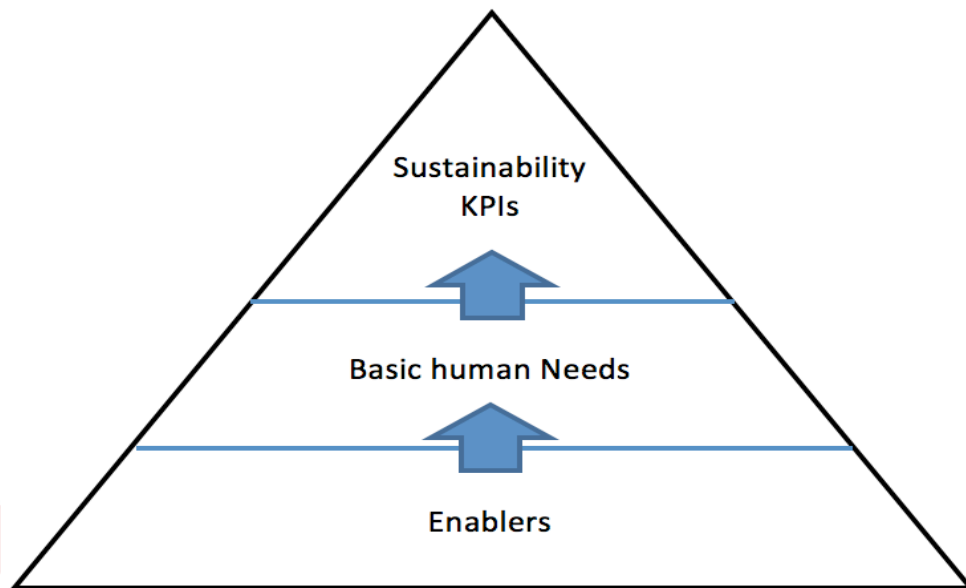


Figure 3 The proposed framework with dependency relationships between levels

- Sustainability KPIs - The apex represents the status of sustainability of a given subject, for examples a city or nation. As mentioned above, the continuation of humankind has been seen as the fundamental end goal of sustainable development. Therefore, the sustainability of the given subject is a function of the survival and reproduction of the subject's population. The status of sustainability can be measured by such indicators as life expectancy, mortality, and fertility rates, belonging to the apex of the proposed framework. These indicators in the apex of the framework are termed as *sustainability KPI* indicators. These indicators of the summarizing type are *lagging* in nature as they are generally the outcomes and manifestations of (un)sustainability.
- Basic human needs - Themes of basic human needs theories include 'to survive', 'to be healthy', 'to avoid harm', and 'to function properly' (Griffin, 1986). Human needs theories essentially postulated that in ensuring minimal life support and to sustain trans-generational continuity (i.e. survival and reproduction), basic human needs must be met (Doyal and Gough, 1991; Corning, 2000). The status of sustainability (in the apex of the proposed framework) is therefore dependent on the status of meeting basic human needs as illustrated in Figure 3. The middle tier houses indicators of basic human needs, termed as *basic human needs indicators* in the proposed framework. These indicators that measure the extent of basic needs being met are explanatory, as they explain the fundamental issues of (un)sustainability.
- Enablers - Beyond the basic needs indicators, policy-makers would also be interested in understanding the underlying determinants of basic need satisfaction. Monitoring them allows policy-makers to have a gauge of trends for effective and preemptive decision-makings. Therefore, the bottom tier of the proposed framework houses the determinants or *enablers* of basic needs satisfaction. An enabler is defined as a function that directly or indirectly facilitates the fulfillment of one or more basic human need in the proposed

framework. Indicators of the enabler-type account for causes that are leading to human need satisfaction effects. As such, they are also called *leading indicators*, which can be explanatory and serving as advance warnings to unsustainability.

As opposed to basic human need, enablers are context (e.g. culture and period)-dependent (i.e. non-universal), substitutable, reducible, and can be almost *infinite*. Similar concepts were identified as ‘specific satisfier’ by Doyal and Gough (1991) and ‘instrumental needs’ by Corning (2000), which all point to the infinite means of satisfying basic needs.

4.0 Categorizing Basic Human Needs

In general, basic need theories serve to describe needs of the humankind that are seemingly borderless, unstructured and infinite. However, as demonstrated by Corning (2000), Doyal and Gough (1991), and Maslow (1970), the range of human basic needs can be categorically defined into types that are finite, universal, non-substitutable, and irreducible. As such, for research and application purposes of the proposed sustainability indicator framework, the middle tier of the framework that is intended to capture indicators of basic needs can be further defined using theories of basic needs.

An example of such an effort is briefly introduced here. Basic needs were categorized into a total of eight basic needs *types* (see Figure 4). Detailed process of such a categorization is beyond the scope of this article, and will be discussed in a further publication.

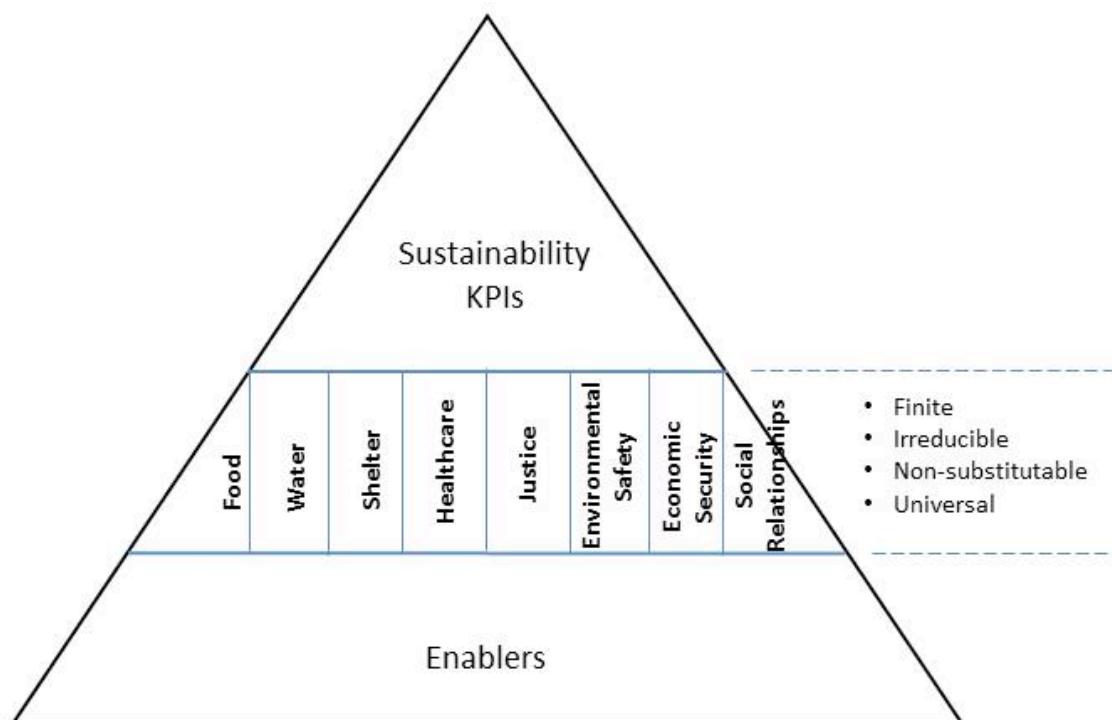


Figure 4 Proposed framework with an instance of basic needs classification

4.1 Explicating enabler networks

In the case of the basic needs classification mentioned in the preceding sub-section, one can visualize enablers forming a directed network of “*enabling relationships*”, rooted at the eight basic needs types. An illustrative network of enablers is shown in Figure 5. Each of the enablers in the network can be reduced and related to one or more basic needs types on which it has effects.

