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Table of Contents

6318
Degradation of AEG PV Modules Parameters after 20 Years of Operation
Emad A. Sweelem
Abd El-Shafy A. Nafeh pp. 1 - 10

7222
Tourist Gaze Concept as an Attempt for Creating City Branding Case Study: Solo the Spirit of Java
Eko Nursanty
Joesron Alie Syahbana
Atiek Suprapti pp. 11 - 23

7274
The Roles of Traditional Markets as the Main Component of Javanese Culture Urban Space (Object of Study: The City of Surakarta, Indonesia)
Istijabatul Aliyah
Bambang Setioko
Wisnu Pradoto pp. 25 - 39

7336
Conversion of Black Wattle to Bio-Oil and Chemicals on the Continuous Pyrolytic Reactor
Witchakorn Charusiri pp. 41 - 53

7567
Awareness on Fish Depletion and Fishing Practices among Fishermen around River Rima and Kware Lake, Northwestern Nigeria
Ibrahim Muhammad Magami
Sani Ibrahim
Sabi'u Musa Yelwa pp. 55 - 59

8618
Towards Sustainable Human Settlements Growth on Urban Fringe Areas with Case Study Semarang City – Indonesia
Bambang Setioko pp. 61 - 67

9065
River Flooding on Taipei City Area Inundation
Reui-Kuo Lin
Kwan Ouyang
Jen-Chieh Wu
Shi-Min Lee pp. 69 - 92

10513
Developing Lifecycle Inventory Indices for Estimating the Carbon Sequestration of Artificially Engineered Soils and Plants
Ben W Kolosz
Mark A Goddard
Ehsan M, Jorat
Saran P Sohi
David A. C. Manning pp. 93 - 112

11317
Management of Sustainability Activities in Projects: The Perspective of Project Managers
Gilman C.K. Tam pp. 113 - 127

11638
Sustainable Urban Transportation with Demand Management Methods: A Case Study for Istanbul
Irfan Batur
Muammer Koc pp. 129 - 145

11781
Exploration of Bacteria Symbionts Pocillopora Damicornis Coral for the Production of Sanitary Hand Gel
Delianis Pringgenies
Eko Windarto
Riyanda Idris,
Anggi Riqqa Khalisa, pp. 147 - 156
Vatimatuzzahra Andhalucya Subchan

11973
Deltas of the World: A Possible Comparison
Vasile Meita
Alexandru-Ionut Petrisor pp. 157 - 170

12090
Nowcasting of Photovoltaic Power Output for an Equatorial-Based Location Using Artificial Neural Network
Kyairul Azmi Baharin,
Hasimah Abd Rahman
Mohammad Yusri Hassan
Chin Kim Gan pp. 171 - 188

12111
Classical Charcoal Making and Properties of the Charcoal from Palmyra Palm Fruit as the Traditional Community Practice
Mookda Suksawat
Nicha Prasongchan pp. 189 - 195
Somboon Prasongchan

12374
Application of Triz in Resolving Water Crisis Guat Guan Toh
Guan Hin Chau
Nikalus Shu Luing Swee
Mum Wai Yip
Chee Sheng Keong pp. 197 - 208

12408
Finding the Leverage Point in the Sustainability Crisis: Global, National and Regional Australian Responses
Murray Craig Lane pp. 209 - 217

12510
Modelling and Analysis of Real Underwater Acoustic Signals Produced by Marine Energy Devices
Oshoke Ikpekha
Stephen Daniels pp. 219 - 229

12571
Effects of Turbulence Models on Microbubble Distributions in Dissolved Air Flotation Process for Water Treatment
Min A Park
Kyun Ho Lee
Jae Dong Chung pp. 231 - 239

12668
The Effect of Deforestation on Sediment in the Upper River Basin of the Lam Phra Phloeng Reservoir, Thailand
Preeyaphorn Kosa
Thanutch Sukwimolseree
Phattaraporn Sangthong pp. 241 - 253

13281
Solar Photocatalytic Degradation of 4-Chlorophenol in Water with Novel Shell-Core P3HT@TiO2 Nanoparticles
Wen-shiuh Kuo
Ren-You Zhang pp. 255 – 266

13480
Assessment of GHG Emissions From Tableware Ceramic Production in Thailand
Kannaphat Chuenwong
Boonrod Sajjakulnukit
Siriluk Chiarakorn pp. 267 - 275

13551
Developing the Methodology to Investigate the Thermal Comfort of The Elderly for Sustainable Living in Hot-Humid Thailand
Sumavalee Chindapol
John Blair
Paul Osmond
Deo Prasad pp. 277 - 292

13584
Optimum Co-Digestion Conditions for Methane Production from Chicken Manure and Napier Grass by Single Stage Digention
Supawadee Yodthongdee pp. 293 - 300

13625
Crude Oil Intensity, Production Efficiency and Adaptability to Energy-Evidence from an Economy with a High Dependence on Energy Imports
Chung-Huang Huang
Han-Pang Su
Chin-Wen Yang
Jian-Fa Li
Cheng-Yih Hong pp. 301 - 315

13649
Energy Efficiency Application in Yanbu Industrial City
Makki Ali Al-Gobbi pp. 317 - 321

13655
Land Use Change with Externalities in the Fringe of Jakarta Metropolitan: Spatial Tobit Model
Rahma Fitriani
Eni Sumarminingsih pp. 323 - 337

13766
Proposal and Discussions of Simple PCs for PV Power Generation as Veranda Solar
Keiju Matsui
Eiji Oishi
Mikio Yasubayashi
Masayoshi Umeno,
Masaru Hasegawa pp. 339 - 353

13789
Solar PVs to Charge EVs in Auckland: Potential for a Community Based Approach
Kiti Suomalainen
Basil Sharp pp. 355 - 371

13790
Comparison Analysis Between Rice and Cassava for Bioethanol Production in Japan Considering Land Use Efficiency
Marisabel Cuberos Balda
Toshihiko Nakata
Takaaki Furubayashi pp. 373 - 388

13824
Coastal Urbanization Impacts on Biodiversity: The Case of Marinas in Singapore
Loke Ming Chou
Kok Ben Toh
Chin Soon Lionel Ng pp. 389 - 395

13827
Environmental Challenges and Economic Growth in Developing Countries: Indonesian Perspective
Sri Wartini pp. 397 - 410

13837
Greenhouse Gas Emissions of Robusta Coffee Plantation in Thailand
Tanomlap Rachawat
Siriluk Chiarakorn
Amnat Chidthaisong pp. 411 - 418

13863
Game Analysis on Stakeholders of Low-Carbon Building Market Promotion
Chen-Chen He
Xiao-Ming Wang
Guo-Chao Zhao
Jingxia Wu pp. 419 - 426

13878
From E-Waste to Green Energy: Waste as a Critical Material Source for Photovoltaic Technologies: A Case Study for Industrial Symbiosis
Rhys Charles
Peter Douglas
Trystan Watson
David Penney pp. 427 - 439

13887
Bioclimatic Solar Home Design in Bangkok, Thailand
Suphawadee Ratanamart
Noppadol Maneerat
Piyabud Duangsawat pp. 441 - 453

13894
Regional Disparity of Productivity and the Factors in Japanese Industries
Mika Goto
Akihiro Otsuka
Toshiyuki Sueyoshi pp. 455 - 464

13937
Discussion on the Elements of Listed Energy Companies' Environmental Information Disclosure in the New Context of China's Environmental Legal System
Chen Yu pp. 465 - 480

13956
The Construction of Low-Carbon Renewal System of Rural Community
Guochao Zhao
Xiaoming Wang
Chenchen He
pp. 481 - 490

13965
A Study on the Energy Certified and Consuming of the Supermarkets in Taiwan
Po-Yen Kuo
Hui-Yen Liao
Jen-Hao Yang
pp. 491 - 502

13966
Light Pollution Mapping of Urban Human Activity and Land Zoning
Yu-Chan Chao
Yi-Sheng Lin
pp. 503 - 512

13976
Soil Water Repellency a Global Problem: Impact, Measurement and Mechanisms
Helen M. Balshaw
Peter Douglas
Sujung Ahn
Stefan H. Doerr
pp. 513 - 523

13977
Renewable Energies in Between Landscape and Landmark: Case Studies
Elisabetta Ginelli
Alessandra Bianchi
Gianluca Pozzi
pp. 525 - 554

14024
Concept and Practice of the Cultural Heritage Conservation after Flood Disaster: A Case Study of Ayutthaya, Thailand
Wittaya Daungthima
Kazunori Hokao
pp. 555 - 566

14058
Stakeholder's Engagement to Assess and Enhance Climate Change Adaptation Strategy for Water Resource Management
Liang-Huey Lo
Hai-Chen Lin
Yueh Wu
Yeun-Jeng Lai
Albert C. T. Li
pp. 567 - 578

14116
Thermochemical Energy Storage as a Way to Increase the Sustainability of Energy Generation
Johannes Widhalm
Thomas Fellner
Markus Deutsch
Andreas Werner
Franz Winter pp. 579 - 593

14132
Comparison of Photometric Quantities and Photon Quantities of Light Sources for Interior Green Wall Illumination
R.T.H. Ng,
H.D. Cheung
M.Y. Chan pp. 595 - 607

14171
The Dynamism of Old Wooden Houses within the Chiang Mai City Wall
Pranom Tansukanun pp. 609 - 626

14684
Energy Demand Exploration for Yogyakarta Energy Efficiency Plan
Lilies Setiartiti pp. 627 - 637

15264
The Distributional and Welfare Effects of the Emission Trading Scheme on Australian Households
Trang Minh Tran pp. 639 - 654

15552
Disaster Adaptation by Community for City Sustainability. Case Study: "Poor vs Rich Settlements" in Coping Flood Hazard in Jakarta, Indonesia
Irene Sondang Fitrinitia pp. 655 - 664

16006
The Impact of Agglomeration Economies on Energy Efficiency in Japan
Akihiro Otsuka
Mika Goto pp. 665 - 679

16207
Sustainability of Local Food Supply Using New Agriculture Theory in Organic Farming Context in Uttarakhand, India
Ricardo Situmeang pp. 681 - 694

16504
Marketing Mix to Promote Tourism in the Nature Education Center for Mangrove Conservation and Ecotourism in Chonburi Province
Pimphun Sujarinpong pp. 695 - 703

16552
IPA Free Texturization Process for Monocrystalline Silicon Solar Cells by PTFE Mask
Thipwan Fangsuwannarak pp. 705 - 711

16553
Effect of Organic Solution based Additive on Exhaust Emissions of an Indirect Injection Diesel Engine
Karoon Fangsuwannarak pp. 713 - 721

16674
Optical Advances in the Field of Selected Solar Technologies for Exploitation in Building Energy Efficiency
Miroslav Čekon
Pavel Rovnaník
Rastislav Ingeli pp. 723 - 735

16683
Corporate Social Responsibility Disclosures: A Study of the Financial Characteristics and Capital Investment of the S&P 500 Firms
Hong V. Nguyen pp. 737 - 750

16744
Sustainable Advances of Windows in Energy Efficient Buildings: A Perspective Novelty Integrating of New Conceptual Solutions
Pavel Oravec pp. 751 - 760

16778
Capacity Building Towards Improvement of Energy, Environment, and Community Development Compliance in Indonesia: A Case Study of Pesanggaran Power Generation
Dewi Permatasari
Igan, Subawa Putra
Ibnu Agus Santosa pp. 761 - 779

16782
Make-Up Water Utilization Using WWTP Effluent Recycle: A Case Study of Grati Combined Cycle Power Plant, East Java Province, Indonesia
Mila Tartiarini
Dewi Permatasari
Harry Nurdianto
Zulfina Dhini Annisawati
Nia Nihayati pp. 781 - 789

16783
Environmental and Biodiversity Information System "E-Bios" towards Supporting Environmental Compliance: Grati Combined Cycle Power Plant, East Java Province, Indonesia
Miftachun Nisa
Dewi Permatasari
Alin Kurniawan Purwanindita
Nia Nihayati pp. 791 - 800

16786
A Study of Electricity Utilization in Beach Resort Hotels, Chonburi Province for Energy Conservation
Nattapas Rasmimanont pp. 801 - 813

16801
Whether to Invest in Energy Saving Technologies or Elsewhere? A Decision Support Tool
Kanishka Chauhan
Mh. Moiez Gohar
M.V. Panduranga Rao pp. 815 - 827

16805
Training Onshore Failure Rate to Offshore Cost Effectiveness Analysis in Condition Monitoring System
Xi Yu
David Infield
Sami Barbouchi
Redouane Seraoui pp. 829 - 841

16814
Eco-Efficiency with Social Performance of Fresh Latex Production in the Southern of Thailand
Weerawat Ounsaneha
Thunwadee Tachapattaworakul Suksaroj
Cheerawit Rattanapan
Kitikorn Chamondusit pp. 843 - 850

17369
Assessment of Carbon Footprint Organization and Analysis of Appropriate Greenhouse Gas Mitigation Measures: Case Study PTA Factory in Thailand
Jiraporn Thamniamin
Chanathip Pharino
Thanapol Tantisattayakul
Premrudee Kanchanapiya
Orathai Chavalparit pp. 851 - 858

Degradation of AEG PV Modules Parameters After 20 Years of Operation

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Abstract
Si-based photovoltaic (PV) modules are now a mature technology and their lifetime is in the range of 25 to 30 years in the operating field. During this period, many times, it is required to find out the health of the PV modules in the field in order to estimate the performance degradation after certain time period. In this paper, the parameters degradation of one AEG PV module (monocrystaline Si-based), operating for a period of just more than 20 years, is studied and compared to their initial reference data. The considered PV module parameters are, firstly, analytically analyzed and then estimated from the experimentally measured module characteristics. The characteristics were measured for the considered PV module twice. The first one was during the first year of purchasing and installing the PV module, while the second one was after a period of about 20 years from installation. The results showed the effect of 20 years aging on the considered PV module.

Keywords: PV Modules, PV Parameters, PV Degradation.

1. Introduction

The monitoring and performance analysis of photovoltaic (PV) modules with respect to possible causes and effects of degradation and PV ageing, over a time-dependent frame, provide a real picture of this critical issue. Degradation effects rise by weathering, initial photon degradation and module package degradation. These effects have different time evolution or dependence under exposure to weather and environmental conditions, in general [1].
PV modules are probably the most important component of any PV system. However, some modules degrade or even fail when operating outdoors for extended periods. Thus, long-term performance of photovoltaic (PV) systems is vital to their continuing success in the market place. The gradual energy output loss over long periods of time is a major concern to all renewable energy stakeholders. A wide variety of degradation rates has been reported in the literature with respect to technologies, age, manufacturers, and geographic locations. Significant variation in the data can be caused by different module types, age, construction (encapsulation, front- and back-sheet), electrical set-up, and measurement uncertainty. The literature contains an excellent review of long-term field testing based on discreet I-V measurements, but fewer reports include more comprehensive I-V parameters investigation, including voltage and current at maximum power point. [2].
The main scope of this work is to study and evaluate the effect of parameters degradation due to aging mechanism on one AEG PV module's performance characteristics after 20 years of in field operation.