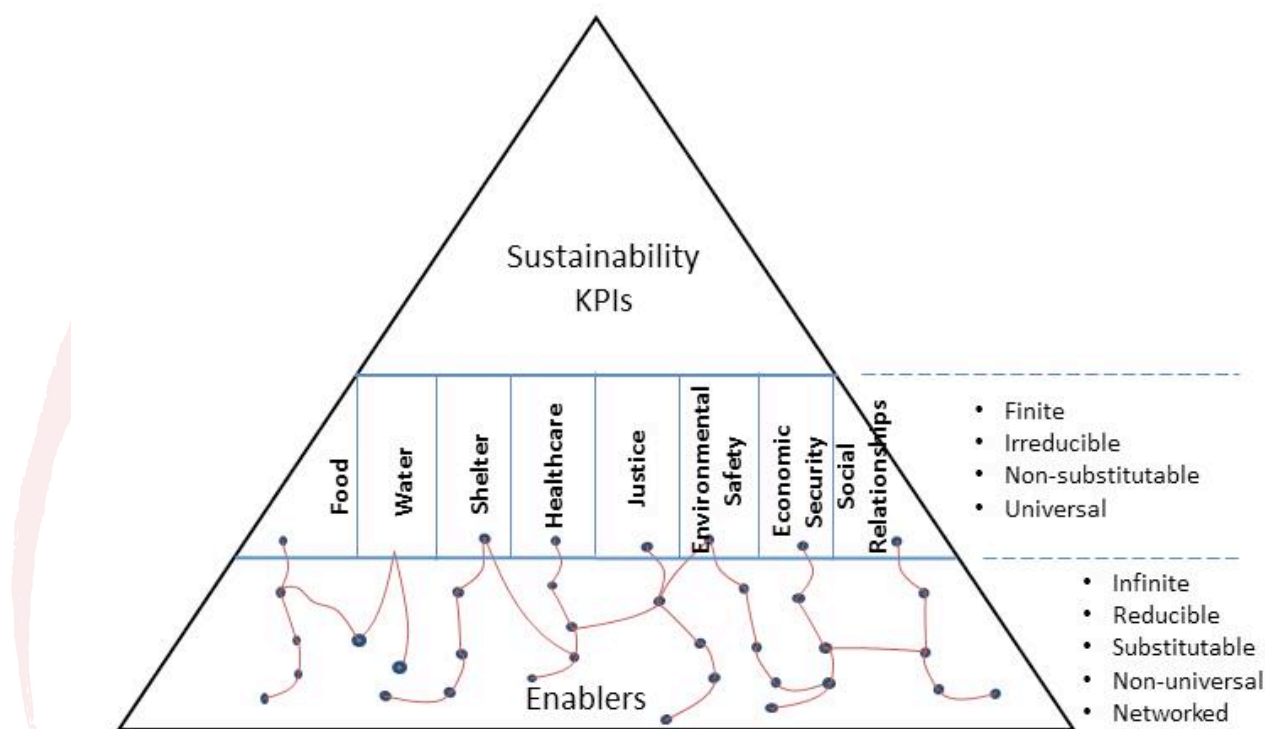


Figure 5 The proposed framework with an instance of basic needs classification, and an illustrative network of enablers

A specific example of an enabler network is shown in Figure 6. It is a directed network relating GHG (Greenhouse Gases) emission to basic human need types. The network was constructed based on findings reported in the assessment of the Intergovernmental Panel on Climate Change (IPCC, 2007). Detailed discussion of this example with reference to the report of the Intergovernmental Panel on Climate Change will be presented separately in another publication.

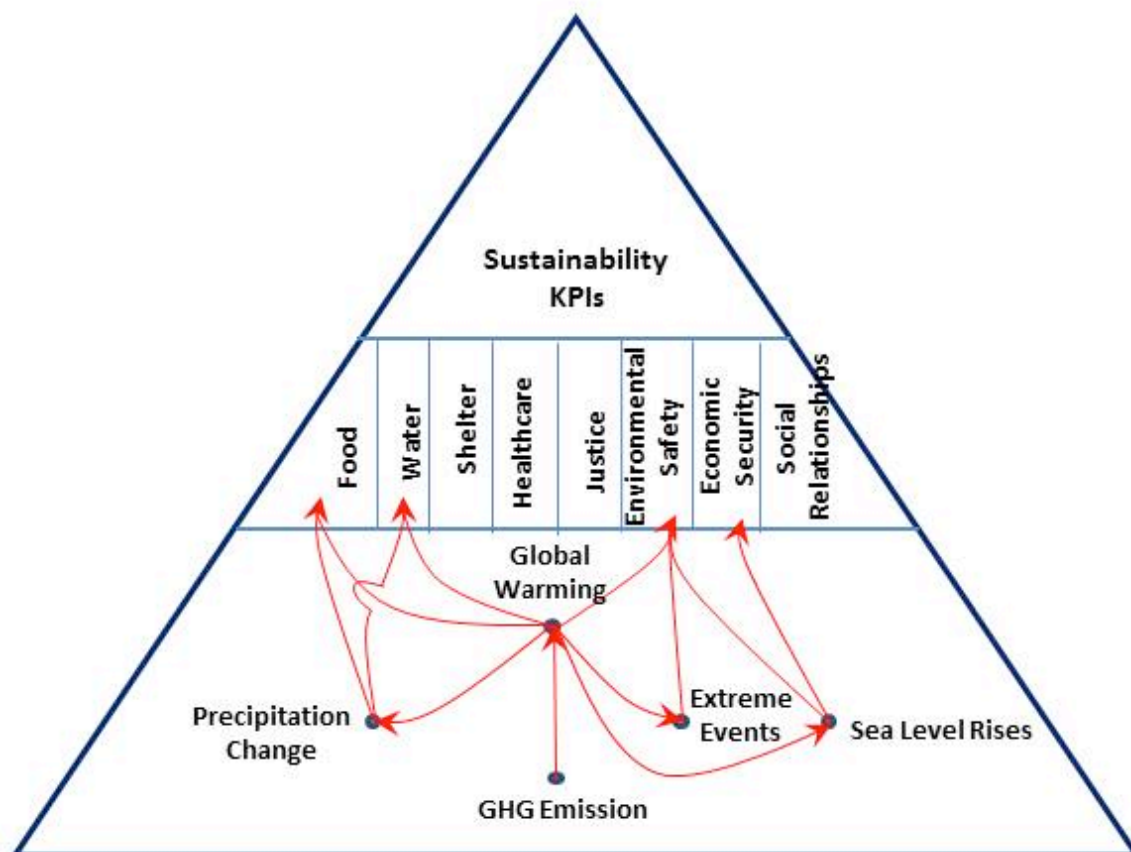


Figure 6 Proposed framework with Greenhouse Gases Emission as a (dis)enabler

4.2 UNCSD indicators in the proposed framework

In 2007, the United Nation Commission on Sustainable Development (UNCSD) published a set of latest national indicators of sustainable development. They have been extensively applied and used in a large number of countries as the basis for the development of national indicators of sustainable development (United Nations, 2007; Winston & Pareja-Eastaway, 2008).

In this research, it is an interest to analyze commonly applied sustainability indicators (the UNCSD indicators in this case) with respect to the proposed framework. The current set of UNCSD Indicators consists of a core set of 50 indicators, and these core indicators are part of a larger set of 96 indicators of sustainable development. Upon a preliminary study, it was noted that the UNCSD set of indicators is overall comprehensive to account for almost all types of basic human needs. Detailed analysis and discussion of the UNCSD set of indicators based on the proposed framework will be presented in a further publication.

5.0 Conclusion

In the midst of a wide-ranging viewpoint of what are to be sustained in the discourse of sustainability, this research performed an extensive review of the relevant literature. The notion of sustaining human needs emerged as a common underlying principle of

sustainability. By investigating and applying basic human needs theories that were prescribed to be universal across localities and time, a sustainability indicator framework of the same universality has been developed. This framework has shown promises in bearing the attributes set out in the introductory section, namely summarizing, explanatory, advance alerts, universality and adaptability, and comprehensiveness, coverage and clarity. Framework of such nature may henceforth serve as a common reference for various countries and communities across different time periods for assessments, decision-makings, and the much needed communication and cooperation in the global march towards sustainability.

Acknowledgment

This research is supported by the National Research Foundation Singapore under its Campus for Research Excellence and Technological Enterprise (CREATE).

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The logo is surrounded by two large, overlapping, brush-stroke-like arcs. One arc is light blue and forms a larger circle, while the other is light red and forms a smaller circle, partially overlapping the blue one.