2. The PV Model

The PV arrays are built up with series and/or parallel connected combinations of solar cells. A solar cell is usually represented by the equivalent circuit given in Fig. 1(a). Therefore, for an array of $n_s \times n_p$ (i.e., cells in series by panels in parallel) the current equation [3,4] is:

$$I_{PV} = n_p I_{LG} - n_p I_{os}\left[\exp\left(G\left(\frac{V_{PV} + I_{PV}R_s}{n_s}\right)\right) - 1\right] - \frac{V_{PV} + I_{PV}R_s}{R_{sh}} \quad (1)$$

Where,

$$G = \frac{q}{A_i\, TK} \quad (2)$$

$$I_{os} = I_{or}[\frac{T}{T_r}]^3 \exp(\frac{qE_{G\circ}}{BK}(\frac{1}{T_r} - \frac{1}{T})) \quad (3)$$

$$I_L = [I_{sc} + K_I (T_c - 28)] \times \frac{Rad}{1000} \quad (4)$$

$$I_{PV} = n_p I_{cell} \quad (5)$$

$$V_{PV} = n_s V_{cell} \quad (6)$$

$$R_s = R_{scell} \frac{n_s}{n_p} \quad (7)$$

$$R_{sh} = R_{shcell} \frac{n_s}{n_p} \quad (8)$$

The array temperature T_c is given, approximately, by the relation [3]

$$T_c = T_{air} + 0.3 \times Rad\% \quad (9)$$

All the symbols in Eqs. (1) – (9) can be defined as

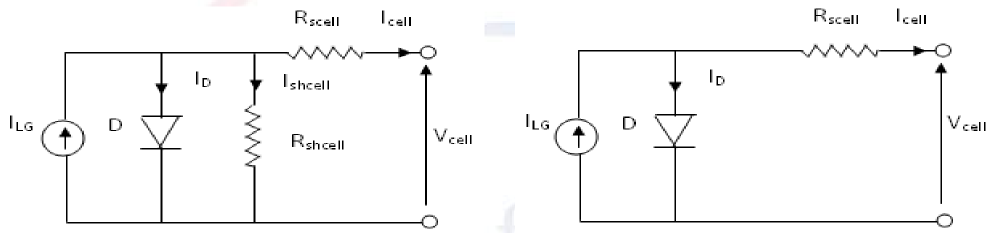
I_{PV}	PV array output current, A
V_{PV}	PV array output voltage, V
n_s	number of cells connected in series
n_p	number of panels connected in parallel
I_{LG}	light-generated current, A
I_{or}	reverse saturation current at T_r, A
$A_i = B_i$	ideality factors
K	Boltzmann's constant (1.380×10^{-23})
G	radiation, W/m^2
q	electronic charge (1.6×10^{-19} coulombs)
T_r	reference temperature ^{o}C
I_{os}	cell reverse saturation current, A
T_c	cell temperature, ^{o}C
T	cell temperature, ^{o}K
K_{Isc}	short-circuit current temperature coefficient, A/^{o}C
Rad	cell illumination, W/m^2 (1000 W/m^2 $\equiv$ 100 % illumination)
I_{sc}	cell short-circuit current, A
$E_{G\circ}$	band gap for silicon, eV
T_{air}	ambient temperature, ^{o}C
R_s	PV array series resistance, Ω
R_{sh}	PV array shunt resistance, Ω
I_{cell}	cell output current, A
V_{cell}	cell output voltage, V

R_{scell} cell series resistance, Ω
R_{shcell} cell shunt resistance, Ω

Since the value of the shunt resistance R_{sh} is very large, the last term in Eq. (1) becomes very small with respect to the other terms. Therefore, the last term will be neglected, in this work, as it will not cause a large error in the PV array model; hence, Eq. (1) can now be modified to the form

$$I_{PV} = n_p I_{LG} - n_p I_{os}\left[\exp\left(G\left(\frac{V_{PV} + I_{PV} R_s}{n_s}\right)\right) - 1\right] \quad (10)$$

Equation (10) can be represented (for one cell) by the simplified equivalent circuit shown in Fig. 1(b).



(a) Actual cell model (b) Simplified cell model

Fig. 1 Equivalent circuit models of a PV cell.

3. PV Parameters

There are some important parameters that can characterize the PV performance. One of these parameters is the short–circuit current I_{SC} which is simply the generated current I_{LG}. A second parameter is the open-circuit voltage V_{OC} which is obtained by setting I = 0 in Eq. (10)

$$V_{OC} = \frac{n_S}{G}.\ln\left((1 + \frac{I_{LG}}{I_{OS}})\right) \quad (11)$$

No power is generated under short or open circuit. The maximum power P_{max} produced by the device is reached at a point on the characteristics where the product I by V is maximum value. This is shown graphically in Fig. 2, where the position of the MPP represents the largest area of the rectangle. While, the third characterized parameter is the fill-factor FF that is defined as

$$FF = \frac{V_{mp} I_{mp}}{V_{OC} I_{SC}} \quad (12)$$

Where, V_{mp} and I_{mp} are the voltage and current at maximum power point.

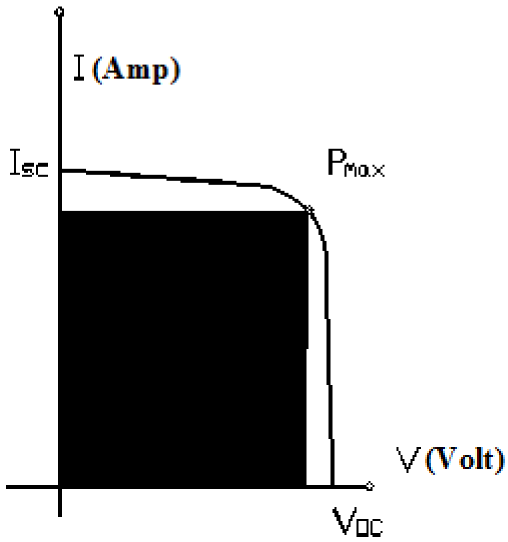


Fig. 2 The I-V characteristics of a solar cell with the maximum power point.

Also, the PV module efficiency η is calculated as shown in the following equation

$$\eta = \frac{P_{\max}}{A_m Rad} \tag{13}$$

Where, A_m is the area of module in m^2.

4. Determination Of Series Resistance

The data of the PV modules are based on actual manufacturers' information. Some of the manufacturers did not supply series resistance specification for the PV modules. However, it can be easily calculated using the method of Wolf and Rauschenbach [4,5] as follows:

1- Trace the I-V characteristics of the module at room temperature and at two different irradiances (magnitudes need not be known). During the two measurements, the cell temperature must not vary by more than 2 ºC.

2- Choose a point P on the higher curve at a voltage slightly higher than the voltage for maximum power (Fig. 3). Measure δI, the difference between the current at this point and I_{sc1}.

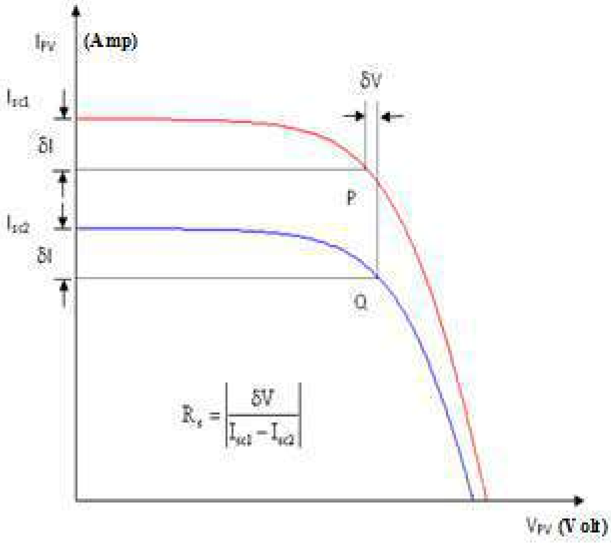


Fig. 3 Determination of R_s.

3- Determine the point Q on the lower curve at which the current is equal to I_{sc2} - δI.
4- Measure the voltage displacement δV between points P and Q.
5- Calculate R_{s1} from

$$R_{s1} = \frac{\delta V}{I_{sc1} - I_{sc2}} \tag{14}$$

Where, I_{sc1} and I_{sc2} are the two short-circuit currents.

6- Repeat steps (3) to (5), using a characteristic taken at a third irradiance and the same temperature, in combination with each of the first two curves, to determine two more values, R_{s2} and R_{s3}.
7- Take the mean of R_{s1}, R_{s2}, and R_{s3} as the definitive value of R_s.

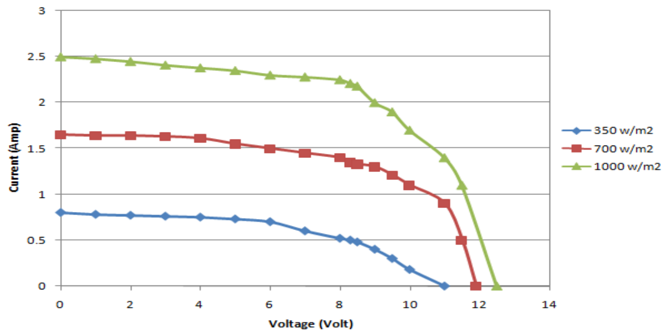
5. Experimental Measuring Circuit

The PV parameters were measured by building up the experimental circuit shown in Fig. 4. In this circuit, the considered PV module, which is connected in series with a variable resistance load, is an AEG module that can give 23.2 W_P at standard test conditions (i.e., 1000 W/m^2 and 25 ^{o}C). This module contains 20 monocrystalline silicon solar cells of 10 × 10 cm^2, connected in series. The variable resistance load is used to vary the PV operating point on a certain I-V curve. Also, two avometers are used to measure the PV voltage and current. In addition, a pyranometer is used to measure the level of the incident solar insolation on the considered PV module. Moreover, a thermocouple, connected to a digital temperature meter, is used to measure the module surface temperature. Thus, the considered experimental circuit becomes able to measure the I-V characteristics of the considered PV module at different atmospheric conditions.

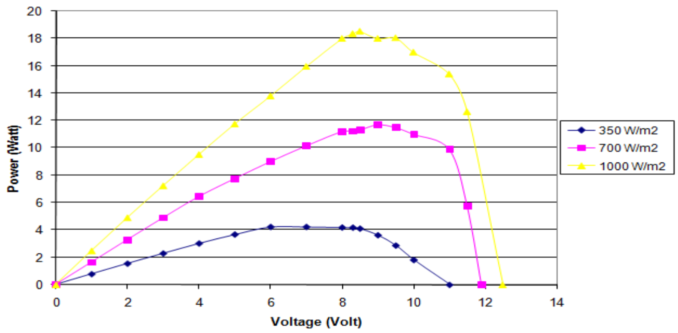
Fig. 4 Experimental PV measuring circuit.

6. Results And Discussion

In this work, the I-V characteristics of the considered PV module were measured, using the experimental circuit, twice. The first one represents the initial-module I-V characteristics during the first year of purchasing and installing the PV module on the roof of the PV Cells Dept., Electronics Research Institute, Cairo, Egypt (i.e., from about 20 years ago). While, the second characteristics represent the currant I-V characteristics of the considered module. Both characteristics are shown, together with their corresponding P-V characteristics, in Figs. 5 & 6. Noting that both characteristics were measured at three different insolation levels (i.e., 350, 700 and 1000 W/m^2) and at nearly 46 ^{o}C. Noting, also, that the module temperature was kept nearly constant at 46 ^{o}C, for both cases, by cooling the PV module throughout the measuring periods. Thus, these two Figurers indicate that the output current, voltage and power of the considered PV module are decreased, at all insolation levels, after 20 years of in field operation. Therefore, the effect of aging mechanism on the considered PV module leads to a corresponding degradation in its performance.

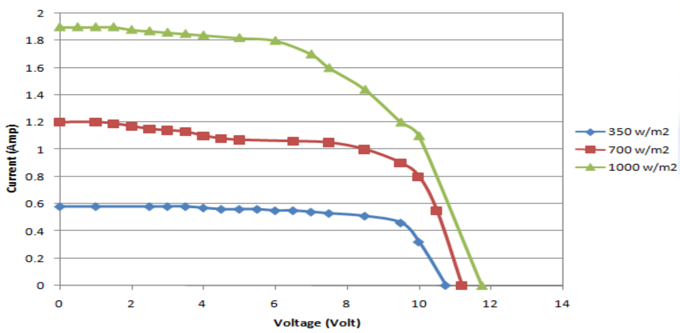


(a) I-V characteristics

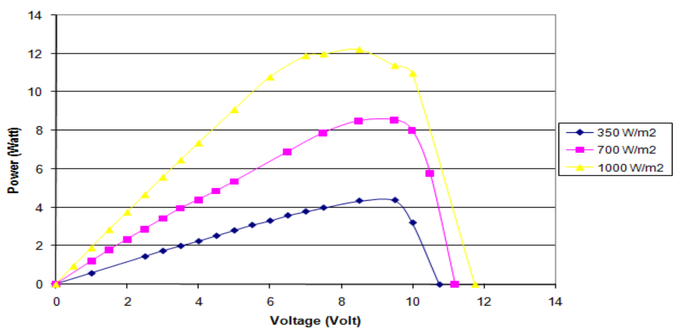


(b) P-V characteristics

Fig. 5 Initial characteristics of the PV module (i.e., from 20 years ago).



(a) I-V characteristics



(b) P-V characteristics

Fig. 6 Current I-V, P-V characteristics of the PV module.

Table 1 shows a comparison between the initial- and the current-module's parameters. Thus, this table indicates that all the current-module's parameters are decreased compared to its initial parameters except for the case of the series resistance.

Table 1 Initial- and current- PV parameters of the PV module.

Par.	V_{oc} (V)		I_{sc} (A)		I_{mp} (A)		V_{mp} (V)		P_{max} (W)		η (%)		FF		R_s (Ω)	
Rad (W/m^2)	Initial value	Current value	Initial value	Current value	Initial value	Current value	Initial value	Current value	Initial value	Current value	Initial value	Current value	Initial value	Current value	Initial value	Current value
350	11	10.7	0.8	0.58	0.55	0.5	9.5	8.74	5.24	4.37	5.8	4.85	0.61	0.6		
700	11.9	11.2	1.65	1.2	1.35	0.9	9.5	9.5	12.83	8.55	7.12	4.74	0.66	0.63	0.46	0.52
1000	12.5	12	2.5	1.84	2.18	1.42	9.5	8.5	19.86	12.2	7.7	4.74	0.64	0.55		

7. Conclusion

The effect of parameters degradation due to aging mechanism on one AEG 23.2 W_P PV module is studied and evaluated for a period of 20 years of in field operation. The considered module parameters are analytically analyzed, at first, and then estimated from the experimental measured module characteristics. The characteristics of the considered PV module are determined by building up an experimental PV measuring circuit, which can measure the I-V characteristics of the PV module at different insolation levels. Experimental results indicate that all the parameters of the considered PV module are degraded due to aging mechanism. Thus, the entire current-module's parameters are decreased compared to that of the initial-module's parameters except for the case of the series resistance.

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Tourist Gaze Concept as an Attempt for Creating City Branding Case Study: Solo the Spirit of Java

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Abstract
The tourism industry has had rapid improvement in the last two decades, and will continue in the future. As much as every culture, the individual who is positioned in tourism need "selling point" in order to draw tourism capital, which are certain aspect of the heritage that can be alocated to give impression to the tourist that they gain genuine experiences. As such, tourism also give the society chances to determine who they are and to promote their identity through comodification of cultural aspects.

The objective of this research is to find cultural activities that have certain characteristic attributes, which is determined by themselves disregard of the other objective. In this case the society choose how they are going to represent themselves to the world.

The research method employed is study case on one of the tourism and also historical city in Indonesia, Solo. The city of Solo along with its history is considered to be able to place its branding as part the marketing attempt of the city, especially in tourism.
The result of the test is expected to be able to uncover any attempt to utilize tourist gazes on the city of Solo which ultimately capable of strenghtening the city branding along with its ability in marketing attempt of the city. The power to create identity and identity mechanism reproduction of groups in the culturel tourism field is inabling the local to express their ethnical pride and inspire the place and event with the most representative identity of their special interest along with the values.

Keywords: tourist gaze, city tourism, city branding, Solo, tourism

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Introduction

Every human needs recreational activitie. Generally human needs certain short time to stay away from their work and daily activities. It regard the process of enjoying product and service, which they cannot have or enjoy. They enjoy these sort of things for they want to enjoy pleasure of different, very unique experiences from their daily routine.

At the very least, some of the different experience is to witness sets of different view, landscape or unusual building arrangement. When someone have a long trip, they will view the environment in a more intenst and serious manner. It will show us how to appreciate or expect of what we are going to do later on.

John Urry, a sociolog, had built the tourist gaze theory based on the theory of human passion to do pleasure activities and the reason the visit certain place. According to Urry (2002), tourism involves long trip activities to find experience, visual object that one does not usually see at home. The main activities of tourist is view signs or "gazing at the signs. In other words, tourist gaze is how the tourist view what the are encountered during tourism activities (Urry, 2002). In tourist gaze, the tourist gazes at certain images on certain space. Like a famous worship place, beautiful and attractive landscape. The example is when one is visiting New York, the tourist wants to gaze at liberty statue. As tourists, they usually want to find something different from what they usually encounter in their daily life. They adopted "tourist gaze".

The difference in societies and their social groups in their own unique history will change the development of tourist gaze. This paper will try to combine the structuring and forming process of tourist gaze and those involved in it, any consequencess for the city space as the object of tourist gaze and their relationship with the various city marketing actors.

The Theoritical Definition Of Tourist Gaze

Tourist gaze is the product of society, social groups, through the historical steps. Each gazes or tourist gaze objects, has different structurization process, there is no general experience in regard to the creation for the tourist. In many historical period, gaze was structured through the relaitonship and irony, into the form of social experience aside from the tourist experience and re-awareness (Urry, 2002).

Parts of the tourist gaze are interdependant for the contrasting nature of the relationship between the non-tourism experiences. The gaze indicated a social activity system as part of the tourism experience itself, where some of them not only have similar characteristic but also contrasting impact with the non tourism experience. Sometime, some of them based on the settlement and salary.

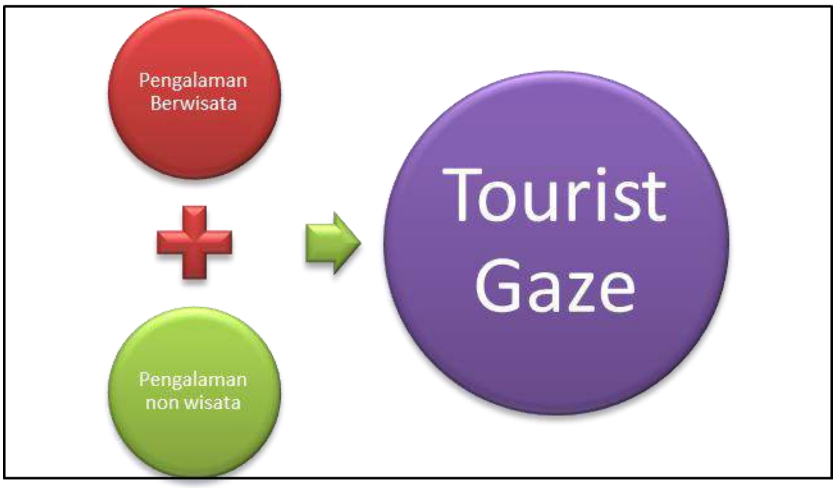

Figure 1: Tourist Gaze Process

While the meaning of tourism itself is one's activities to make use of spare time which activities are planned. It is one of the manifestation of how works and recreational activities put in separate place and ruled by social practice in modern societies. Tourists grows from the process of human movements to many tourism object they are visiting. The movement between space and duration of stay will produce their own type of trip.

The space that is chossen by the tourist and become tourist gaze has been anticipated through intens expectation and fantasy, and any influence occuring in many different scale. Some anticipation is built and developed through the variation of any non tourism experiences like film, television, literature, magazine, video recorder, which all of them will build and strenghten gaze. Tourist gaze are shown by the images of landscape and city buildings that are different from what they usually see everyday. some of the aspect view for they capture an unusual feeling.

The tourist view are often influenced by the different shape of the social pattern, with more sensitifity for the visual elemen of landscape or city buildings compare to the their normal daily life. They maintain those imaging through the picture taking, post card, film, model (miniature), etc. Those mentioned are enabling the long lasting nature of the gaze to be reproduce and pictured back. Gaze is built through the sign where tourist is on the attempt to collect those signs.

Gaze can be taken of two form, romantic and collective. The romantic gaze depict space as place with its uniqueness on certain location and certain moment, like Tokyo on spring for sakura flower. While collective gaze is the combination of certain theme, like culture and the uniquenes of certain location and season or moment. The example is the atmosphere of Sonkran in Thailand cities.

Figure 2: Tokyo on autum.

Despite the distance between these two there are many things that are possible to be connected by some industry, which is build to unite the difference of these gazes (Urry, 2002). The complex relationship between these two elements are influenced by the regulation of tourism services. On the other hand, there are some cultural experience had by the tourist that promote sets of social activitiy options built by feeling differences. Human wants definite spaces, seeing part of the objects of several human tipe's combinations. On the other parts, some different tourism services have also being produced, especially under the maximum benefit of the tourists. As we all have witnessed, there are many internationals industries have build sets of tourism services which is low cost and cover large market segments to be built.

Figure 3: The atmosphere of Bangkok during Sonkran
Source: Thailandnews Daily

Thus, we can conclude that the relationship between the theory of Tourist Gaze in urban design is by preparing spaces that can be parts of tourist gaze as the space capable of providing characteristic uniqueness compared to what they have already experience at home or even other places they have visited before. This space will give spaced experience that looks unique for the tourists who are visiting and do gazing in their activities.

City Tourism and the History

World Tourism Organization and European, (2005) define town and history tourism as those which cover (1) human movement to enjoy cultural attraction in the cities that is different from their daily life, with the emphasize on sharing new information and culture that satisfy their cultural need and (2) all human's dynamic specifically destined to enjoy new cultural attraction, such as historical sites, art form like dancing and theatrical play on certain city that is different from their own in their original environments or countries. In regard to the structuring attempt, a city can be view as tourism destination for tourist is depict in tabel 1 below:

Type of place / Product category	**Village**	**Town**	**City**	**Metropolis**
Heritage	Cluster 1	Cluster 2		
Heritage + The Arts		Cluster 3	Cluster 4	
Heritage + The Arts + Creative Industries			Cluster 5	Cluster 6

Figure 4: Space clasification and cultural product
(World Tourism Organization and European, 2005).

There are six cluster stages, which determine the relationship between type of space and the category owned by the them (World Tourism Organization and European, 2005). Cluster 1 is village area along with its heritage, in this case usually traditional custom village. Cluster 2 is the heritages that become part of a city, which usually have product that is capable to use as gaze objects. That is cluster 3, the heritages themselves along with the owned art, like the area of Little China or Little India in some part of big city. Cluster 4 is similar to cluster 3 but it is tend to be a big city. An old city which is capable of attracting tourist can be considered cluster 4. While cluster 5 is the combination between, heritage, art, and creative industries in a city. Cluster 5 has scale and uniqueness of a city, while cluster 6 has similar content with cluster 5 but the cover has become metropolis, which it has been connected with other larger environment, in some area, international.

According to Richards (2000), there are four types of cultural tourism according to existing definition. Those four types are: tourism-derived definition, motivational definition, experiential definition, and operational definition. These different definition are decipts on the following diagram.

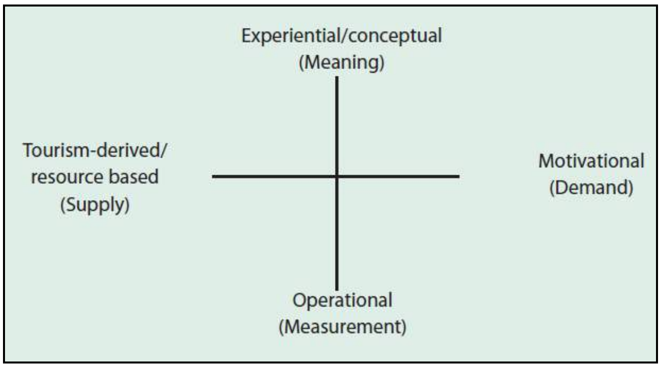

Figure 5: The Division of Cultural Tourism Definition
(World Tourism Organization and European, 2005).

On the vertical axis, the definition that states the meaning related to the experience that is being experience by the tourist and the opposite is the one related to operational size or scale. While the horizontal axis is taken from the motive-encouraged needs, while the fullfilment is in the form of city-owned resources. the culture itself is divided into inner and outer circle diagram as follows:

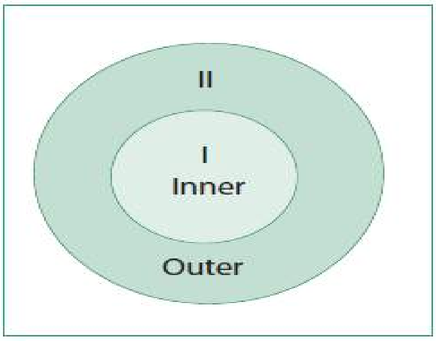

Figure 6: The categorization of cultural tourism
(World Tourism Organization and European, 2005).

The inner circle I depict the primary elements of cultural tourism, which is divided into two part, they are historical tourism (related to old artefact), and art tourism (related to the contemporary culture like visual art, contemporary architecture, etc) while the outer II is the secondary elements consist of dua part that are lifestyle (such as the element of belief, tradition, society, etc) and creative industries (such as, fashion design, film, media, entertainment, etc).

Hospitality or friendly attitude in welcoming the visitors rely on various economical, political, and ethical even as the attempt to widden the tourist gaze all over the world and draw it into warm and abundance social environment between the host and visitors. The existing relationship shows the combination of hospitality and competitive attempt between wold’s large industry have been commercialized (Derrida, 2000)

Human is interested on how the space can interact with them through a system that can re-display this space and anything in it. A part of physical environment cannot naturally emerge as a tourism site. It must be designed into building, social utilities, family lifes, friendship and memories. A place can re-emerge as tourism sites if it can be part of expectation, display, and memories. It most also posses economical features, like the product of culture, the politic of human dynamic, objects, signs and information (Urry, 2002).

Thus, city tourism along with its history or heritage, is an important part of tourist gaze, for it offers sets of unique images and experiences, which is unusual and very different from those of visitor's origin. The urban design should also prepare some convenience for this activities in the form of sets of appropriate circulation for the capturing of gaze on many potential places, like in table I.

City branding and City Branding attempts

The tourist gaze theory is growing through the support of mass tourism that is triggered by rising of budget airways. At the same time the same happen to new industries, which are based on information technology, and run by the tourism and traveling agencies. According to MacCannel, (1999), the growing number of pictures or images being spread enabling a "site" to become "sight" or merely place into meaningful location. Tourists is starting to visit church not for religious cause but to take picture of on that location. In fact, something that somehow special on certain city is capable in attracting tourist. The most populer items are seen differently from what people usually meet at home or work, in term of scale, meaning, or experience.

Tourists visits a city to stare at the object that is built on the city's environment. Based on Lynch's research (1960), stated that most of the individual's perception on a city is as a package consist of objects such as: patch (road, railways, where people travel); edges (area limit)' districts (part of a city with its characters like settlement, neighbourhood, etc)' nodes (strategically located meeting places like square, street corner, etc); ladmarks (special objects functioned as general reference point). Lynch also found the through parts of city have the effect of making the city image stronger for human, some city are more memorizeable than others. For tourist, edges and landmark are especially have more function to address the image of city, for they are more eye-catching, and easier to noticed and remembered.

Tourists visit a city because they associated it with a person personality, like famous painter, musicion, author, etc. It is not rarely that site's claim whcih has special link with the famous individual is the result of city branding. Thus, Ashworth (2009) called this brand technique Gaudi Gambit after the Barcelona's succesfull brand making with its architec and designer Gaudi. Painter and musicion are the appropriate icon for a city, whether or not they are exclusively related to the regarding place. By using the theory of tourist gaze and the decpition of a town, we are able to gain more understanding of why the number of tourist visiting one city is higher than the other. These place are usually comprise of more edges, nodes, and landmark on them.

Object and method of research

The research sites is Surakarta city, which usually called Solo city. The reason for this selection as research sites is the building of city branding' Solo the spirit of Java, which implies on the city's policies at govermental, economic, investment and city planning affair. One of the implication for the Solo municipal government policy is the attempt to provide convenient transportation for visiting tourist by using *Werkudara* buses. This tourism buses cross the main street of Solo, exploring rows of both heritage and modern objects. They give unique experience and object for the tourism as one attempt to display as many gazes as possible for the town visitor. City space along with its facilities are bunch of gaze capable of support each other to give different uniqueness. It is the sets of gaze in the city space that expected to promote the brand of a cities, especially Solo.

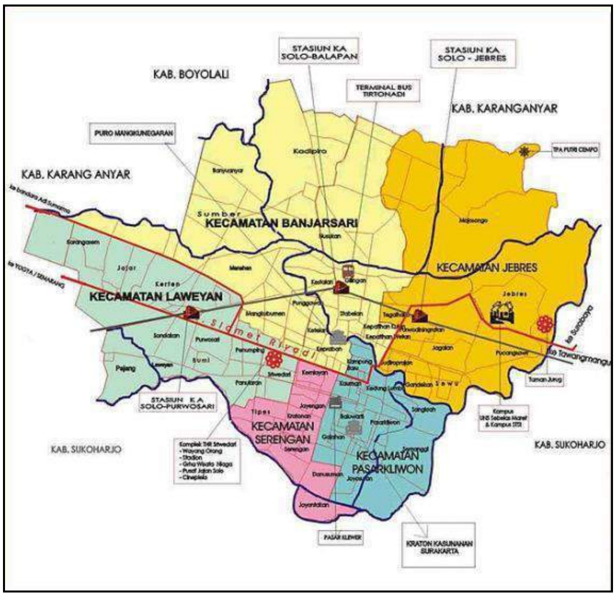

Figure 7: Area Map of Sukakarta City (Wikipedia, 2014).

In the attempt to apply the concept of city branding which has been part of the Slogan "Solo the spirit of Java", it's the only city in Indonesia that has tourism buses along with city tourism route, served by buses called *Werkudara.* This buses attempt are usually done by developed country in the form of *hop on bus,* which routes are meant to introduces the areas of their Cities.

Figure 8: Hop on Bus at Solo (Indonesia) – Singapore – Kuala Lumpur (Malaysia)

The tourism buses in the city is a legal attempt to create brand for tourists, to depict not only locations, but also activities and the organization system of the city. For Solo, the routes are as follows;

Figure 9: the route map of Werkudoro tourism buses
(source: Dishup Kota Surakarta)

Result and discussion

There are variety of aspect of tourist gaze and it has been known that it could take different forms in regard to its possible kinds and organizaiton in relation between tourism industries built to unite different gazes. There are two elements involved in tourism service practices. One part is the practices in the field of services constructed based on different taste, such as to lead people to be in certain places, to see and gaze at certain object, etc. On the other side, there are many provided and conducted services for tourist in order to maximize the benefit, such as those seen in international industry that develop segmented-market-enabling cost to be profitably developed.

The set experienced by the tourists who use werkudoro tourism buses comprise of different existing building functions both modern and heritage, which some of them are tourism destination. This gazing activities to the certain panorama conducted by the tourist, are conditioned by the personal experience and memories framed by rule and style, and also circulation of pictures and tekst. In Solo, this circulation is highly influenced by the tourist's perspective inside the bus, street's widht, and building height, which produce perspective of their roof, which can only be seen on certain corner of the street, such as in picture bellow:

Figure 10: Street corner leading to Pasar Gede Solo

In this case, it is quite difficult to create frame that functioned as tourist gaze regarding that this set of sight is expected to become critical, technical, cultural source with the potential of enabling the tourist to see the physical and material space at their sight range as something that is interesting, nice, or beautiful. They do not only belong to sight. And without this lens, the beautiful sequence found in the nature or world are built will be very different. It is different way of sight where it has a lot of consequences in the world physicaly and developmental.

There are many tourism fascilities are passed by existing tourism route. Some of them are modern and some of them are traditional having heritage nature. Total, ther are still 13% of them with the chance of maximum function of having heritage power and built to provide the need of modern society in addition to tourism site function. It is also found that there 6% of this set of touris gaze with the heritage value but does not function at all. In regard to the concept stated by Lynch (1960), Solo is trying to creates nodes which are passed by Werkudoro. There are two kinds of monument that each of them depict solo differently: Manahan statue depict Solo as the city in Java with the reputation of Mataram kingdom, and Supriadi statue that depict solo as part of Indonesia who once experience struggle to gain freedom from the hand of colonialist. Generally, this set of tourist gaze has 63% potential of heritage and 36% potential as modern.

The tourist gaze effect has huge impact on the revenue from the tourists (Hospers, 2009). The many serials depict many heritage ini Solo are expected to give positive impact on Solo branding as the Spirit of Java. One of the challenge emerge is the tall tress in solo, which are as tall as the best position on the top of the bus, making the creation of gaze is not at the maximum.