References

- Brundtland Commission. (1987). *Report of the World Commission on Environment and Development : Our Common Future*.
- Corning, P. A. (2000). *Biological Adaptation in Human Societies : a 'Basic Needs' Approach*, 41–86.
- Doyal, L. and Gough, I. (1991). *A Theory of Human Need*, Macmillan.
- Gasparatos, A., El-Haram, M., & Horner, M. (2008). A critical review of reductionist approaches for assessing the progress towards sustainability. *Environmental Impact Assessment Review*, 28(4-5), 286–311.
- Giannetti, B. F., Bonilla, S. H., Silva, C. C., & Almeida, C. M. V. B. (2009). The reliability of experts' opinions in constructing a composite environmental index: the case of ESI 2005. *Journal of environmental management*, 90(8), 2448–59.
- Griffin, J. (1986). *Well-Being: Its Meaning, Measurement, and Moral Importance*. Oxford: Carendon.
- Intergovernmental Panel On Climate Change. (2007). *Climate Change 2007 : Synthesis Report*.
- Lawn, P. A. (2003). A theoretical foundation to support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and other related indexes. *Ecological Economics*, 44, 105–118.
- Lyytimäki, J., & Rosenström, U. (2008). Skeletons Out of the Closet : Effectiveness of Conceptual Frameworks for Communicating Sustainable Development Indicators. *Sustainable Development*, 16, 301–313.
- Manderson, A. K. (2006). A Systems Based Framework to Examine The Multi-contextual Application of the Sustainability Concept. *Environment, Development and Sustainability*, 8(1), 85–97.
- Maslow, A. H. (1970). *Maslow - Human Motivation*. Harper & Row: New York.
- Mitchell, G. (1996). Problems and fundamentals of sustainable development indicators. *Sustainable Development*, 4, 1–11.
- Parris, T. M., & Kates, R. W. (2003). Characterizing and Measuring Sustainable Development. *Annual Review of Environment and Resources*, 28(1), 559–586.
- Redclift, M. (2005). Sustainable development (1987-2005): an oxymoron comes of age. *Sustainable Development*, 13(4), 212–227.
- UNCSD (2012). *RIO 2012 Issues Briefs No.6* . Rio de Janeiro, Brazil.
- United Nations. (1992). *The Rio Declaration on Environment and Development* (1992).
- United Nations. (2007). *Indicators of Sustainable Development : Guidelines and Methodologies (Third Edition)*.
- Winston, N., & Pareja-Eastaway, M. (2008). Sustainable Housing in the Urban Context: International Sustainable Development Indicator Sets and Housing. *Social Indicators Research*, 87(2), 211–221.

The Impact of Energy Transition on Sustainable Supply Chain Management of Oil and Gas: A Content Analysis Oof Corporate Sustainability Reports

Wan Nurul K. Wan Ahmad¹, Marisa De Brito²

¹Delft University of Technology, Netherlands, ²Breda University of Applied Science, Netherlands

0508

The Asian Conference on Sustainability, Energy and the Environment 2013

Official Conference Proceedings 2013

Abstract

Concerns over environmental impact of oil and gas (O&G) and its future availability have resulted in increased call for transition to low carbon energy. Although various studies have been conducted on energy transition, few researchers studied the impact of the transition to O&G supply chain. Since O&G is one of the primary sources of energy, it is important to examine how the transition is impacting its operations. The issue here is not only about the sustainability of its supply chain, but also how O&G industry can remain resilient against changes in its environment and its compatibility to sustainable future. Therefore, a content analysis of sustainability reports of 30 O&G companies was conducted to identify the impact of the energy transition on O&G supply chains and how the issue is addressed by the companies. The analysis revealed that there are two types of transition currently happening in the industry – transition to (1) unconventional O&G and (2) alternative energy. While the industry is supportive to the development of alternative energy, 60% of the companies are involved in research and development of green technologies, it is also apparent that their main focus is on the development of unconventional O&G. In addition, increased efforts are being concentrated on improving efficiency of operations and products, which could help in addressing sustainability issues especially in terms of carbon emission reduction. Overall, it was found that the O&G companies seek for opportunities in alternative energy development that create synergies with their current business and areas of operations.

Keywords: energy transition, supply chain management, oil and gas, sustainable development

1 Introduction

The O&G industry plays a major role in driving economic and social growth. According to the Energy Outlook 2030 (Bp, 2011), the world primary energy consumption will grow for about 39% over the next 20 years. Even though the percentage of O&G in the future energy mix is predicted to be lower, these fuels combined will remain one of the most important sources of energy for decades to come. However, concerns over the environmental impact of O&G and the move towards low carbon economy have encouraged the development of renewable energy as its substitute. Even though the evolution process from high carbon to low carbon energy is currently very slow (Jiping, 2010), studies should be done to identify how the shift will affect the supply chain of oil and gas.

A lot of O&G companies had diversified into renewable energy business to address the issues of energy transition and increased pressure for sustainable practices. However, the impact of these moves on their sustainable supply chain management practices hardly received any attention. This gap should be addressed so as to identify the strategic and structural changes in the management of the O&G companies' supply chain due to the diversification. Therefore, this study aims to explore the impact of energy transition on sustainable supply chain management of O&G by conducting a content analysis of sustainability reports of 30 O&G companies. The following questions are addressed in this study:

1. To what extent is energy transition being discussed in sustainability report of O&G companies?
2. What are the types of energy currently being developed by the companies?
3. What are the impacts of the development to the companies supply chain management?

The outline of this paper is as follows. In Section 2, a review of literature is discussed. The methodology used in this research is presented in Section 3. Then, the result is discussed in Section 4. Finally, conclusions and recommendations for future research are presented in Section 5.

2 Literature review

Sustainable supply chain management is defined as “the strategic, transparent integration and achievement of an organization’s social, environmental and economic goals in the systemic coordination of key organizational business processes for improving the long-term economic performance of the individual company and its supply chains” (Carter and Rogers, 2008). There are two keywords in the definition which are especially relevant to this study about the impact of energy transition on O&G industry – strategic and long-term.

Achieving more sustainable supply chain is not only important in ensuring that the O&G industry could contribute towards sustainable development, but most importantly its ability to sustain itself in the future. Carter and Rogers (2008) stress that it is socially irresponsible for a company to undertake social and environmental goals of sustainable supply chain management without considering the broader context of the company’s strategic and financial goals. Taking this view into consideration, by making a transition to include alternative or renewable energy to its

business portfolio, the O&G industry will not only be able to green its supply chain but also ensure that the industry can still remain in business in the future.

2.1 *The oil and gas supply chain*

The O&G supply chain comprises of companies that can be categorized as operators (oil companies), main contractors, sub-contractors and suppliers (Anderson, 2003). There are two industrial segments in the O&G supply chain – upstream and downstream. The upstream segment which is also known as exploration and production (E&P) finds and produces crude oil and natural gas from onshore and offshore production fields. The output of exploration and production activities is used by downstream segment to produce and market various refined petroleum products for domestic and business consumers.

The O&G industry is facing increased difficulty in finding and developing new sources of fuels. This is because increasing reserves of O&G constitute of unconventional sources which are located in difficult environment such as tight rock, deepwater and the arctic which are costly to be developed (Kjärstad and Johnsson, 2009; Edwards *et al.*, 2010). The difficult environment and different types of sources require changes in the production processes as well as distribution and logistics system (Edwards *et al.*, 2010). Concerns about future availability of O&G have resulted in increased calls for transition to low carbon energy systems.

Edwards *et al.* (2010) note that the emergence of alternative energy is expected to have an impact on O&G companies in the future. According to Exxonmobil (2010), there are three factors that will shape future energy trends which are expansion, evolution and efficiency. The development of technology that enable environmentally responsible energy production will determine the ability of energy sector to expand all energy sources to meet demand and the efficiency of the fuels produced. A lot of O&G companies are transitioning itself into energy companies by investing in alternative energy development such as biofuel, wind and solar. Little is known about the impact of these ‘transition’ on O&G companies and their sustainable supply chain management strategy.

2.2 *Energy transition*

According to Smil (2008), *energy transition* “encompass the time that elapses between an introduction of a new primary energy source (oil, nuclear electricity, wind captured by large turbines) and its rise to claiming a substantial share (20 percent to 30 percent) of the overall market, or even to becoming the single largest contributor or an absolute leader (with more than 50 percent) in national or global energy supply”. It is also a term that refers to the gradual diffusion of the technology used to generate and deliver energy for household, industrial, and transportation use (Smil, 2008).

An oil transition is currently happening in the O&G industry – transition from conventional to unconventional sources. Farrell and Brandt (2006) suggest that oil transition is not a transition from abundant to scarce sources of oil. It is rather a transition to high quality to lower quality resources that simultaneously caused increased risks to the environment, as well as economic and strategic risks to O&G industry operations (Farrell and Brandt, 2006). They stress that the main challenge in the oil transition is to simultaneously manage these risks: (1) the risks of

environmental damage, (2) economic risks to consumers and investors, and (3) strategic risks associated with access to oil reserves and supply disruption.

According to multi-level perspectives of transition, the sociotechnical landscape of energy systems comprise of material and immaterial elements at macro level in which regimes and special niches exist (Kemp, 2010). The regime of energy system is dominated by fossil fuels which have been used to power the industrial and societal growth since the early 20th century. However, the regime – fossil fuel industry – is currently under pressure by the ‘landscape’ especially from the political forces, regulations, and society to operate sustainably. In addition, the regime is also experiencing uncertainty in their business as a result of economic instability and uncertain future availability of fossil fuels. Therefore, these factors have resulted in an ‘opening’ in the regime that encouraged the development of niches of alternative technology namely renewable energy.

The renewable energy accounts for about 3% of primary energy consumption in the world with major sources are from hydropower, geothermal and wind (Lior, 2010). According to Fouquet (2010), the opportunities to produce cheaper or better energy service are the main economic drivers for energy transition. In the case of transition to low carbon energy, cheaper renewable energy can be produced because its feedstock can be obtained from various sources which are abundantly available such as solar, wind, and plants. In addition, it also provides better energy service in terms of its carbon emission. The renewable energy is expected to grow at 8.2% per annum in the next two decades (Bp, 2011). However, until considerable progress is made to the renewable energy technology, its potential is limited. Currently, the renewable energy development is very slow and cost intensive since the technology used is fairly new (Lior, 2010). In addition, the viability of renewable energy supply in the long run is questioned because of various factors associated with the availability of its feedstock (Stoeglehner and Narodoslowsky, 2009; Lior, 2010; Mu *et al.*, 2011).

As one of the major players in energy sector, the O&G industry will be affected by the energy transition (Edwards *et al.*, 2010). They can either continue doing what they do best – exploring and producing O&G – but risk running out of business in the long run (Savitz and Weber, 2007); or involve in the so called cleaner energy race to remain resilient against the changes in their business environment. Fouquet (2010) notes that while it is too early and complex to identify the strategies that fossil fuel supply companies will develop to respond to the energy transition, the companies can be expected to ensure that they become more competitive and harder to be replaced. Their responses to the transition process “will probably be on a scale unprecedented in the history of energy transitions” (Fouquet, 2010).

A lot of O&G companies are involved in the development of alternative energy. It is interesting to study the impact of this move to their supply chain management strategy as they strive to operate more sustainably. Since every type of energy is different, it is important to identify the changes that the companies have to make in the management of their supply chain. To the best of our knowledge, there is a lack of research on sustainable supply chain management practices in energy transition. Literature on energy transition can generally be categorized into three areas of research namely (1) history of energy transition, (2) transition management, and (3) transition in oil and gas energy systems. Major focus of energy transition studies is concentrated on the

transition management to alternative energy or its variants – transition to low carbon economy or sustainable energy. This study, therefore, aims to add to the discussion on sustainable supply chain management aspects of energy transition by exploring this issue through content analysis of sustainability reports of O&G companies.

3 Methodology

This study used content analysis method to answer the questions listed in the introduction. Data were collected from sustainability reports of 30 O&G companies through keywords search. Sustainability reports offer rich source of secondary data that could help us understand how sustainability is being addressed by companies (Tate *et al.*, 2010). Secondary data sources are also useful in understanding logistics and supply chain phenomena, that could result in more practical managerial relevant applications especially when the data are collected from the field (Rabinovich and Cheon, 2011).

The companies selected for this study were identified using three listings: (1) 2011 Dow Jones Sustainability Index, (2) Platts top 250 global energy company ranking 2011, and (3) O&G Journal’s World’s largest O&G company ranking. The listings were used so that the companies selected comprises of those which are among the best in the industry in terms of sustainability and/or financial performance, and also among the largest O&G company in the world – some companies are listed in more than one listing.

Table 2: List of companies selected according to listings

	Dow Jones Sustainability Index	Platts Top 250 Global Energy Company	World’s Largest O&G Company
Company name	Repsol, Petrobras, Ecopetrol, BG Group, Eni, Statoil, Total		
	MOL, Sasol		
		Hess, Exxon Mobil, BP, Shell, Occidental, Gazprom, Chevron, Rosneft, Lukoil, PetroChina, Suncor	
		CNPC, TNK-BP, Marathon Oil, Gazprom Neft, OMV, Husky Energy and Galp Energia	Saudi Aramco, ADNOC and Petronas

Purposive sampling method was used to select 30 companies that published sustainability or corporate responsibility report. The companies selected are as shown in Table 2. The latest report available was used in this study – the reports are from 2009 (two companies), 2010 (25 companies), and 2011 (three companies).

Table 3: Keywords used in this study

Topic	Keyword
Energy transition	Transition, shift, energy transition, diversify/ diversification,
Types of energy	(Un)conventional, renewable, alternative, new energy
(Un)conventional oil and gas	Oil, petroleum, natural gas, shale oil/gas, tight gas, coal seam gas, coalbed methane, heavy oil, oil/tar sands, bitumen
Renewable / alternative energy	Biofuel, biomass, biogas, solar, wind, geothermal, nuclear, hydro,
Sustainable supply chain	Supply chain, network, transport, distribution, logistics, supplier, production

Data were collected from the sustainability reports using keywords listed in Table 3. Statements or sentences related to the keywords listed were gathered and categorized according to its topic category. They were analyzed to identify patterns in the discussion about the energy transition and sustainable supply chain management practices. The results are discussed in the following section.

4 Results and discussions

The results of this study are discussed according to the questions stated earlier in the introduction.

4.1 *Extent of energy transition discussions in sustainability report of oil and gas companies.*

Review of sustainability reports of companies selected in this study indicates that energy transition is an issue that attracts considerable interest from the O&G companies. About 37% of the companies mentioned energy transition explicitly in their reports. Generally, the discussions among these companies revolved around the following issues: (1) challenges and opportunities of energy transition, (2) strategy in dealing with the transition, and (3) the role of natural gas in the transitional phase towards low carbon energy systems.

The energy transition presents both challenges and opportunities to O&G companies (Hess, 2011; Mol, 2011; Sasol, 2011; Suncor, 2011). Demand for energy is growing especially from developing countries due to increased economic activities and improved standard of living. However, energy options which are favored for its economic and political appeal may not be environmentally sustainable and vice versa. Therefore, a balanced approach towards transitioning the energy systems to lower-carbon sources is required. Sasol believes that urgent developmental needs of emerging economies must be considered when making the transition (Sasol, 2011). This is to ensure that the transition is not disruptive to economic and social development, while necessary steps are also taken to reduce the impact of energy development and use to the environment. Integrated public policies that consider the contextual environment of the regions in which they apply are needed to address this issue (Sasol, 2011).

The O&G companies are also concerned about the risks that could result from legislative and regulatory requirements on issues related to the transition such as carbon emissions reduction (Bg, 2011; Hess, 2011; Repsol, 2011). Sector-based regulations being developed by governments could cause regulatory and compliance risk. This may lead to changes in technical and trade requirements in the O&G supply chain. It can also increase operating cost and reduce the industry's competitiveness. The biggest challenge of all is that the national and regional regulatory measures and international agreements to minimize emissions are evolving at different phase and timing (Petrobras, 2011). It is therefore difficult to predict its business impact and could discourage investment in necessary energy and emissions measures (Hess, 2011).

MOL reported that it has conducted a detailed study to assess the impact of energy transition to its business. Based on the study, the company is aiming to diversify its business portfolio to include power generation business, construct geothermal energy-based power plants and to continue developing more efficient and sustainable biofuels (Mol, 2011). Similar strategy is also being adopted by many other O&G companies. This is to ensure that broader options of energy products are available for customers during the transition phase (Hess, 2011). It could also help them, to some extent, green their businesses and cater for growing niche of sustainable energy markets. Energy transition, therefore, creates new business opportunities to the companies. It also contributes in helping the country where a company operates in to start transitioning the country towards low carbon energy systems (Suncor, 2011).