Romantic gaze/ a gaze of novelty is the gaze that has been attached deep in tourist mind who gaze at a space accompanied with the understanding that the space still remind him of previously seen space (ryan, 2013). The result of the research reveal that 68% of the responder have greater admiration to the background story of historical destination than other elemens except for the beauty of building's ornament, building funciton and also physical items such as building as function and physical properties like the function of the area that has been adjusted for the need of current space user. Still in regard to the responder result, the location they have been traveled using Werkudara buse, the places they want to visit further are the location depict in this map:

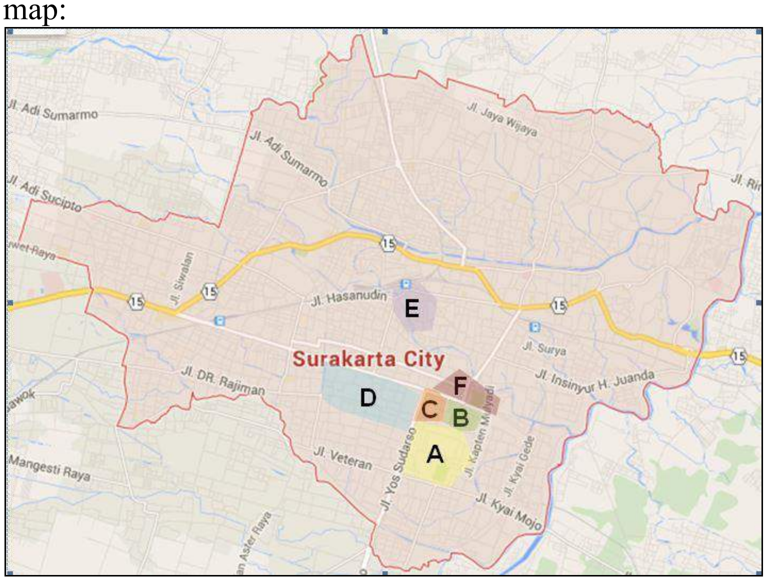

Figure 11: The Area with the power of novelty, chossen by the responder

Some of the area that become responder choice are as follows (depict in figure 11). They are: A: Kasunan office area (23%); B: Pura Mangkunegaran area (21%); C: Kauman Area (18%); D: Laweyan Area (21,5%); E: Balapan trainstation area (9%) and F: Gede market area (7,5%).

Generally, the A and B area are once the center of Mataram Kingdom milestone, thus it become the center of genuine Javanese culture in Solo. Thus the gaze attached all over Solo is greatly influenced by this area where they have not only original physical building, but also people life and their activities with their unique variety and never bored the tourists.

A brand can generate significant meaning to the process of differentation thus itu would generate competence of a product of in this case the destination along with the accompanied services (Barnes, Mattsson, & Sorensen, 2014). From the figure 10, Gede market is less attractive to the tourist despites the attractive historical and novell architecture. But it’s function as a market greatly influence the tourists in a way that they treat it only worth for sightseeing and taking picture. Bellow is the market during imlek compared to the changes has been made, as depicted in figure 12:

Figure 12: Pasar Gede atmosphere when the Lunar 2015.

To comprehend, explain, and predict the appreciative manner to the brand of destination, the concept need to be used is: destination image (Baloglu & Brinberg, 1997). In this reserach, the respon occured in the city space around Gede market, that it is becoming the chossen space for 100% responden to spend most of the time in this area, to do different kinds of public activity and to enjoy other fascility around the area like the monastery next to the market as part of China Town brand, which strongly related to the theme of Chinese new year for chinese people.

Conclusion

This research has found that the tourism transportation owned by a city is proven capable to strenghten the role of the gaze to the visiting tourist of a certain city. With the right planning of the passenger view from the bus and the planned chossen locations, the tourism vehicles are able to give strong image of a city that eventually give brand to this city in order to compete for the destination selection conducted by the tourist.

Althought the tourist had have the emerging gaze before they come to intended destination, which previously acquired information could be from the history and uniqueness of a destination, the city planner can have another attempt in the form of brand strenghtening by adding the service on the certain destination in hoping that it would strenghten the extended theme. This emerging them is appropriately adjusted to certain periode, which make the area is not only for its space function but also for the special moment such as Chinese New Year, Ramadhan, etc.

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The Roles of Traditional Markets as the Main Component of Javanese Culture Urban Space (Object of Study: The City of Surakarta, Indonesia)

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Abstract
Traditional markets function not only as a mere trading place but also as a place for life conception and socio-cultural interaction. In the scope of traditional Javanese city, traditional market is a part of typical basic urban structures and an ever-existing part of the spatial arrangement pattern of cities in Java, for instance, Surakarta. This study was conducted in Surakarta, which is aimed at investigating the roles of traditional market as a structure component of traditional Javanese urban space. This study is an inductive qualitative research employing several methods of analysis, i.e., Spatial Analysis to find out the interrelationship between traditional market with the structure of traditional Javanese urban space and Interactive-Analysis Model. The results of this study suggest that the roles of traditional markets, physically, are the urban space component namely "Catur Gatra Tunggal" (Four Single-Slot), and being a part of city space structure which upholds the concept of Javanese cosmology where traditional market is placed in "Negaragung" zone. Not to mention, in traditional market networking, the location is determined based on "Mancapat Mancalima" which brings influence on the operational system of traditional market in traditional cities of Java.

Keywords: Traditional market, the traditional city of Java, the city of Surakarta Indonesia

Introduction

During the kingdom era, a city was composed by the existence of big/small settlements, open space (markets, religious ceremonies, public festivals), and streets, which was known as 'Majapahit Complex'. It is strengthened by the presence of several typical traditional Javanese cities mentioned by experts such as Stutterheim, Maclaine Point, Palmier, Witkamp, Van Mook, and Santoso. The variety of typical traditional Javanese cities suggests that traditional markets' component and position occupy a core region of a kingdom called *Negaragung* or the city center. As a component of traditional Javanese cities, traditional market is an ever-existing part of the spatial planning pattern of cities in Java (Santoso, 2008). Traditional market is a part of urban activities' catalysts having various functions. The location of traditional markets occupies a particular area with or without buildings used as the place where the trading activities take place. Sellers and buyers meet at the specified place, at a time set within a certain interval (Jano, 2006). On the other hand, traditional markets function as a node of the exchange of goods and services on a regional basis which then grow and develop evoking various activities in a city (Sirait, 2006).

In a traditional Javanese city, traditional markets have strategic roles, both spatially and non-spatially, namely as the space for socio-culture and socio-economic of the society. At macro level, the presence of traditional markets is a part of the typical basic structure of a city (Adrisijanti, 2000). Moreover, traditional markets located downtown can be seen as a subsystem of a larger economic system to encourage the development of a region and form a circuit round of trade (Sunoko, 2002). The traditional markets having critical roles are usually located in the city centre with higher rank, whereas the supporting markets are located in the suburbs (Pamardhi, 1997).

Unlike the structure of traditional Javanese cities, the urban structure of modern or western cities is marked by the existence of desentralisation, dispersion, and several activity centres, eventually forming a spatial structure which is complex and susceptible to conditions (Anas, Arnott, & Small, 1998). Urban space is generated from the city's surface as the floor and the building's facade as the enclosure. Specifically, a city's features are strongly related to the activities done within a city, thus there are trading city, industrial city, and other cities in accordance with available activity features in the cities (Gallion & Eisner, 1983). Besides, these features will produce a synergy of physical planning and activities within urban spatial planning which gives solid void composition, inter-part relationship, and responsive condition towards the users' needs (Trancik, 1986). Meanwhile, at macro level, modern urban space according to Spreiregen, Krier, and Gallion & Eisner emphasizes more on physical and economic aspects. In other words, all spatial formations in a city are emphasized more on market driven, with the city's service system towards *Central Place Theory* (Christaller, 1966).

In this current era, all regulations related to the provisions of health, education, shopping, and praying facilities are allocated with service distribution consideration which refers to *Central Place Theory*. Various urban spatial planning and development decisions are taken based on service scale principles in accordance with the number of population and the demand of public needs service from social and economic aspects. Meanwhile, cultural, historical and public values do not become the main orientation in formulating urban development planning.

Those situations are completely different from the existing phenomena in traditional Javanese cities. The allocation of facilities and infrastructure in traditional Javanese cities which are particularly related to the main elements (Karaton, mosque, square, and market) cannot be examined by employing modern (western) theory comprehensively. Therefore, urban area development should consider the urban development process throughout a period of time, experiences from the past, and values attached to urban traditional forms towards continuing cities (Sharifi & Murayama, 2013). Consequently, these bring influence on today's free market climate in response to the establishment of Asean Economic Community. All planning forms are orientated towards goods supplies and distribution as well as economic values or market driven. Every strategic position in a city will be perceived as assets which can be developed economically, as a regional node to encourage various activities within a city generating the relations between social, economy and production (Sirait, 2006).

From the above differences, thus, it can be inferred that the concept of traditional Javanese urban space positions traditional markets as cultural product, social function and life conception of Javanese society. Besides, in its development, the concept orientates more on socio-culture or socio-culture driven. On the contrary, the urban space concept based on modern theory positions traditional markets as economic facility and regional trading node, and in its development it orientates more on economy or market driven. Nevertheless, how traditional markets' roles position themselves as a component of the traditional Javanese urban structure has not been identified in detail yet. Hence, it is necessary to conduct a research aimed to examine the roles of traditional markets as a component of the traditional Javanese urban structure. In this case, Surakarta is one of the traditional Javanese cities having specifications and phenomena related to the problems. Therefore, the case study of this research chooses Surakarta as the research locus.

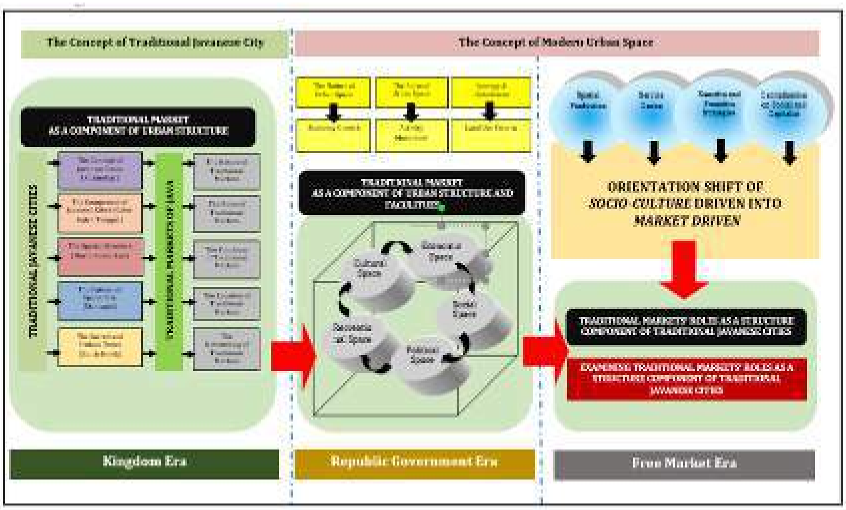

Figure 1: Mindmap and Background Knowledge

Literature Review

A. The Definition of Javanese Traditional City

According to several Javanology experts, traditional Javanese city is identical with the terms 'kingdom' or 'kraton' or 'state' or 'complex'. These terms are used differently, but have the same meaning, that is the central government as the city centre. The term 'central kingdom', which is then called 'state', is used by Selo Sumarjan (in Santoso, 2008) to explain that state is a place where noblemen and high class government employees reside. Meanwhile, the term 'complex' is used by Pigeaud to refer to 'Majapahit Complex' as a city comprising a number of big and small settlements which are separated by open spaces and wide streets. The open spaces are utilized for public interests, for instance markets, meeting sheds, cockfighting arena, religious ceremony venues and public festivals (Santoso, 2008). The spatial concept of traditional city in the golden period of Islamic Mataram kingdom is known as *Cosmology* concept in which the region is divided into four parts, namely *kutagara*, *nagaragung*, *mancanegara*, and *pesisiran* (Tjiptoatmodjo, 1980).

On the other hand, in modern context, a city is perceived as a relatively big, populous and permanent settlement, consisting of heterogeneous individual groups as seen from social perspective. City is one of complex human life expressions (Zahnd, 2008). In other words, city is seen as a space experiencing interrelationship processes between people as well as between people and their surroundings. These relationships create land user pattern forming a city structure. Based on urban space classical theory, urban space is formed from a city surface as the floor and building's façade as the enclosure and creates an urban life situation place (Spreiregen, 1965). Furthermore, city is a settlement having relatively big population, limited area, generally non-agrarian, relatively high population density, place for groups of people at particular number living together within particular geographical area by economic and individualistic rational relationship pattern (Kostof, 1991). Meanwhile, according to sociologists, the meaning of city is strongly related to the existence of market, that is a place in which people can fulfill most of their economic needs at local markets. A city's characteristics include the existence of markets as fortress, as well as private law system and cosmopolitan (Weber, 1994).

B. Traditional Market as a Component of Urban Structure

As mentioned by Wiryomartono, market as a noun is synonymous with "peken" and the verb is "mapeken" which means to gather (Wiryomartono, 2000). The primary requisite of market formation is there is a meeting between sellers and buyers either in one place or in different places. Market is also an economic element which can bring benefit and prosperity to human's life (Toni, 2014). The presence of market as the media for production and distribution of production output contributes significantly in accelerating working system, mindset and quality of production types. In other words, markets can be an indicator in the change of production, consumption and distribution of certain goods. Some of traditional markets in Java reflect agrarian life pattern and cannot be separated from livelihood's characteristics of the surrounding society (Sunoko, 2002).

Traditional markets particularly located in urban areas have grown in Indonesia since the early settlement or kingdom. In the period of Majapahit Kingdom in 14th century, markets have developed within the city center area which were located at intersections (Santoso, 2008). In addition, one of the Eerste's historical notes (in Adrisijanti, 2000) shows that Banten city had owned several traditional markets in 1646 located in Paseban, Pecinan and Karangantu. In the early growth, traditional markets were in the form of spacious field without permanent buildings (Graaf, 1989). As the time passes by, traditional markets were established in many cities, formed by trading activities which are developed in open and adjacent spaces, fields and roads, and adjacent to settlements. Traditional markets are usually located in strategic places, reachable by both sellers and buyers which are not far from village, inter-villages and safe place from common interference (Rutz, 1987).

Besides, traditional markets have humane characteristics so that they can develop closeness and "kinship" relationship between sellers and buyers. In line with this, Rahadi also suggests that service quality and consumer identification factors play critical roles in encouraging consumers to shop or make a purchase again in traditional markets. Indeed, these friendly and acquainted relationships between sellers and buyers become special characteristics of traditional markets (Rahadi, 2012).

1. The Roles and Functions of Traditional Markets in Urban Space

Traditional markets grow and develop as a node of goods and services exchange on a regional basis which subsequently evoke various activities in a city. The activities are not only in the form of goods and services exchange or selling-buying, but also information and knowledge exchange (Ekomadyo, 2012). It is in accordance with Geertz's theory which suggests that "market" is an economic principle as well as a way of life, a general style of economic activity covering various aspects of particular society up to socio-culture life aspect comprehensively (Geertz, 1963). In the scope of Javanese society, the strength of economic activity is centralized in traditional markets. Traditional markets function not only as a selling buying place but also a life conception and socio-culture interaction (Pamardhi, 1997). On the other side, traditional markets also reflect the society's life, marked by society's social economy domination as the environment where markets are established (Hayami, 1987). According to Bromley, traditional markets in Asian countries are located in rural and urban areas (Bromley, 1987). Furthermore, it can be figured out that the existence of traditional markets lies on social factors including norms, beliefs and bargain which can strengthen loyal network of market visitors to keep shopping in traditional markets (Andriani & Ali, 2013).

2. Traditional Markets in Urban Economic System

Traditional markets are seen as an organizational system comprising interconnected and interdependable elements, thus forming a complex unity which supports each other components. In this case, market system includes several components, namely rotation, production, distribution, transportation and transaction (Nastiti, 1995). Traditional markets cannot be separated from many problems, either financial or operational system. The sellers of traditional markets encounter several difficulties, including goods delivery, service and payment with producer or consumer. Besides, there are time and weather problems. Throughout this time, sellers overcome these problems by establishing relationship with middlemen, consumers (sellers) and between sellers, both producers and distributors even with market officers and 'goods carrier'. In addition, sellers always keep working hard, and getting used to thrift habits, as well as religious improvement among seller community (Sutami, 2012).