Energy transition is a complex process that takes decades to complete. General belief among O&G companies studied is that natural gas can play a big role in the transitional phase towards low carbon energy systems (Eni, 2011; Total, 2011). Natural gas has lower carbon content than other fossil fuels and therefore, is a cleaner energy option that could help reduce the emissions. According to Total (2011), 40% of world energy is generated using coal. If the coal is replaced by natural gas, it will help to reduce carbon emissions from power generation to 50%. Hess (2011) believes that natural gas "is a game changer that has fundamentally transformed the economics of electricity generation". It will play a critical and central role in the energy mix during the transition phase (Chevron, 2011; Shell, 2011).

4.2 *Types of energy being developed by oil and gas companies*

In line with existing literature on energy transition, content analysis of the sustainability reports indicates that there are two types of energy transition currently happening in the O&G industry – (1) transition from conventional to unconventional O&G sources; and (2) transition from non-renewable to renewable energy sources.

Table 4: Number of companies involved in unconventional oil and gas

Types of unconventional source	Total
Shale oil/gas; tight gas	16
Oil/tar sands; bitumen	12
Heavy oil (extra heavy oil)	9
Coal seam gas; coalbed methane	7

Generally, 60% of the companies discussed about unconventional O&G development in their reports. Table 4 shows the types of unconventional sources currently being developed by the companies. About 37% of the companies did not mention that they

are developing any of the sources. Among these companies are Saudi Arabian Oil Company (Saudi Aramco), Abu Dhabi National Oil Company (ADNOC) and Rosneft which are the 2nd, 6th and 11th largest O&G company in the world respectively. Overall, 13 companies are involved in the development of at least two types of the unconventional sources. Only three of them are national O&G companies (NOCs) namely China National Petroleum Company (CNPC), MOL and Gazprom Neft.

Increasing share of global O&G reserves are controlled by national O&G companies (NOCs). International O&G companies (IOCs) on the other hand, are facing deteriorating fiscal terms and increasing difficulty in accessing reserves (Kjärstad and Johnsson, 2009). The five largest O&G companies in the world are NOCs and together they are controlling about 62% of the world's total oil reserves (Petrostrategies, 2012). Edwards et al. (2010) believe that IOCs are the ones which are likely to diversify into other energy business such as biofuels. They will also continue to play important role in the O&G development since they possessed the technical know-how and the technology that are more advanced than the NOCs – they will be important service providers to NOCs (Edwards *et al.*, 2010). The result of NOCs versus IOCs involvement in the development of unconventional O&G sources mentioned earlier support Edwards et al. (2010) suggestions. IOCs are more likely to explore O&G sources which are difficult to be accessed to increase their reserves since the 'easy reserves' are being controlled by NOCs.

Table 4: Number of companies involved in alternative energy development

Types of alternative source	Total
Biofuel/ biogas/ biomass	19
Solar	11
Wind	11
Geothermal	8
Hydropower	3
Nuclear	1

Table 4 shows the types of alternative energy sources that are discussed by the companies studied. Overall, 10 companies did not report if they are involved in the development of alternative energy. Seventeen companies are developing more than two types of energy sources – seven of them are NOCs. Among the top ten largest companies studied, only two companies gave no indication of their involvement in alternative energy.

As can be seen in Table 4, biofuel is the most favored alternative energy to be developed among O&G companies. This is because biofuel is compatible with current O&G industry infrastructure and technology. Fuel from vegetable oils and animal fat can be blended with fossil fuels to be used for transportation and electricity generation (Petrobras, 2011). It can also be used to reduce sulfur content and improve quality of diesel (Ecopetrol, 2011). Total (2011) notes that biomass is the only alternative energy that could supplement fossil fuels supply. However, it is important to ensure that the crops used to produce this fuel do not compete with crops for food supply in order for its production to be sustainable.

The companies' decision regarding the type of energy that they invest in depends on their ability to create synergies between the new energy development with current business and areas of operations. The choice also depends on the ease of access to the feedstocks which are required to develop the energy. Substantial investments are also needed for infrastructure as well as research and development activities. Therefore, various other factors must be considered before an O&G company could pursue its low carbon energy ambition.

4.3 Implications of the energy transition on oil and gas companies' supply chain management

Approximately 73% of the companies discussed about issues related to supply chain management in their reports. However, most of their discussions generally revolved around O&G supply chain. Discussions on alternative energy supply chain are mostly concentrated on biofuel.

Other sources of alternative energy are discussed on a more strategic level. This could be due to the level of involvement of the companies in the development of these energy sources. Eighteen companies disclosed that they are in planning and/or research and development phase of the technologies. Partnership with, for example, other energy company or research institute in the development of alternative energy are discussed by eleven companies. Some companies such Repsol and Total acquired other companies to provide stronger platform for their involvement – i.e. Repsol acquired a company that promotes alternative energy projects and Total acquired a start-up company involved in developing purified silicon for solar power (Repsol, 2011; Total, 2011).

Issues which are related to supply chain management of unconventional oil and gas, and alternative energy discussed in the reports can be categorized as follows: supply management, production management and logistics management. The issues are summarized in Table 5.

Table 5: Supply chain management issues discussed in sustainability report

SCM areas	Unconventional O&G	Alternative Energy
Supply management	<p><i>Supplier selection & monitoring</i></p> <ul style="list-style-type: none"> - Discussion with suppliers on environmentally friendly fracking fluids; - Requirement for disclosure of chemicals used in hydraulic fracturing; <p><i>Support for suppliers' sustainability initiatives</i></p> <ul style="list-style-type: none"> - Participation in suppliers' initiatives to develop an infrastructure for sustainability disclosure (e.g. FracFocus's chemical disclosure registry) 	<p><i>Sustainable sourcing</i></p> <ul style="list-style-type: none"> - Use of local & family farmers; - Source of feedstock (i.e. from non-food crops, waste etc); - Land management / sustainable agricultural development - Inclusion of sustainability clauses into new and renewed supplier contracts; - Supplier certification; - Supplier compliance audit program;

	<p><i>Supplier development</i></p> <ul style="list-style-type: none"> - Use of local suppliers; 	<ul style="list-style-type: none"> - Supply traceability – recording system of feedstock origin; - Reliability of supply (e.g. in the event related to weather etc.); <p><i>Supplier development</i></p> <ul style="list-style-type: none"> - Integration of family farmers and small, medium & large producers; - Establishment of farmers’ networks; - Training for farmers; - Provision of inputs (e.g. for farming)
Production management	<p><i>Materials usage</i></p> <ul style="list-style-type: none"> - Disclosure of chemicals used in hydraulic fracturing; <p><i>Emissions reduction</i></p> <ul style="list-style-type: none"> - Process efficiency; - Source of energy used in production processes <p><i>Water management</i></p> <ul style="list-style-type: none"> - Water sourcing, measurement and reporting; - Water supply availability and potential impairment; - Treatment of produced water; - Use of recycled water; - Water transportation system; - Water storage; <p><i>Reduce, Reuse, Recycle (3R)</i></p> <ul style="list-style-type: none"> - Treatment and/or disposal of byproducts according to local, state & federal regulations; <p><i>Safety, Health & Environmental risks</i></p> <ul style="list-style-type: none"> - Public health and safety risks; - Effect on indigenous community; - Ground disturbance 	<p><i>Production process</i></p> <ul style="list-style-type: none"> - Integration of alternative energy production infrastructure with existing O&G production infrastructure; - Harvesting machineries; - Use of process waste to generate energy for production process <p><i>Water management</i></p> <ul style="list-style-type: none"> - Water use; - Wastewater management; <p><i>Life cycle assessment</i></p> <ul style="list-style-type: none"> - Field / agricultural area survey; - Feedstock origin; - Carbon emissions; - Environmental and community impact; - Profitability and marketability of energy produced
Logistics management	<p><i>Transportation</i></p> <ul style="list-style-type: none"> - Traffic safety; - Prevention of road deterioration; - Transport infrastructure 	<p><i>Transportation</i></p> <ul style="list-style-type: none"> - Transport infrastructure

One of the major concerns in the development of unconventional O&G is the environmental impact of its production process. This issue therefore dominates the

discussions on its supply chain management specifically with regard to the use of chemicals, water and energy as well as management of waste and byproducts of the production process – sustainability of shale oil/gas, tight gas and oil/tar sands and bitumen are discussed more than other sources. The measures taken to address the issue are basically similar to the ones taken in the development of conventional O&G sources.

However, due to increased attention on sustainability of hydraulic fracturing activities for the development of shale gas/oil and coal seam gas, among others, most O&G companies focus their discussions on the efforts to disclose chemicals used in the fracking activities specifically through cooperation with their suppliers. Water management was also given considerable attention by the companies since production of unconventional O&G requires the use of and withdrawal of huge amount of water. Water produced from the production process must be treated before it can be used or disposed off. Therefore, the O&G companies need effective water management systems that could help them to manage their water sources, its treatment, storage and transport.

In the case of O&G companies' involvement in the development of alternative energy, significant investment must be made in the supply chain such as with regard to sourcing of feedstock and development of production and logistics infrastructure to produce and deliver the energy. Planning process may take years before initial groundwork can begin considering the investment needed. Changes to the present supply chain management structure and strategy in the O&G companies are required since alternative energy sources, to large extent, differ greatly from O&G. However, it is interesting to note that issues in the management of alternative energy supply chain basically revolve around the same issues as O&G supply chain.

While alternative energy is cleaner than oil and gas, its feedstocks must be acquired from sustainable sources and irregularity of energy supply for wind and solar, for example, could cause serious energy security issues. Production process requires effective management of water, energy and waste. Logistics infrastructure such as storage and transport systems must be efficient so as to reduce cost and time to deliver supplies to users since many of production sites are located in remote areas. Therefore, similar sustainability concerns which are associated with the management of O&G supply chain – such as sustainable sourcing, supplier management, clean production, water and energy management, waste management, carbon footprint of production process and logistics activities – are also need to be considered in the development of alternative energy.

5 Conclusions

The content analysis of O&G companies' sustainability reports revealed that the discussions on energy transition among the companies are mostly on strategic level. It was found that the O&G companies are transitioning itself towards becoming energy companies by developing alternative sources apart from unconventional O&G. While the industry is supportive to the development of alternative energy, it is also apparent that their main focus is on the development of unconventional O&G. The companies also seek for opportunities in the development of alternative energy that create synergies with their current business and areas of operations which is clearly

indicated by the extent to which the alternative energy are currently being developed.

This study seeks to identify the impact of energy transition on sustainable supply chain management practices among O&G companies. Based on the findings, it can be concluded that the strategy which are being implemented by the companies – whether in the development of unconventional O&G or alternative energy – are basically similar in nature. The analysis focused on three supply chain management functions namely supply management, production management and logistics management. Regardless of the types of energy, the companies have to deal with similar sustainability issues throughout their supply chains. However, due to the limitations of the data used in this study, it is difficult to identify the structural changes in the supply chain management resulted from the diversification of the companies' businesses – i.e. changes that occurs in the key supply chain business processes and functions in the companies. Future research could look into this aspect through case studies since it enable for more detailed investigations to be conducted.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is surrounded by two large, overlapping circular arcs. The upper arc is light blue and the lower arc is light red, both with a soft, feathered edge. The overall design is minimalist and modern.

iafor

Reference

- Anderson, E. (2003) "Supply Chain Strategy in the Oil and Gas Sector." *Business Briefing: Exploration and Production*, 108-111.
- BG (2011). Sustainability Performance Report 2010. Berkshire, United Kingdom, BG Group Plc.
- BP (2011). BP Energy Outlook 2030. *BP Statistical Review*. London, British Petroleum.
- Carter, C. R. and Rogers, D. S. (2008), "A framework of sustainable supply chain management: moving toward new theory", *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 5, 360 - 387.
- Chevron (2011). 2010 Corporate Responsibility Report. San Ramon, CA, Chevron Corporation.
- Chima, C. M. (2007), "Supply-Chain Management Issues In The Oil And Gas Industry", *Journal of Business & Economics Research*, Vol. 5, No. 6,
- Ecopetrol (2011). Sustainability Report 2010. Bogota, Colombia, Ecopetrol S.A.
- Edwards, S., Ishaq, O. and Johnsen, O. (2010) "Oil and gas 2030: Meeting the growing demand for energy in the coming decades."
- Eni (2011). Eni for Development 2010. Rome, Eni.
- Farrell, A. E. and Brandt, A. R. (2006), "Risks of the oil transition", *Environmental Research Letters*, Vol. 1, No.
- Fouquet, R. (2010), "The slow search for solutions: Lessons from historical energy transitions by sector and service", *Energy Policy*, Vol. 38, No. 11, 6586-6596.
- Hess (2011). 2010 Corporate Sustainability Report. New York, USA, Hess Corporation.
- Jiping, Z. (2010), "Embracing the Low-Carbon Economy of Sustainable Energy Development", *Journal of Petroleum Technology*, Vol. No. April 2010, 18-20.
- Kemp, R. (2010), "The Dutch energy transition approach", *International Economics and Economic Policy*, Vol. 7, No. 2, 291-316.
- Kjärstad, J. and Johnsson, F. (2009), "Resources and future supply of oil", *Energy Policy*, Vol. 37, No. 2, 441-464.
- Lior, N. (2010), "Sustainable energy development: The present (2009) situation and possible paths to the future", *Energy*, Vol. 35, No. 10, 3976-3994.
- MOL (2011). MOL Group Annual Report. Budapest, MOL Hungarian Oil and Gas Plc.
- Mu, D., Seager, T. P., Rao, P. S. C., Park, J. and Zhao, F. (2011), "A resilience perspective on biofuels production", *Integrated Environmental Assessment and Management*, Vol. No. n/a-n/a.
- Petrobras (2011). Sustainability Report 2010. *Corporate Communication/ Social Responsibility/ Sector Management for Guidelines and Practices of Social Responsibility*. Rio de Janeiro, Brazil, PETROBRAS.
- PetroStrategies. (2012). "World's Largest Oil and Gas Companies ", 2012, from http://www.petrostrategies.org/Links/worlds_largest_oil_and_gas_companies.htm.
- Rabinovich, E. and Cheon, S. (2011), "Expanding horizons and deepening understanding via the use of secondary data sources", *Journal of Business Logistics*, Vol. 32, No. 4, 303-316.
- Repsol (2011). Repsol Corporate Sustainability Report. Madrid, Repsol.
- Sasol (2011). Sustainable Development Report. Johannesburg, Group Safety, Health & Environment Centre.

- Savitz, A. W. and Weber, K. (2007), "The sustainability sweet spot: How to achieve long-term business success", *Environmental Quality Management*, No.
- Shell (2011). Sustainability Report 2010. The Hague, Royal Dutch Shell PLC.
- Smil, V. (2008). Moore's Curse and the Great Energy Delusion. *The American*. USA.
- Stoeglehner, G. and Narodslawsky, M. (2009), "How sustainable are biofuels? Answers and further questions arising from an ecological footprint perspective", *Bioresource Technology*, Vol. 100, No. 16, 3825-3830.
- Suncor (2011). 2011 Summary Report on Sustainability. Calgary, Canada, Suncor Energy Inc.
- Tate, W. L., Ellram, L. M. and Kirchoff, J. F. (2010), "Corporate social responsibility reports: A thematic analysis related to supply chain management", *Journal of Supply Chain Management*, Vol. 46, No. 1, 19-44.
- Total (2011). Society and Environment Report 2010. Courbevoie, France, TOTAL S.A.

The logo for 'iafor' is centered on the page. It consists of the lowercase letters 'iafor' in a light blue, sans-serif font. The text is enclosed within a large, stylized circular graphic composed of two overlapping, thick, curved lines. The upper line is light blue and the lower line is light red, creating a sense of a circular path or a stylized 'O'.

*The Preparation of a Strategy Plan at Community Level to Produce Diesel Fuel from
Biomass of Fast Growing Tree Species*

Kittapas Suppagornmongkol, Nikom Laemsak, Panapa Saksoong

Kasetsart University, Thailand

0677

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Petroleum price has increased consistently, while the quantity of fossil fuel has decreased continuously. The increase of petroleum price has adverse effects on petroleum import in Thailand. This also leads to negative effects on Thai economics and energy security. Thailand is an agricultural abundant country. It is rich in water resources and has appropriate weather for agriculture. As Thailand is an agricultural country, Biomasses from agriculture waster are plenty. The biomass can be used in many ways directly and indirectly. One way to employ Biomass is to turn it into alternative energy. Using Biomass for energy will add the value to agricultural product and waste, which will also increase farmer's income. Additionally, the Biomass energy from agricultural sector is a clean energy and has less negative effects on environment.

The objectives of this research were to analyze economics feasibility on production diesel fuel from biomass of fast growing tree species and to study the production technology of diesel production and in addition. The result showed that the production of diesel from biomass of fast growing tree species using liquid fuel synthesis technology through chemical conversion wear diesel-like structure.