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3. The Scope of Traditional Market Service

The market system usually culminates in one main central settlement or other centres, which eventually leads to networking among markets. A market is a space or particular area with or without buildings used as a place where selling-buying activities take place. The goods sellers and buyers meet at the specified places, at a time set within a certain interval (Jano, 2006). Traditional markets have become urban public space, a place where society gather and build social relationship between them (Ekomadyo, 2007). In the scope of traditional markets, there is several work divisions including the sellers who manage the goods transportation from one market to other markets, the sellers who manage goods sale to rural area, the sellers who manage goods weighing or wholesale, and the others may sell textiles, baskets, livestocks or corns (Geertz, 1963). On the other hand, the seller's effort to sustain the continuity of traditional markets is to maintain the social advantage created by a business life tradition in traditional markets which becomes the basic reference of conduct for sellers in daily business by preserving values and norms of honesty, trustworthiness, cooperation between sellers and consumers and cooperation among sellers in traditional markets (Laksono, 2009).

In its development, traditional markets reach larger scope as a node of goods and service exchange on a regional basis which then grow and develop evoking various activities within cities (Sirait, 2006). It is supported by the result of Karnajaya's research suggesting that the relocation of traditional markets can change field utilization, street pattern, movement and pattern or type of building, circulation way distribution and land use (Karnajaya, 2002).

Research Methods

The research location is the city of Surakarta. Meanwhile, the data collection procedures include collecting information through observation and interview both structured and unstructured, documentation and visual materials (Creswell, 2009).
The techniques employed in collecting data are as follows:

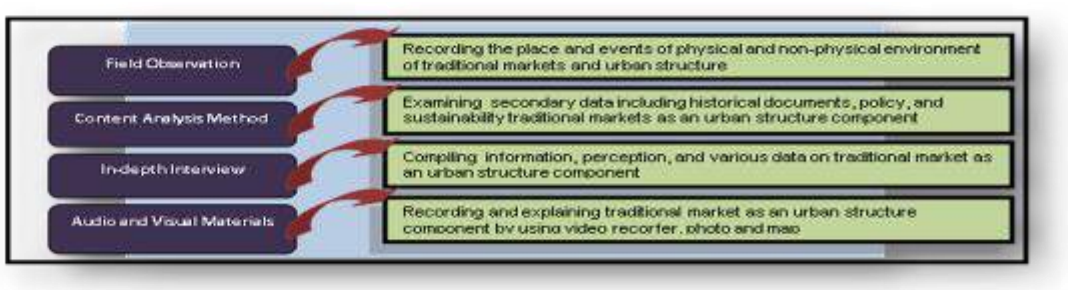

Figure 2: Technique of Data Collection

The research informants are focused on the related parties including market users and policy makers of traditional Javanese urban space. Nevertheless, there are possibilities to expand the involvement of other informants for instance cultural observers and public figures related to historical data of Javanese traditional cities (Arikunto, 2010).

In addition, the technique of data analysis applied in this research is Spatial Analysis to examine traditional market scope as a component of Javanese traditional urban structure, and Interactive-Analysis Method to analyze the roles of traditional markets as a component of Javanese traditional urban structure (Miles & Huberman, 2002).

Results and Discussions

A. The History of Surakarta

In the historical establishment of Surakarta Hadiningrat city, as written in *Babad Tanah Jawi*, *Babad Sala* and *Babad Giyanti*, the relocation of Mataram Kingdom from Kartasura to Surakarta was because of the doom of Kartasura Kingdom as a result of Geger Pecinan incident in 1740-1743. Finally, through physical and mystical considerations, "Sala Village" was chosen as the best place to establish new Keraton Mataram. The selection of Sala village was based on the following considerations (Aliyah, 2002):

- Sala village is located near *tempuran*, which is a meeting place of two rivers namely Pepe and Bengawan.
- The location of Sala village is near Bengawan, the biggest river in Java island which has been known since ancient period having important meaning as the connector of East Java and Central Java and used for the sake of economy, social, politics and military.
- Sala has become a village, thus in order to establish keraton, it is unnecessary to call for forest cutting laborers from other places.
- The meaning of the word Sala is connected with the word *Cala* which means a large room or shed as a sacred building.

Keraton Surakarta was built based on the pattern of Keraton Kartasura which was only wreckage at that time. When the building of Keraton has been built, in the condition that there has not been brick wall fence in the surrounding keraton, Sunan Paku Buwono II pronounced the establishment of Surakarta Hadiningrat Country in 1745. In the process of relocation, several buildings of old kingdom including Pangrawit shed which are now located in Pagelaran were also relocated. According to historical notes and Solo Heritage Society document, this relocation passed Kartasura-Sala street, through west street passing Laweyan Kampong dan Kemlayan Kampong (Secoyudan street) (Aliyah, 2002).

The city arrangement started in the reign of Paku Buwono II in the early relocation of Keraton Surakarta from Kartasura. In this case, Surakarta is centralized in the Keraton Surakarta Sunanate which becomes the central government as well. Meanwhile, the city's facilities including squares, mosques and markets were located in the northern Keraton. Surakarta as a kingdom city in Java has a belief on the effort of cosmology world creation, namely believing the existence of harmony between small world (Microcosmos) and big world (Macrocosmos). This influence can be seen from the governmental system, namely a king as a single ruler (small world ruler). Another influence is the royal area division portrayed as a concentric circle of authority distribution. The first authority is in the most inner circle and the more outer part refers to the less authority. Meanwhile, the area of keraton is the most inner constellation or the first order namely *Kutanegara* (Aliyah, 2002).

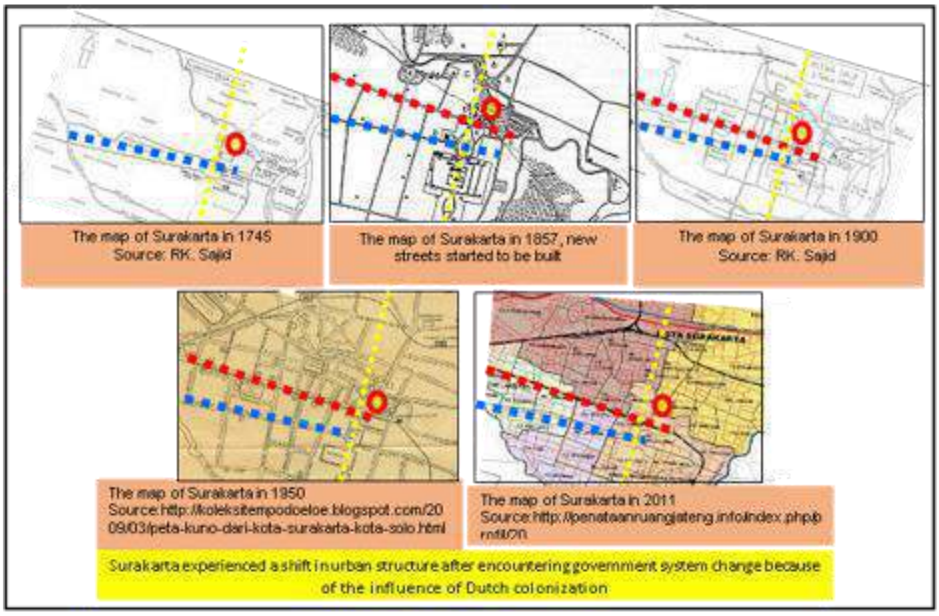

Figure 3: The Map of Surakarta's Development

Several prominent characteristics of Surakarta as a traditional Javanese city are as follows: (Santoso, 2008):

a. Surakarta has two squares namely Northern square and Southern square.
b. The complex of keraton is located between Northern ans Southern squares.
c. The relocation of urban area to rural area is quite harmonious. Athough there is no information regarding to the early city border.
d. In Surakarta there is a wide road stretching from the east to the west dividing Surakarta into south and north parts.
e. The mosque, keraton and the houses of the prince are located in the west part of the city. This part tends to be situated in southwest (Hasta Brata), which in Javanese cosmography refers to a direction having characters from fire that owns strength and divine power and is able to conquer all attempts against universe law.

B. The Area Of Pasar Gede In Surakarta

1. The History of Pasar Gede in Surakarta

One of the traditional markets existed in Surakarta Hadiningrat Kingdom period and becoming a part of urban constellation is Pasar Gede. Pasar Gede is perceived as one of the traditional Javanese urban structures. Besides, before the Keraton relocation from Keraton Kartosura to Surakarta on 17 February 1745, there has been trading activities in the valley areas of Semanggi river, Bengawan Solo river dan Pepe river (Soedarmono, 2004 in Mutiari, 2010). Pasar Gede is one of the plans of PB X and Dutch colonialists to develop economy sector in Surakarta (Mutiari, 2010).

2. The Roles of Pasar Gede as a Traditional Market in Surakarta's Constellation

In the spatial planning of Javanese kingdom area, especially in Surakarta, traditional markets are situated in the scope of *negaragung* or the city centre which is sacred, or *dhalem* as the centre. The location of traditional markets is in the scope of keraton, square and mosque (Santoso, 2008). It is also strengthened by the concept of traditional markets' location in Surakarta during kingdom period which refers to the concept of *catur gatra tunggal* (Rajiman Gunung, 1991 in Sunoko, 2002). In this case, the complex's composition is keraton is in the south of square, mosque is in the west of square and market is in the northeast of square (Basyir Z.B, 1987). Meanwhile, the primary components of a city regarding to the Islamic Mataram kingdom consist of the fortress and *jagang*, *cepuri* and *baluwarti*, keraton-square-mosque-market. On the other hand, the supporting component of a city comprises *loji, lumbung, gedong obat, warung eca* (Adrisijanti, 2000). It is even emphasized that the location of traditional markets is not merely as physical meaning in the main spatial structure of a city. In fact, traditional markets in the past spatial planning elements have political function as a control element towards social mobility (Soemardjan, 1991).

At macro level, Pasar Gede as a traditional market is a part of typical basic structure of Surakarta. Several typicals of traditional cities in Java portray that traditional market is an ever-existing part in the spatial planning pattern in Java. Various typical structures of Javanese cities have been suggested by Stutterheim, Maclaine Point, Palmier, Witkamp, Van Mook, and Santoso based on Mintobudoyo's information showing that the component and location of traditional markets occupy the main area of kingdom called *Negaragung* or the city centre. Meanwhile, the part of kingdom area located in the periphery is called *mancanagara* (Santoso, 2008).

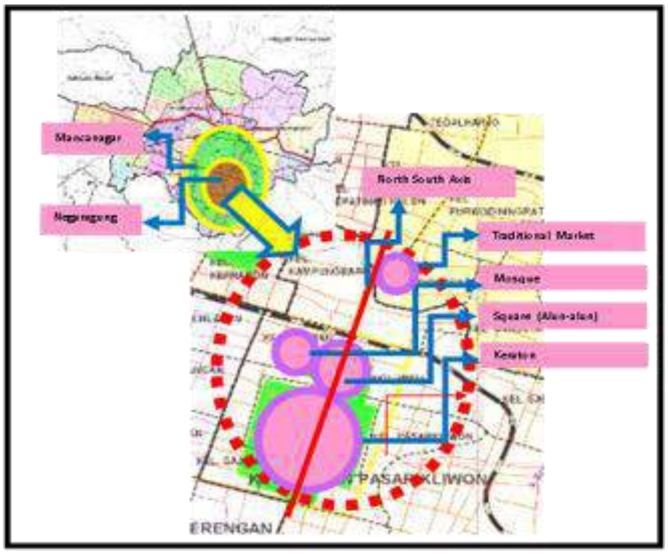

Figure 4: The Structure of Surakarta

3. Traditional Markets as a Part of Urban Spatial Component in "Negaragung" Zone

Tjiptoatmodjo mentions the existence of Cosmology concept dividing an area into four parts namely *kutagara*, *nagaragung*, *mancanegara* and *pesisiran*. The part of kingdom area located on periphery is called *mancanagara*. Meanwhile, according to Ossenbrugen, *mancapat* urban structure is derived from the word *manca* which refers to a central point surrounded by four points and each point is located in the west, east, north and south. Besides, based on Witkamp, urban structure is dominated by North South Axis as urban orientation. Maclaine Point also highlights that a city consists of two parts namely sacred city centre and profane periphery (Santoso, 2008). It is supported by the view that a city or *kuta-negara* is a secular and spiritual authority central place and *kuta-negara* citizens are no more than the lord's servants having the role as servants of their ruler (king) with centralized power (Wiryomartono, 2000). Therefore, it can be pointed out that traditional markets as a part of urban spatial component based on the Javanese cosmology concept are located in ”Negaragung” zone.

4. The Networking of Traditional Markets Based on ”Mancapat Mancalima”

Traditional markets play strategic roles in maintaining the growth centre structure. It is shown by the ability of traditional markets in evoking economic activities in their surroundings (Alexander, 1987). In addition, the relocation of traditional markets is capable of changing land use, street pattern, movement and pattern or type of building, equalization in circulation path, and land use (Karnajaya, 2002).

Traditional markets are seen as an organizational system comprising interconnected and interdependable elements, thus forming a complex unity which supports each other component. Meanwhile, market system includes several components, namely rotation, production, distribution, transportation and transaction. It means that 1) The components of rotation are related to production output specifications which eventually determine the cycle of five-day week. In terms of five-day week, there are *mancapat* and *mancalima* systems in Java, namely the role division of a village surrounded by other 4 villages located at 4 directions. Thus, the time rotation division comprises *Legi*, *Pahing*, *Pon*, *Wage* and *Kliwon*. One rotation which lasts 5 days is called a five-day market week and the roles of each market is controlled by five-day rotation; 2) The components of production are related to the path and accessibility of distribution and transportation; while 3) The components of transportation cannot be separated from a market’s location which is reachable by sellers and buyers; and 4) The components of transaction are influenced by the preference or selection of a market’s location. It is because the more strategic a market is, the more sellers and buyers will come, so that it will optimize transactions which result in the improvement of production (Nastiti, 1995). These are the same with Surakarta in which the networking of traditional markets includes the selection of location based on ”*Mancapat Mancalima*” that affects the operational system of traditional markets.