The project gives low benefit in both economical and financial aspects. From financial analysis, it is found that the project has Financial Internal Rate of Return (FIRR) -1.93%, Net Present Value (NPV) -135.71 million baht and Benefit Cost Ratio (BCR) 0.43. The capital costs for the production is 219.56 baht/liter. For encouraging the investment, the government may subsidize 146.57 million baht or 89% of the capital investment.

PROJECT PRINCIPLE

Energy is a key factor in the economic and social development of the country. The rapid development has led to a lot of energy especially fuel such as petroleum. Most of the energy sources used in Thailand are imported from abroad. The current situation of the oil price increase and volatility of prices, depending on the situation of abroad, causing instability in the energy and directly affect the cost of production, both in agriculture and industry. Petroleum price has increased consistently, while the quantity of fossil fuel has decreased continuously. The increase of petroleum price has adverse effects on petroleum import in Thailand. This also leads to negative effects on Thai economics and energy security.

Thailand is an agricultural abundant country. It is rich in water resources and has appropriate weather for agriculture. As Thailand is an agricultural country, Biomasses from agriculture waster are plenty. The biomass can be used in many ways directly and indirectly. One way to employ Biomass is to turn it into alternative energy. Using Biomass for energy will add the value to agricultural product and waste, which will also increase farmer's income. Additionally, the Biomass energy from agricultural sector is a clean energy and has less negative effects on environment.

OBJECTIVE

The objectives of this research were to analyze economics feasibility on production diesel fuel from biomass of fast growing tree species and to study the production technology of diesel production and in addition.

METHODOLOGY

1. Study the process to produce diesel fuel from biomass of fast growing tree species of two types is Acacia and Eucalyptus.
2. Analysis of cost – benefit of investment for the 2 types of wood used as raw material in the production of diesel. Analyze the costs and benefits of the project on the basis of Cost-Benefit Analysis, the Net Present Value (NPV) Benefit-Cost Ratio (BCR) and Financial Internal Rate of Return (FIRR).

RESULT

Biomass to Liquid Technology

Pyrolysis

Pyrolysis and Gasification are very similar. In general, Pyrolysis process occurs faster than Gasification. The biomass that contains Cellulose, Hemicellulose and Lignin and 20-30% of moisture will be dried at temperature 120-150 °C. After that, the temperature will be increased until 500-600°C for breaking chemical compounds. The gas products from pyrolysis are Carbonmonoxide (CO), Carbondioxide (CO₂), Methane (CH₄) and Hydrogen (H₂). The products from Biomass pyrolysis also includes volatile liquids such as water, Acitic acid, Formic acid, Acetone, Methanol, Methyl Acetate, Phenol, Tar and Char. When the temperature has reached 900-1,100 °C, the process becomes Gasification. At this temperature, the oxidant will be added in order to break down Tar and Char. Figure 1 shows pyrolysis process.

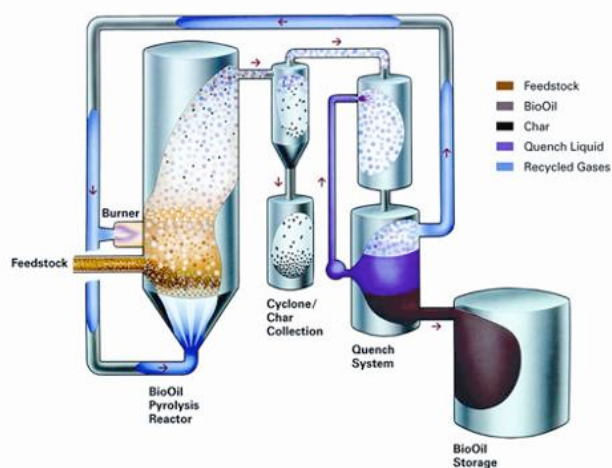


Figure 1 Pyrolysis process

Gasification via Fischer Tropsch (FT) Synthesis

Liquid fuel from Biomass production has three main processes as illustrated in Figure 2. The production process consists of:

- Biomass gasification
- Gas cleaning
- Fischer-Tropsch Synthesis

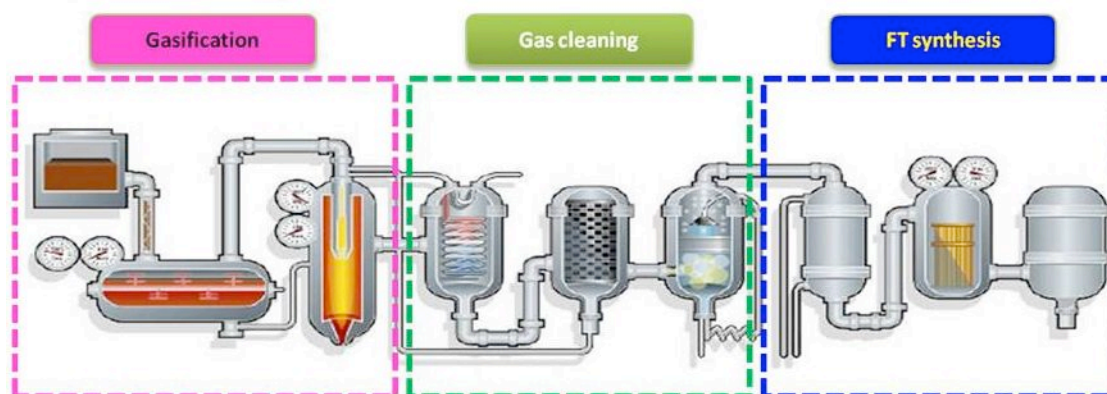


Figure 2 Production process for producing liquid fuel from Biomass

1) *Biomass gasification*

Biomass gasification is a partial oxidation process that turns solid material into gas, which is called Synthesis gas or syngas. The syngas mainly contains Hydrogen (H_2), Carbonmonoxide (CO), Methane (CH_4), Carbondioxide (CO_2), water (H_2O), Hydrocarbon compound (C_xH_y) and Nitrogen (N_2). The oxidation reaction of the process will occur at temperature $500-1400\text{ }^\circ\text{C}$ and at atmospheric pressure to 30 bar.

The oxidant can be Air, Oxygen (O_2), steam or combination of all. The oxidation that uses Air as an oxidant will produce relatively high Nitrogen concentration. Thus, heating value of the syngas is low ($4-6\text{ MJ/Nm}^3$). If Oxygen or steam is used as an oxidant, the concentration of syngas, Hydrogen and Carbonmonoxide will be high. The heating value of syngas will be $10-20\text{ MJ/Nm}^3$.

2) *Gas Cleaning and Conditioning Process*

Gas cleaning is necessary for gas synthesis. Generally, the cleaning process also includes removing of unwanted compounds. The cleaning process will remove unwanted compounds in syngas that may affect the next process, and adjust the gas composition especially the proportion between Hydrogen and Carbonmonoxide (H_2/CO). In the overview, gas cleaning will remove certain amount of unwanted compound, however, depending on type and properties of Biomass and conditions of gasification process (e.g. type of oxidant).

3) *Fischer-Tropsch (FT) Synthesis*

FT is a process that changes synthesis gas to Hydrogen compound by adding Iron or Cobalt as a catalyst. In the process, the synthesis gas that contains H_2 and CO will be put through a chemical reaction process to create Hydrocarbon chain in form of liquids. These liquids are Naphtha, Oil and Wax.

The product from the synthesis process consists of Hydrogencarbon compounds, Oxygenated compounds, CO_2 and water. The Hydrogencarbon compounds mostly are Paraffins and Olefins that are in forms of Straight Chain, Branched Chain and Aromatics. The Oxygenated compounds are Alcohol, Aldehyde, Ketone, Acid and Esters. The product from this process can be used for fuel, and the by-product can be used as an initial substance for several chemical reactions.

The FT process is a high exothermic reaction, which deteriorates the catalyst. The temperature increase in the process will increase Methane production but decrease Hydrocarbon chain. Therefore, it is very necessary to have heat exhausting system in the FT process. The exhausted heat can be used also for generating electricity using steam turbine.