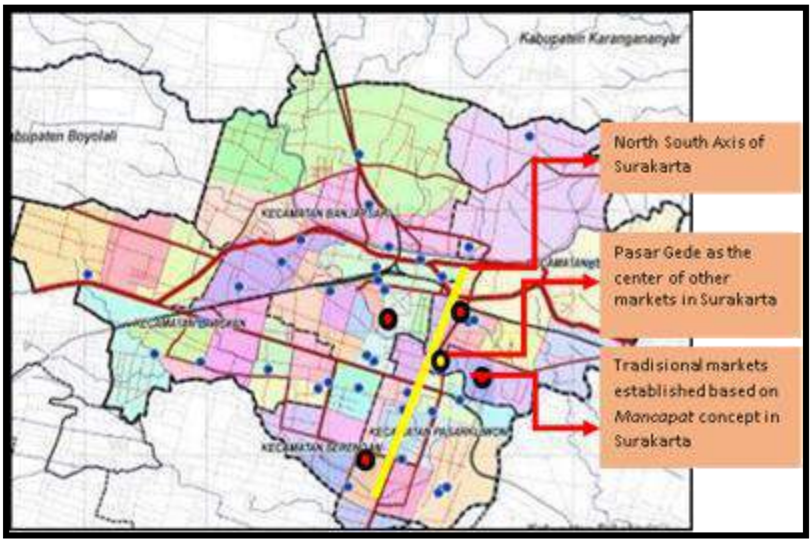

Figure 5: The traditional market networking based on *mancapat mancalima* concept in Surakarta

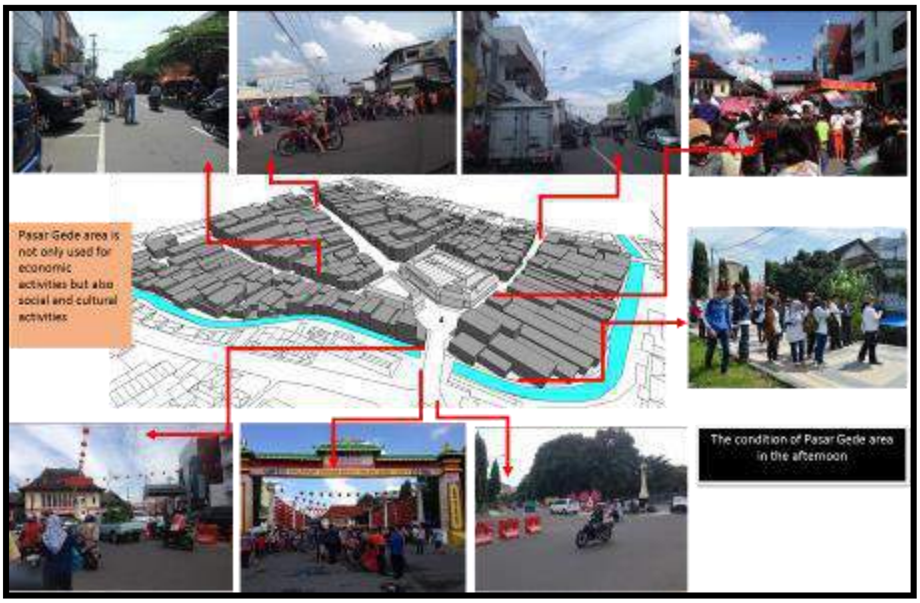

Figure 6: The condition of Pasar Gede area in the afternoon

Figure 7: The condition of Pasar Gede area at night welcoming Imlek celebration

Conclusion

Traditional markets function not only as a trading place, but also as a place for life conception and socio-cultural interaction. In the scope of traditional Javanese city, traditional market is a part of typical basic urban structures and an ever-existing part of the spatial planning pattern of cities in Java, e.g., Surakarta. The roles of traditional market, physically, are one of the urban spatial components called "Catur Gatra Tunggal" (Four Single-Slot), and being a part of urban spatial structure which upholds the concept of Javanese cosmology where traditional market is placed in "Negaragung" zone. Not to mention, in traditional market networking, the location is determined based on "Mancapat Mancalima" which brings influence on the operational system of traditional markets in traditional Javanese cities.

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Conversion of Black Wattle to Bio-Oil and Chemicals on the Continuous Pyrolytic Reactor

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Abstract
Black wattle (*Acacia auricaliformis*) is a fasting tree which used as fuels to electrical generation plant and a feedstock to paper mill industry. Biomass residues considered as a renewable resources with highly potential for energy production while pyrolysis is application to converted biomass to bio-oil and fuels for the future. The pyrolysis of black wattle were performed in a small size reactor at 400-600 ^{o}C under feeding rate of 0.4 – 1.2 $kghr^{-1}$ under N_2 flow with 10 $^{o}C/min$ heating up. The yield of char, liquid, and gas rarely investigated. Pyrolysis liquid product as a bio-oil and tar were in two separated phase with yield of 26.90 - 49.77 wt.%, bio-oil yield were obtained varied about 12.86-37.63 wt.% whereas gases and solid product were obtained. Both of liquid products were analyzed by gas chromatograph-mass spectrometry. The highest bio-oil yield of 39.00 wt.% was obtained at temperature of 550 ^{o}C for feeding rate of 0.6 $kghr^{-1}$ whereas the highest tar yield at 12.63 wt.% at 550 ^{o}C for feeding rate of 1.2 $kghr^{-1}$. The bio-oil contained mainly aliphatic, substituted aromatic, nitrile and oxygenated compound at of 0.07, 1.50, 4.96, 60.03 respectively. Moreover, tar had mainly oxygenated compound with high molecular weight and phenol. The results show that the fasting tree residual can be considered as a potential renewable energy and revelant to valuable chemical feedstock.

Keywords: bio-oil, biofuels, biomass, pyrolysis, chemical feedstock

1. Introduction

As for the energy resources were depleted in the available of fossil energy resources while the increasing demand of energy response to the production on industrial sector, transportation and economic growth overconsumption in all developing countries. Many researchers look towards the best mean of studies emphasized on the alternative renewable energy sources for replacement the fossil fuels.

Thailand is an agricultural country which many agriculture products gave a residuals were not used for utilization worthily and discomposing as a waste in landfills. On the other hand, biomass now being considered as a renewable energy that can alleviate the energy consumption by direct combustion, gasification, liquefaction and pyrolysis were many technologies available to convert the biomass into higher value fuels.

Pyrolysis is one of the most promising approaches for production liquid fuels from biomass can be achieved both thermal and catalytic conversion in which biomass is composed by heat on the absence of oxygen, leading to the production of charcoal, char, gaseous, and liquid product. (Mohan et al., 2006) In slow and fast pyrolysis were mainly difference in amount of products, (William et al., 1996) on slow reaction gave char production is maximized whereas fast pyrolysis gave bio-oil as mainly liquid products is one most valuable product and can be replace conventional fossil petroleum products (Zhong et al.,2010)

In this study, Black wattle (*Acacia auricaliformis)* is the fasting tree which used as fuels to electrical generation plant and feedstock to paper mill industry while the residuals from black wattle not necessary utilized, it identified as a potential petrocrop to produced bio-oil. The emphasized of this research to report the characterization of products from thermo and catalytic conversion in small pyrolyzer were investigated the properties of bio-oil for obtaining the maximum yield of bio-oil fraction. In order to define their potential as alternative renewable energy resources for transportation vehicle fuels replacement the fossil fuels and highly potential raw materials for chemical industry, the gas chromatography – mass spectrometry to understand the natural of chemical constituents formed during pyrolysis studies. Product yield, composition of bio-oil and tar phase and the most relevant physicochemical properties were obtained.

2. Experimental

2.1 Materials and characterization

The raw materials used were residues from black wattle biomass in agricultural fields which fed to paper mill industry. This residues were obtained by crushed and sieved to particle size from 0.5 to 5 mm. represented about of 18 %wt of Black wattle tree to paper mill industry. This raw material were oven dried at 100 ^{o}C during 5 hr to reduced the moisture content before experiment, proximate and ultimate analysis following the procedure by ASTM. Oxygen levels in feedstock were calculated by difference method of ultimate analyzed (Oasmaa et al., 2001)

2.2 TGA measurement

In order to investigate thermal decomposition behavior of black wattle residues, the studies performed thermal gravimetric analysis (Netzch 409 Simultaneous STA) under heating up rate of 5°C/min to determine the correlation between time and weight loss of the residue were recorded

2.3 Pyrolysis

The bio-oil fraction and tar fraction in liquid product were obtained from the pyrolysis under N_2 atmosphere to avoid oxidative degradation on a continuous pyrolyzer. Figure 1 show schematic diagram for this experiment, it consisted of under-screw feeding reactor which was made from stainless 316 of 120 cm. length and covered by an insulation device. Under screw feeder carried the biomass residues and weight of dolomite as catalyst of 1-5 %wt inside pyrolyzer with nitrogen gases flow rate of 2 to 6 mL/min. The temperature of pyrolysis was explored under the temperature of 400 to 600 °C, the heating up rate of 10°C/min from room temperature to be the final temperature of desired and kept constant during for 15 min using a PID controller. A cold trap was used to separate the gaseous form the entrained lighter and the gaseous product. The detention time was controlled by reactor screw feeder at feeding rate of 100 to 300 rpm. The higher speed (rpm) cause the lower detention time and conversely.

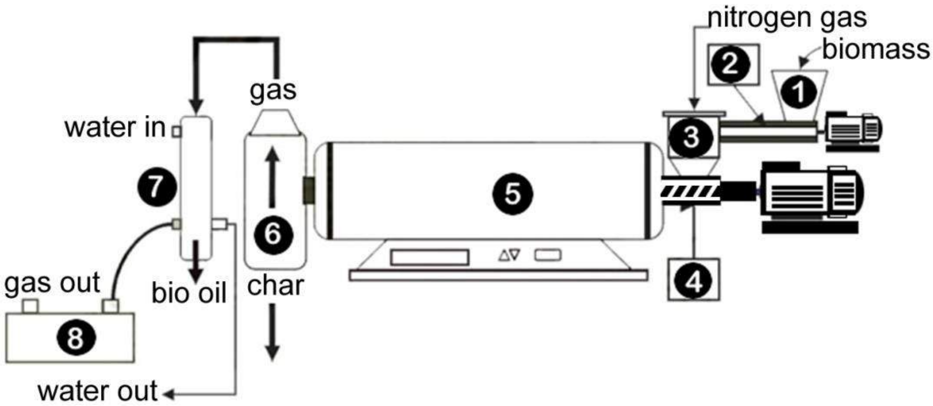

Figure 1: Schematic diagram for the continuous pyrolyser
1) Hooper1 2) Nitrogen gas feeding 3) Hooper2 4) under-screw feeder
5) Pyrolyzer 6) Gas Chamber 7) Condenser 8) Gas collector

2.4 Experimental design and mathematical model

The statistical method of factorial design of experiments (DOE) eliminates the systematic errors with an estimate of the experimental error and minimizes the number of experiments. 2k experimental design is an effective method to determine how various reaction parameters affect the system. It is very useful in the primary experiment study when there are many factor effects to determine. The main parameters in the pyrolysis of black wattle residues are temperature of reaction (A) residence time (B) N2 gas feed rate (C) and amount of dolomite catalyst (D) and each is considered at three levels, namely low(-1), central(0), high(+1) as shown in table 1. For the two level factorial design, the yield of bio-oil and tar fraction, amount of aromatic content, and acidity were defined as the response by a change on the level of these factors. The treatment combination is standard order can be written as (1), a, b, ab, c, ac, bc, abc, d, ad, bd, abd, cd, acd, bcd, and abcd. The experiments were designed to run a double replicate to obtain the response data as the yield of bio-oil, aromatic content, and acidity represented in table 2

Accordingly, 35 experiments were conducted with the first 32 experiments organized in a factorial design and the remaining 3 involving the replication of the central points for each stage. Model terms were selected or rejected based on the P values with 95% confidence level. Variance, normality and residual test were analyzed by Design Expert^{TM} software

2.5 Product characterization

The yield and conversion were calculated by the equation as following

Yield (wt%) = Liquid Phase/feedstock x 100 .....1)

Conversion (wt%) = amount of products/feedstock x 100 .....2)

The analytical procedure involved measuring the yield of each product, identifying the various compounds using GC-MS, elemental determination using CHN analyzer. The total liquid phase was physicochemical analysis for density, water, ash content, acidity and heating value compared to those of diesel fuels.

All liquid and gases products were analyzed by conventional gas chromatography in Algilent 7820 with a flame ionization detector. Tar fraction on was separated from liquid product and dissolved at 10%wt in methanol to perform this analysis together. Bio-oil phase was performed by gas chromatography-mass spectrometry (GC-MS) in Algilent GC7890/GCMS5978. The GC was fitted with a 30 m x 0.25 capillary column coated with 0.25 μm thick film of 10% Dimethylpolysiloxane (HP-5MS) mass selective and the chromatographic peaks were obtained using response factor for each of the chemical groups were identified with NIST mass spectral data library.

3. Results and Discussion

3.1 Characterization of feedstock

The properties of black wattle residue shown in Table 1, the analysis in proximate, ultimate and composition of the residues were obtained which show high lignocellulosic material. The content of oxygen is relatively high therefore higher heating value (HHV) are low value.

Table 1: Characterization of Black Wattle residue (dry basis)

Proximate Analysis	(wt%)
Moisture	6.07
Volatile matter	64.46
Fixed carbon	20.15
Ash	9.32
Ultimate Analysis	(wt%)
Carbon	29.74
Hydrogen	5.16
Nitrogen	1.75
Oxygen	63.35
Composition	(%)
Lignocellulosic	84.16
Lignin	16.63
Cellulose and hemicellulose	67.53
Higher Heating Value (HHV)	19.85 MJ/kg

3.2 Themal Gravimetic Analysis

TGA thermogram and the mass loss rate of this residues, which was began to loss mass at 348 ^{o}C to 576^{o}C, this behavior of slightly mass loss due to the moisture removing and thermal decomposition of volatile matter from cellulose at ranging of 400^{o}C

3.3 Product yield in the pyrolysis.

This study were investigated the effect of temperature, feeding rate of feedstock, flowing rate of N_2 gas, and %wt of dolomite catalyst which produced bio-oil through fast pyrolysis. The liquid products consisted of two phase made up of a large number of compounds representing various chemical group derived from lignocellulosic component of biomass residues. It mainly depend on the reaction of temperature and time of residence by feeding speed rate of feedstock whereas, the N_2 flow rate and %wt of dolomite catalyst have not a significant effect on the product fraction. The variation of the liquid yield over the long residence time of slow feeding rate at of 0.6 kghr^{-1} shown in Figure 2. The results show that the liquid product is mainly a bio-oil fraction reached a maximum at 550^{o}C, whereas the tar fraction was constantly proportional with temperature increased. Furthermore, the highest bio-oil yield was obtained at the temperature of 550 ^{o}C. The explanation for this results implies that the feedstock fed into pyrolyzer at high temperature, thermal effect is mainly effect to promote devolatilization of cellulose and hemicelluloses in the black wattle residue to bio-oil (Demira et al., 2011; Xiong et al., 2013) whereas oxygen content had been substituted to the oxygenate compound in tar fraction were occurred (Bertero et al., 2012) Moreover, at high temperature favored the reaction which contributed to the increase in gas yield product. Figure 3 show the variation of the yield at the optimum temperature of 550^{o}C, the yield of liquid product decreased with increasing feeding rate. At feeding rate of 0.6 kghr^{-1} shows the highest liquid yield depending on suitable long residence time.

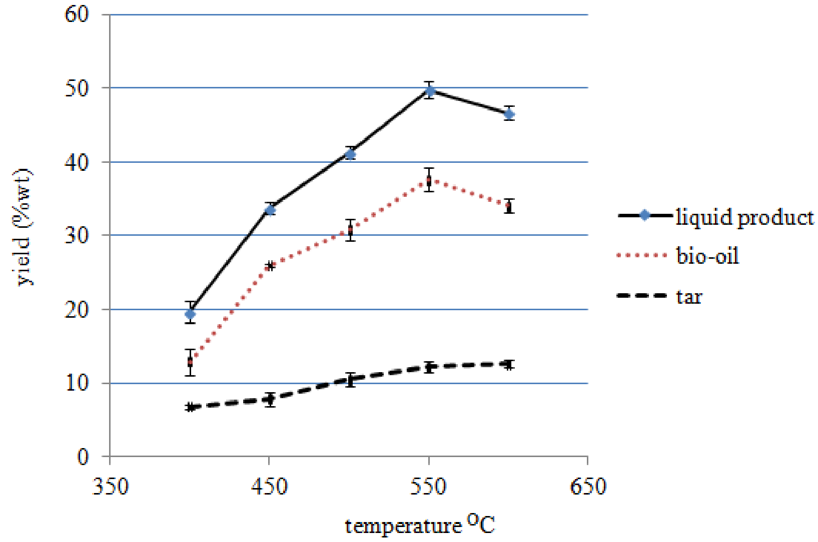

Figure 2 : the effect of temperature depended on liquid fraction

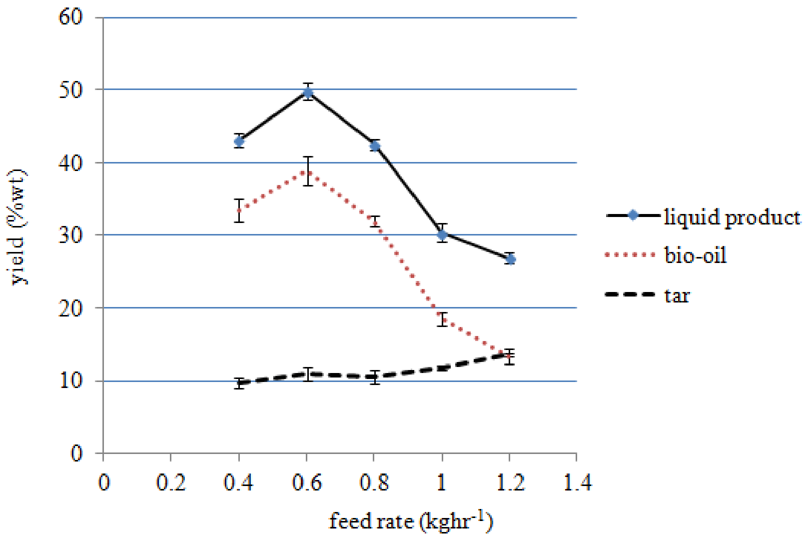

Figure 3: the effect of feeding rate depended on liquid fraction

Effect of temperature

In order to explore the effect of temperature implies that the yield of liquid products increased with temperature rapid increasing to 600 ^{o}C and was dropped because of high temperature, the pyrolysis reaction still received the effected of high temperature to pyrolyzed the composition of celluloses and fiber which composing of long chain hydrocarbon molecule and was trap-cooled into middle hydrocarbon into mixture of bio-oil and tar phases as well, while the gaseous product were made up mainly CO and CO_2 indicating a higher extent of deoxygenation through decarboxylation reaction occurred (Putun et al., 2005; Bertero et al.,2014) At temperature reached 600 ^{o}C, it seems that the gaseous were mainly product cause from high temperature effect in the pyrolyzer (Zhang et al., 2007). At 550^{o}C reaction temperature was selected as the highest liquid products yield was obtained with this temperature.