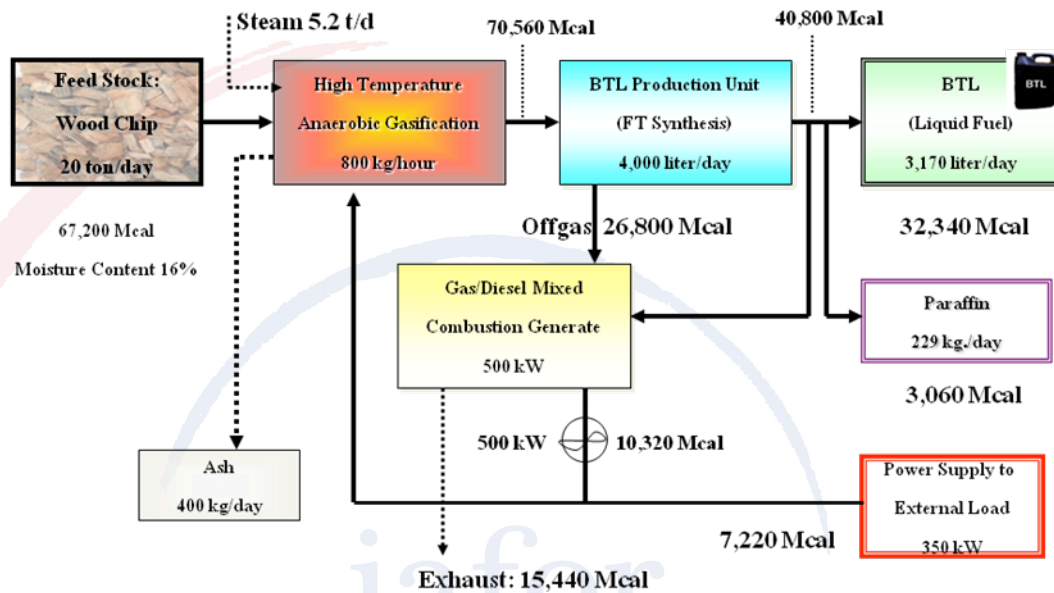


Figure 3 Energy Balance of Commercial Scale System

Cost – Benefit Analysis on Production Diesel Fuel from Biomass of Fast Growing Tree Species

Assumptions used in the study are as follows:

1. The project duration is 20 years.
2. Production capacity diesel oil is 3,170 liter per day.
3. Working hours is 365 days per year.
4. BTL sales price is 30 baht per liter.
5. Acacia crop area is 520 rai for biomass production of 20 tons per day.
6. Eucalyptus crop area is 852 rai for biomass production of 20 tons per day.
7. Product of Acacia is 3.81 tons per rai per year (moisture content 16%).
8. Product of Eucalyptus is 2.85 tons per rai per year (moisture content 16%).

Table 1 Cost benefit project analysis on production diesel fuel from biomass of Acacia

Detail	Value
Benefit Present Value (Bath)	422,083,205
Cost Present Value (Bath)	408,325,961
Net Present Value (Bath)	13,757,244
Benefit – Cost Ratio	1.03
Internal Rate of Return (Percentage)	0.084
Payback Period (Year)	9.7 (10 Year)

Table 2 Cost benefit project analysis on production diesel fuel from biomass of Eucalyptus

Detail	Value
Benefit Present Value (Bath)	417,387,602
Cost Present Value (Bath)	397,071,446
Net Present Value (Bath)	20,316,156
Benefit – Cost Ratio	1.05
Internal Rate of Return (Percentage)	0.089
Payback Period (Year)	9.1 (9 Year)

In case of production diesel fuel from biomass of Acacia, The results of the analysis show that the project has the possibility to invest. The return on investment is at an acceptable level. Considering each of the indicators and found that the net present value (NPV) is positive, meaning that when the investment plant project can provide a higher return than the cost of the entire project period. The project's rate of return (IRR), which means that the rate of return on investment equal to 0.084 percent of the present value of the income equals the present value of the costs. The payback period is 10 years.

In case of production diesel fuel from biomass of Eucalyptus, The results of the analysis show that the project has the possibility to invest. The return on investment is at an acceptable level. Considering each of the indicators and found that the net present value (NPV) is positive, meaning that when the investment plant project can provide a higher return than the cost of the entire project period. The project's rate of

return (IRR), which means that the rate of return on investment equal to 0.089 percent of the present value of the income equals the present value of the costs. The payback period is 9 years.

CONCLUSION

Biomass to Liquid (BTL) is technology of synthetic liquid fuels from biomass by providing materials. Gasification is process to heat the biomass to be burned completely. Yields a compound with a structure CO H₂ called Syngas, and then use the Fischer Tropsch (FT) to change the chemical structure of Syngas is hydrocarbon oil which has a similar feature.

The results of the cost – benefit analysis show that the project has the possibility to invest. In case of production diesel fuel from biomass of Acacia, The return on investment is at an acceptable level. Considering each of the indicators and found that the net present value (NPV) is positive, meaning that when the investment plant project can provide a higher return than the cost of the entire project period. The project's rate of return (IRR), which means that the rate of return on investment equal to 0.084 percent of the present value of the income equals the present value of the costs. The payback period is 10 years. And in case of production diesel fuel from biomass of Eucalyptus, The results of the analysis show that the project has the possibility to invest. The return on investment is at an acceptable level. Considering each of the indicators and found that the net present value (NPV) is positive, meaning that when the investment plant project can provide a higher return than the cost of the entire project period. The project's rate of return (IRR), which means that the rate of return on investment equal to 0.089 percent of the present value of the income equals the present value of the costs. The payback period is 9 years.

2014 upcoming events

March 27-30, 2014 - ACP2014 - The Fourth Asian Conference on Psychology and the Behavioral Sciences
March 27-30, 2014 - ACERP2014 - The Fourth Asian Conference on Ethics, Religion and Philosophy

April 3-6, 2014 - ACAH2014 - The Fifth Asian Conference on Arts and Humanities

April 3-6, 2014 - LibrAsia2013 - The Fourth Asian Conference on Literature and Librarianship

April 17-20, 2014 - ACLL2014 - The Fourth Asian Conference on Language Learning

April 17-20, 2014 - ACTC2014 - The Fourth Asian Conference on Technology in the Classroom

May 29 - June 1, 2014 - ACAS2014 - The Fourth Asian Conference on Asian Studies

May 29 - June 1, 2014 - ACCS2014 - The Fourth Asian Conference on Cultural Studies

June 12-15, 2014 - ACSS2014 - The Fifth Asian Conference on the Social Sciences

June 12-15, 2014 - ACSEE2014 - The Fourth Asian Conference on Sustainability, Energy and the Environment

October 28 - November 2, 2014 - ACE2014 - The Sixth Asian Conference on Education

October 28 - November 2, 2014 - ACSET2014 - The Second Asian Conference on Society, Education and Technology

November 13-16, 2014 - MediAsia2014 - The Fifth Asian Conference on Media & Mass Communication

November 13-16, 2014 - FilmAsia2014 - The Third Asian Conference on Film and Documentary

November 20-23, 2014 - ABMC2014 - The Fifth Asian Business & Management Conference

November 20-23, 2014 - ACPEL2014 - The Second Asian Conference on Politics, Economics & Law

July 3-6 - ECSS2014 - The Second European Conference on the Social Sciences

July 3-6 - ECSEE2014 - The Second European Conference on Sustainability, Energy & the Environment

July 3-6 - ECPCL2014 - The Inaugural European Business and Management Conference

July 3-6 - EBMC2014 - The Inaugural European Conference on Politics, Economics and Law

July 9-13 - ECE2014 - The Second European Conference on Education

July 9-13 - ECTC2014 - The Inaugural European Conference on Society, Education & Technology

July 9-13 - ECSET2014 - The Second European Conference on Technology in the Classroom

July 9-13 - ECLL2014 - The Second European Conference on Language Learning

July 17-20 - EuroFilm2014 - The Inaugural European Conference on Film and Documentary

July 17-20 - EuroMedia2014 - The Inaugural European Conference on Media and Mass Communication

July 17-20 - ECAH2014 - The Second European Conference on Arts & Humanities

July 17-20 - LibEuro2014 - The Inaugural European Conference on Literature and Librarianship

July 24-27 - ECCS2014 - The Inaugural European Conference on Cultural Studies

July 24-27 - ECAS2014 - The Inaugural European Conference on Asian Studies

July 24-27 - ECES2014 - The Inaugural European Conference on European Studies

July 24-27 - ECP2014 - The Inaugural European Conference on Psychology & the Behavioral Sciences

July 24-27 - ECERP2014 - The Inaugural European Conference on Ethics, Religion & Philosophy

For more information on all our latest events, please go to www.iafor.org