Effect of feeding rate of feedstock

In order to studies the effect of feeding rate of black wattle residues as a feedstock into pyrolysis, the yield of liquid product increased with decreasing feeding rate. It seems that lower feeding rate implied the long residence time in the pyrolyzer (Jale et al., 2007) The residue of black wattle still received the effect of high temperature for a long time, the pyrolysis reaction with the decomposition of volatile matter undergo and condensation to liquid phase. At feeding rate of 0.6 $kghr^{-1}$ shows the highest liquid yield depending on suitable long residence time.

Table 2 : Analyzed composition of bio-oil and tar fraction at the highest yield

Composition	%wt
gases yield	38.49
solid yield	10.48
liquid yield	51.03
bio-oil fraction	40.37
tar fraction	10.48

The reactivity of various compounds representing each of the chemical fraction is presented in table 2. The product consisted of liquid, solid and gas fraction whereas the chemical properties of liquid phases were analyzed by Gas chromatography - Mass spectrometry. Figure 3 and Figure 4 show the GC-MS chromatograms of bio-oil phase and tar phase respectively.

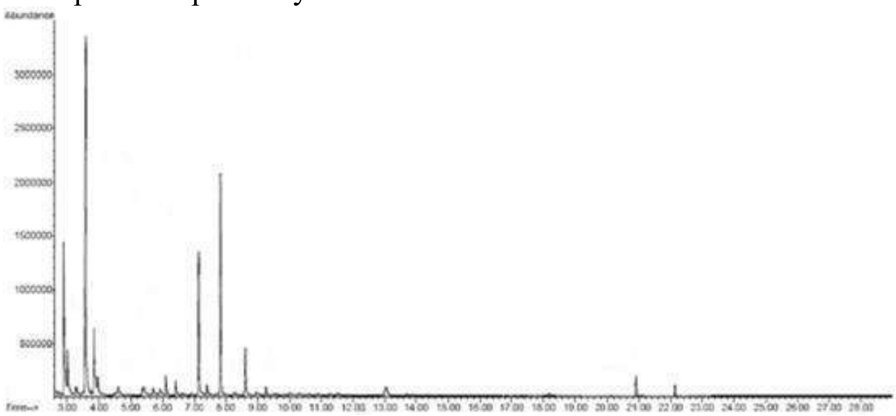

Figure 4: GC-MS Chromatograph on bio-oil fraction

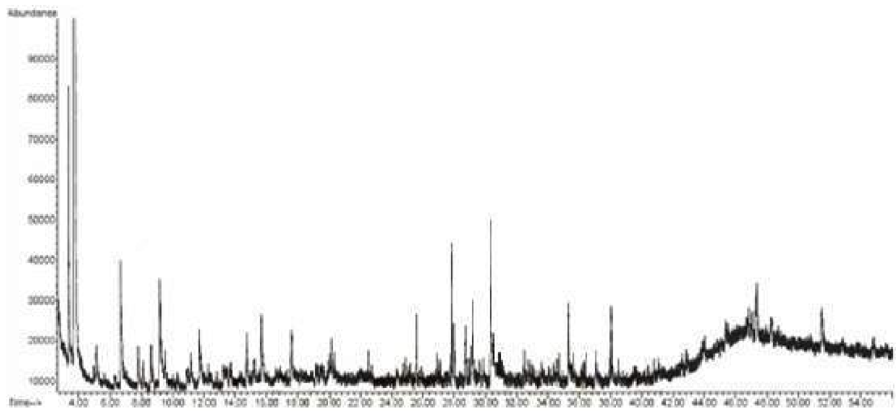

Figure 5: GC-MS Chromatograph on tar fraction

In order to determine its composition were carried out with GC-MS and the various peaks were identified by GC-MS analyzer. Table 3 shown the peak chromatograms of bio-oil, it consisted of aliphatic, substituted aromatic, ketone and other oxygenated compound. The reaction of pyrolysis shows the decarboxylation were occur in the first step through dehydration and formation of carbondioxide from the effect of high temperature, following the initial deoxygenation, hydrogenation and cyclization to formed aromatic compounds occurs (Grierson et al., 2013; Yang et al., 2014) resulting on the formation of olefins and lower molecular weight oxygenated compounds. Also alkylation and isomerization of phenol occurs to form various alkyl-substiture phenols, table 4 show the peak of tar phase, it consisted of aliphatic, aromatic, and other oxygenated compound.

Table 3: Detailed analyses of bio-oil by Gas Chromatograph – Mass Spectometry

RT (min)	Compounds	Peak area (%)
	Aliphatic hydrocarbon	
18.752	Cyclohexane, hexaethylidene-	0.07
	Substituted Aromatic	
20.912	Benzene, 1,1'-sulfonylbis[4-chloro-	1.44
21.038	Benzene, 1,1'-sulfonylbis[4-chloro-	1.44
23.336	Benzene, 1-butyl-4-	0.06
24.012	Benzene, 1-butyl-4-	0.06
	nitrile	
2.998	1H-Pyrazole, 4,5-dihydro-1,5-dimethyl-	4.13
6.112	Piperidine, 3-methyl-	0.83
	Oxygenated compound	
2.643	1-propen-2-ol	0.04
2.912	1,3-Cyclopentanedione	10.57
3.435	2-Pentanone, 4-hydroxy-4-methyl-	28.72
5.561	2-Cyclopenten-1-one, 3-methyl-	1.57
5.638	Phenol	1.16
6.439	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	0.35
7.714	4-Piperidinone, 2,2,6,6-tetramethyl-	10.82
8.935	.beta.-(N-tert-Butylformamido) acrolein	3.54
9.315	1,4:3,6-Dianhydro-.alpha.-d-glucopyranose	0.5
12.998	d-Allose	1.84
17.915	Hexadecanoic acid	0.17
21.967	Hexanedioic acid, bis(2-ethylhexyl) ester	0.75

Table 4 : Detailed analyses of tar by Gas Chromatograph – Mass Spectometry

RT (min)	Compounds	Peak area (%)
	Aliphatic hydrocarbon	
15.68	3-Methyl-2-(2-methyl-2-butenyl)	0.62
25.584	1-Decene, 9-methyl-	0.51
28.001	2-Hexadecene, 3,7,11,15-tetrame	0.57
	Substituted Aromatic	
35.318	Benzene, 1,1'-sulfonylbis[4-chloro-	0.81
	Nitrile	
27.864	Neophytadiene	1.13
30.575	Phenylpropanolamine acetate	0.48
	Oxygenated compound	
3.361	2-Pentanone, 4-hydroxy-	2.06
3.746	2-Pentanone, 4-hydroxy-4-methyl	84.94
6.582	Phenol	1.90
9.072	Phenol, 4-methyl-	1.82
11.651	Phenol, 3-ethyl-	0.31
28.939	Trimethylhexahydroindanone	0.86
29.345	2-Octylfuran	0.84
30.360	Hexadecanoic acid	2.02
38.175	Hexanedioic acid, dioctyl ester	1.13

Table 5 : the physicochemical of bio-oil and tar fraction

	bio-oil	tar
Ultimate Analysis (wt%)		
Carbon	61.75	50.56
Hydrogen	8.13	11.02
Nitrogen	1.42	0.96
Oxygen	26.70	37.46
The acidity (pH)	3.2	3.0
Higher Heating Value (HHV)	28.62 MJ/kg	20.85 MJ/kg

The properties of bio-oil do not meet standard for diesel fuels especially the higher heating values of bio-oil which contained the oxygenated compound, carboxylic acid and ketone whereas the lower temperature and short time of residence, lignocellulosic components were incompletely decomposition and depolymerization to the desired component similar to those of transportation fuels (Zhong et al., 2010; Yang et al., 2014) Furthermore, tar fraction show that the heating value is lower than bio-oil fraction. It could be explanation that high oxygen content in cellulosic component may be formed to the oxygenated compounds and given lower heating value (Oasmaa et al., 2001) The pHs of a bio-oils and tar were about of 3.2 which implied that high concentration of organic acid. This acidity makes bio-oil corrosive and not suitable direct use as fuels. (Zhong et al., 2010; Bertero et al., 2014)

Conclusion

The fast pyrolysis of black wattle (*Acacia uricaliformis*) residues produced liquid yields from 20.00 – 40.00 wt%. Each liquid product was consisted of a bio-oil and tar fraction, bio-oil fraction was obtained maximized at temperature of 550 ^{o}C and feeding rate of feedstock at about 0.6 kghr^{-1} which favor to be decomposition and depolymerization to liquid fuels while a nitrogen atmosphere and %wt of dolomite catalyst were not affected to the yield components significantly.

Liquid Products consisted of bio-oil and tar fraction, it seems that bio-oil were produced by cellulosic components via thermal decomposition of volatile matters and condensation to bio-oil phase. GC-MS chromatogram of bio-oil contain mostly aliphatic, substituted aromatic and the oxygenated compounds while tar phase consisted of aliphatic, aromatic, substituted aromatic, the oxygenated compound such as phenol, aldehyde, ketone and carboxylic acid, a very wide of complex organic chemicals. The physicochemical properties of bio-oil shown the heating value and the acidity which were not suitable to direct used as transportation fuels substitution unless it is upgraded through catalytic cracking and hydrogenation similar to petroleum diesel fuel.

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Awareness on Fish Depletion and Fishing Practices among Fishermen around River Rima and Kware Lake, Sokoto Northwestern Nigeria

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Abstract
Human dependence on freshwater fish is significant, owing to the nutritional value provided by fish to populations particularly in the developing world. Fishes are overexploited or severely depleted as a result of excessive fishing quotas, illegal fishing practices and poor management of our freshwater resources. Fishermen around River Rima and Kware Lake were surveyed to investigate their awareness on fish depletion and fishing practices using structured questionnaire. The survey reveals that unawareness of fish depletion among the fishermen was 100% from both River Rima and Kware Lake. On fishing regularity, 80% of the respondents from River Rima fish every day, compared to those from Kware Lake that have 90%. Only 10% of the fishermen from Rima were subsistence, while 100% of Kware Lake Fishermen were local commercial Fishermen. Kware Lake Fishermen amounting to 10% were among those that use nets only during fishing, while the remaining 90% use other additional local gears apart from the net. On the other hand, 40% of the Fishermen around River Rima use nets only and other gears (60%). Fishing activities are regular and routine in these freshwater bodies, and the fishermen were encouraged by their customers due to their consistent patronage. But the awareness of fish depletion among them remains deficient. Therefore there is need to set laws and educate the Fishermen on fish depletion around the area.

Keywords: Awareness, Depletion, Fishing, Fishermen, Freshwater, Kware, Nigeria,

Introduction

Fishing is a human tradition, a traditional activity that involves hunting and gathering of aquatic fauna for food (Olaoye, 2012). Nigerian fisheries can be broadly classified into: Artisanal fisheries (85%), industrial fisheries (14%), and culture fisheries (1%) according to Federal Department of Fisheries (2005). Nigeria's demand for fish outstrips the local production and the country is one of the largest fish consumers in Africa and also among the largest fish consumers in the world with a record of over 1.5 million tons consumed annually. Surprisingly, Nigeria imports more than 900,000 metric tons of fish while its domestic catch is only450,000 metric tons per year (Ozigbo, 2013). Depletion of fish has been confused with the word overfishing; in defining depletion it must be recognized that the term represents a condition and must not be confounded with the cause (overfishing) that leads to this condition or with signs that identify it. Fish depletion is reduction, through overfishing, in the level of abundance of the exploitable segment of stock that prevents the realization of maximum productive capacity. In other words catches are well below historical levels, irrespective of the amount of fishing effort exerted, before depletion can be experienced. Overfishing may have serious implication on fish supply for the Nigeria population (UNDP,1998) because, when the fish resources are exploited intensively and frequently than what the water body can supply, even though it has the capacity to renew itself naturally, the water body will begin to deplete and income, sustenance will begin to be affected (Enaikele and Olutayo, 2010). In addition to an assortment of active and passive capture gears, traditional methods are being used by fishermen for decades (Reynolds, 1996). Some of these traditional gears do not select a size of fish to catch, therefore frequency of such type of fishing not just leads to depletion but even extinction of some species. In view of these, this paper aims to evaluate the status of fishing practices and awareness of fish depletion in River Rima and Kware Lake in Sokoto State, Northwestern Nigeria.

Methodology

River Rima, is located in Sokoto, Northwestern Nigeria, which lies between longitudes 4˚8`E and 6˚5`E, and latitudes 12˚N and 13˚58`N (Mamman, 2000). The climate of Sokoto is tropical continental, with much of the rains between June and September, while the long dry season is from October to May (Ita *et al.*, 1982). The River flows northwest to reach its confluence with River Niger. The plains around the river are widely cultivated and the river is used for irrigation and other domestic purposes. Kware Lake on the other hand is natural water that is fed primarily by underground water sources located at various places. It is situated 3 kilometers away from Kware local government area of Sokoto State and 20km north of Sokoto metropolis. The Lake is located on longitude 5˚15` 58`E, latitude 13˚ 13` 20`N. It is flanked by River Shella to the northeast and River Rima to the east. It's also used primarily for fishing and irrigation among others. (Yahaya, 2009). The study drew predominantly on a descriptive survey using structured questionnaire and careful observation of the fishing practices and interviews with the fishermen in the areas under study. The study parameters assessed included fishing gears used, frequency of fishing, size of fish preferred, purpose of fishing and awareness of fish depletion.

Results and Discussions

Responses obtained from respondents shows that majority of the fishermen (80%) are considered to be subsistence fishermen at Kware Lake and River Rima (Table 1).The awareness of fish depletion among fishermen seems to be lacking, as only 10% of the fishermen at River Rima are said to be aware. This survey also found that 50% of the respondents at River Rima had no choice of specific species to catch and the number went up to 70%in Kware Lake. There were different practices among the fishermen on the fishing gear used. At River Rima (40%) used only net during fishing, while 10% are using the net at Kware Lake. The remaining using other fishing gears (Table 2). Most of the respondents go for fishing everyday at both River Rima and Kware Lake. This may result to overfishing and consequently a decline of species as reported by Mustapha (2010) and possible factors responsible to that decline include; reduced availability of food, overexploitation of the species, and low rate of breeding. Another serious problem in depleted water bodies is the extinction of populations, particularly those with high ages of maturity (Mayers and Maertz, 1998).

The choice of size to catch among the fishermen varied between River Rima and Kware Lake in which at Rima 60% of the respondents prefer adult fish while at Kware it was 50% (Figure 1). From the results obtained River Rima and Kware Lake have shown that fishing in these areas has contravene the laws and regulations of a community, State, country or even International agreement. It also undermines management efforts to conserve species and ecosystems as reported by Ekundayo *et al.* (2014). The major problem of fishing practices in the study area was the everyday fishing, which may contribute to existing problem of overfishing, jeopardizing future revenue, livelihoods and long term food security. It is also putting several species at risk of extinction and drastically altering the sensitive balance of water ecosystem. Similarly, this is also a problem because by-catch are not returned especially those that use net as a fishing gear, the fishermen were also encouraged by their customers due to their consistent patronage. These problems make the conservation and management of the fisheries resources impossible (Ekundayo *et al.*, 2014). It has also been observed that global wild fishing effectively masks the successive depletion of stocks and without decisive action to reduce fishing effort, many more stocks will suffer and undernourishment impacts for the major fishing of inland waters (Srinivasan *et al.,* 2012).

Table 1: Choice of Fish to Catch, Fish Depletion at River Rima and Kware Lake, Sokoto, Nigeria

Question	River Rima		Kware Lake	
	YES	NO	YES	NO
Awareness of fish depletion	0(0)	10(100)	0(0)	10(100)
Awareness of effect of fish depletion	1(10)	9(90)	0(0)	10(100)
Choice of species to catch	5(50)	5(50)	3(30)	7(70)

Footnote: Percentage in parenthesis.

Table 2: Fishing Practices of River Rima and Kware Lake, Sokoto, Nigeria

Question	Response	River Rima (%)	Kware Lake (%)
Purpose of Fishing	Selling	30	20
	Feeding	10	0
	Selling and Feeding	60	80
Fishing Gear used	Net	40	10
	Other Gears	60	90
Regularity of Fishing	Every day	80	90
	After two days	20	10

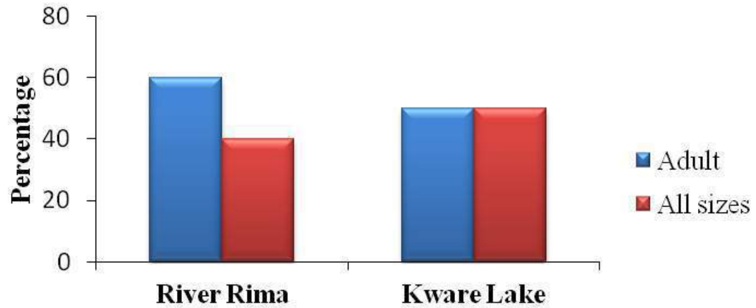

Figure 1: Preferred Size of Fish by the Fishermen

Conclusion and Recommendations

The awareness of fish depletion in River Rima and Kware Lake is lacking, even though little is known by Fishermen at River Rima. The fishing practices are against the law in most developed countries. Because they catch with net without returning by-catch (fingerlings etc), though some of the fishermen prefer the adult fish. Fishing activities are regular and routine in these freshwater bodies, and the fishermen were encouraged by their customers due to their consistent patronage. But the awareness of fish depletion among them remains deficient. For these reasons, there is need to set laws on fishing practices and educate the Fishermen on fish depletion around the area.

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Towards Sustainable Human Settlements Growth on Urban Fringe Areas (A Case Study of Semarang City – Indonesia)

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Abstract
Early urbanization generally took place within an urban core but in the last few decades the process has moved towards fringe areas. Urban core is eventually characterized by marginalities, but on the other hand fringe areas have central characteristics. The decreasing role of an urban core and the increasing role of fringe areas occur in almost all metropolitan regions. The growth of fringe areas is commonly predominated by the development of urban sprawl. Many empirical researches on urban growth have concerned on the fringe areas. Until recently, many research findings on urban growth still lack of the main element of the growth and to a larger extent fail to provide an explanation on why the phenomenon happens. This study will take the concepts and views of urban growth as a state of progressing, and not state of being and done with a qualitative approach within naturalistic paradigm umbrella. Semarang's urban fringe areas indicated dualistic characteristics, a mixing of formal and informal, urbanity and rurality, modern and traditional, planned and un-planned settlements. These conditions raise complicated social problems. This study explores whether the process of urban growth in fringe areas is specific and characterized by local wisdom. The integration process of several types of settlements will shape the urban form's future. The Semarang urban growth policy does not lead to the integration of spreading sprawl development on its fringe areas, and should be adjusted into the sustainability issues, in order to make livable city and to ensure the future generation meet their needs.

Keywords: urban fringe, sprawl, sustainable, dualistic characteristics, local wisdom.

1.Introduction

The location of growth on the fringe areas of the cities is becoming world-wide phenomenon. Fringe areas development occurred both in developed countries as well as in developing countries. It is a contradictory phenomenon. Ever-expanding metropolitan region; that is most suitable occurred in wealthy countries; is often portrayed as an inevitable feature of large cities in the developing countries. As a matter of fact, physical growth in fringe areas is dominated by sprawl development. The declining centrality of urban core and increasing fringe areas has occurred in most metropolitan cities.

Early urbanization generally took place within an urban core but in the last few decades the process has moved towards fringe areas. Urban core is eventually characterized by marginalities, but on the other hand fringe areas have central characteristics. The decreasing role of an urban core while increasing role of fringe areas occur in almost all metropolitan regions. The growth of fringe areas is commonly predominated by the development of urban sprawl. Many empirical researches on urban growth have concerned on the fringe areas. Until recently, many research findings on urban growth still lack of the main element of the growth and to a larger extent fail to provide an explanation on why the phenomenon happens.

2.Research Objectives and Methodology

The objectives of the research are to reveal the existence of local wisdom that can be used as a reference to direct the growth of the settlements in the fringe area of Semarang city. The proper method to diagnose the problem of a city has to begin by recognizing the historical and social phenomena and starting the perspective to respect for local wisdom and indigenious urban characteristics. To obtain an authentic and original local wisdom, generalization manner cannot be employed. Therefore the research is conducted by employing qualitative approach within naturalistic paradigm umbrella.

3. Locus of the Research

Since 2010 until 2014, along with 0.97% average population growth, the total population of Semarang was 1.723.988 inhabitants. The percentage of population growth in Semarang is considered low compared to other metropolitan cities for instance Bandung, Medan and Palembang. Meanwhile, the most populous sub-district is Pedurungan whereas the least populated sub-district is Tugu. In 1986, 62% of Semarang population was still concentrated in the city center, but in 1995 the population concentration shifted to sub-district fringe by 64%. The population data indicated that there was a population shift from the city center (Sub-districts of East Semarang and Central Semarang) to the fringe areas (Sub-districts of Mijen, Genuk, Tembalang and Ngaliyan). This tendency is predicted to continue since the gross density level of population and building in fringe areas is indeed low. The increasing interest of people to live in fringe areas is motivated by several factors, including the increasing number of real estates which build various types of new settlements; to embrace various social strata; and the easiness of house ownership process by the availability of many housing credit scenarios.

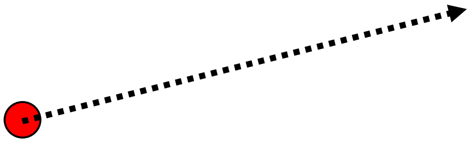
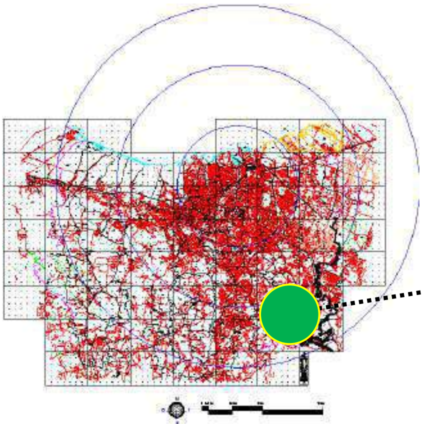


Figure 1: Map of Indonesia

Figure 2: Map of Semarang Municipal Administrative area. 2005
Source: Semarang Municipal Planning Development Board



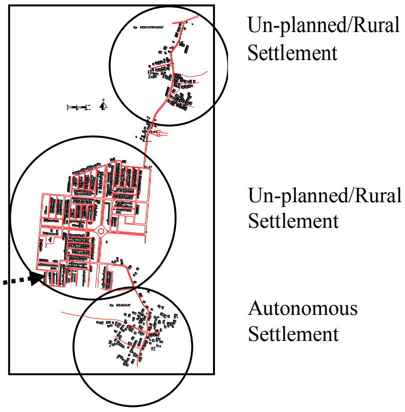


Figure3: Locus of the research
Source: Semarang Municipal Planning Development Board.

This research was conducted in Meteseh village - Tembalang sub-district, one of the fastest growing urban fringes in Semarang city. The research area consists of three types of settlements i.e planned settlement in the form of housing estate, rural settlement in the form of Rejosari hamlet and autonomous settlement in the form of Kedungwinong hamlet (Setioko, 2011) (Figure.1,2,3).

4.Discussions and Results

Nowadays, the roles of urban fringe areas turn to be more critical as one of the urban tendencies is the population movement from urban core to fringe areas (Kivel, 1993). Urban development no longer takes place in the city center but moves to fringe areas. Urban morphology undergoes a metamorphosis in the form of peripheral urbanization and growth from inside to outside, causing the presence of inverted metropolis so that the roles of fringe areas improve, whereas the roles of city center decrease and change. This phenomena causes urban landscape anomaly in which the characteristics of the city center is marginal while fringe area is central (Gillham,*et al* 2002; Soja, EW.2002). Therefore, there is an interest clash between accelerating urban development versus urban ecology threat.

According the data analysis of settlement growth pattern, Semarang undergoes a shift from united city form into scattered city form, namely the population settlement which in the beginning of its growth is located around urban core spreading to follow road growth pattern, towards fringe areas.

On Semarang urban fringe areas there are three typology of settlements: [1] Unplanned settlements. [2] Planned settlements and [3] Autonomous settlements. (See Figure: 3).Unplanned settlements which are indigenous housing. The people generally belong to the low social strata to middle income group. Social cohesion among the community categorized high level. Planned settlement generally is a housing estate, built and managed by developer which has three categories: [a] Big enterprise; people who live usually belong to middle income to high income groups, usually equipped with well urban infrastructure and luxurious facility. Community's social cohesion categorized low level. [b].Small enterprise which is inhabited by mixed strata, from middle income to low income; and [c]. Public housing estate facilitated for low income groups. Autonomous settlements is mixed settlements, scattered and incrementally built around the planned settlements areas. They owned, equipped and maintained local urban amenities, like water, electricity by themselves.

Settlements in Semarang urban fringe areas have several characteristics as follows:

a. Alienated Areas

Alienated area is a remote, excluded and isolated area; not bound to a network of urban basic facility and infrastructure system; thus it is ignored and connoted backwardness and left behind.

Alienated area tends to be separated from the main flow of urban life, either economically, socially and culturally. Several facts found in the field indicate that basic environmental scale facility and infrastructure including roads, consumed water, electricity, sanitation, garbage and public transportation are very minimal and even unavailable in several locations. Fringe areas do not have enough attention and always be positioned as the last priority by the stakeholders in every urban bureaucracy level. Even though it has been identified that the percentage of population growth is higher than the urban core, the mindset change on accelerating priority scale in planning, preparing and managing basic urban facility and infrastructure has not been accomplished.

b. Brotherhood-based Areas

A strong social cohesion considers that all people within a settlement area is a ”family” although it does not necessarily mean that they have blood relation. Hence, this research employs the term brotherhood because it tends to have connotation of friendship rather than kinship. This brotherhood is formed by two groups, namely [1] low social strata villagers and [2] middle strata newcomers. There is neither domination nor exploitation of particular people by other people groups, by reciprocal relationship or solid collaboration. Empirical facts are found in the villagers of Rejosari and Kedungwinong with brotherhood attitude having meaning of strong friendship which resembles biological brotherhood relationship.

c. In Transition Areas

The presence of large scale planned settlement alongside the distribution of rural settlement which later on evoking the growth of autonomous settlement, is a relatively new urban fringe areas growth phenomena. Traditional and informal social structure which has existed for so long suddenly has to adapt to a distinct new situation. There are several emerging assumptions, namely 1) A stronger social structure will dominate; 2) The integration of two different types of entity which co-existents one another; 3) Segregation between traditional and informal social structure (standing on its own). Several facts indicate that in this areas there is a process of integration, as seen from the intensity of communication and interaction among villagers and newcomers.

These conditions become evident in the presence of the main road entering rural areas which unintentionally converge with planned settlement, and brings positive implications for the relationship between society, so that it can improve meeting frequency among society. The increase of meeting frequency between society is able to shorten social distance and horizontal distance among them. Furthermore, in later development, there is a new center of gravity in the form of instant market functioning as a meeting place between planned settlement, unplanned settlement and autonomous settlement. Besides, societies with different culture find it comfortable to live side by side, without any physical segregation.

Semarang's urban fringe areas indicated dualistic characteristics, a mixing of formal and informal, urbanity and rurality, modern and traditional, planned and un-planned settlements. These conditions raise complicated social problems. This study explores whether the process of urban growth in fringe areas is specific and characterized by local wisdom.

5.Conclusion

This research has revealed the behavior of three groups of urban spatial doers living alongside, interdependent in developing concessions to cooperate in fulfilling joint interests and aims which are interrelated with the way to share roles and experiences. The urban spatial fragmentation in Mateseh apparently does not trigger social structure segmentation of its spatial doers (Figure 4).

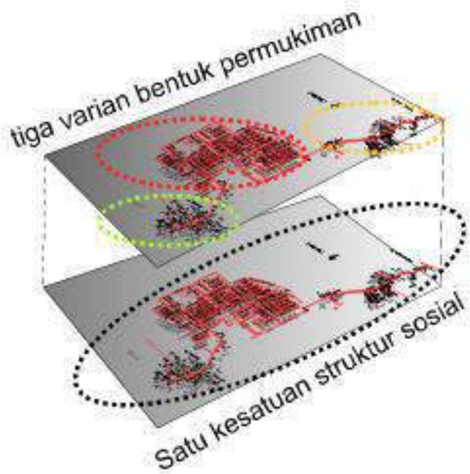


Figure 4: overlay of the spatial and social configuration

Three variants (planned settlement, rural settlement and autonomous settlement) which are not identical to social structure configuration of united spatial doers.

In several settlements located in fringe areas, there is a growing center of gravity in the form of instant market where the occupants living in planned settlement,

unplanned settlement or autonomous settlement interact. They collaborate based on each role and ability. This local wisdom-based activity plays a big role in forming social unity towards settlement groups which are physically scattered.
As a matter of fact, the formal planning on the settlements in fringe areas tends to employ cluster pattern which does not enable its occupants to integrate freely.

In fact the integration process of several types of settlements will shape the urban forms future. Recently Semarang urban growth policy does not lead to the integration of spreading sprawl development on its fringe areas, and it should be adjusted into the sustainability issues, in order to make livable city and to ensure the future generation meet their needs. In an increasingly globalized society, solving by relying on local wisdom is not a backwards step, even perhaps it is a strategic policy.

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River Flooding on Taipei City Area Inundation

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Abstract

Owing to geographic location of Taiwan being on subtropical monsoon zone, so typhoons and storms occur frequently. Typhoons and storms during summer and fall always cause several flooding, flood damages, and human lives loss in Taiwan. The major factors that cause flooding, landslide, and debris-flow in Taiwan are typhoons and storms of monsoon rain season. The function of hydraulic structure has its limit, it must cooperate with urban flood improvement action to mitigate flood damages. The urban flood improvement action must improve the locations of flood area, flood depth, flood duration, and calculate flood damages in the floodplain when heavy rainfall happens and effective mitigately the flood disaster loss.

We present a two-dimensional unsteady flow model bases on the TVD finite difference method with structured grids in basin system. The Digital Terrain Model (DTM) is employed to treat the input and output data for the model. The final global of this project is to simulate Taipei city (Shilin area) and provide the most important information, including the inundation range and depth for Shilin. As an important aid to the flood improvement action review and evaluation for warming policy, and prepare step of decision. Then, we test the suitability of this model on Taipei city (Shilin area), and present the result and discuss.

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Introduction

Flooding damaged river upstream reservoir numerical model of development, mainly to assess potential flooding floods in Taiwan. Simulation can be divided into a barrage of destruction, namely dam break flood; calculus of categories and flooding downstream. Dam-break flood simulation, thrust in a simulated dam collapse caused by the severity of the flood, flood extent and the degree of loss of life and property downstream areas could cause it to develop emergency contingency measures, to assess reservoir potential disaster to assist reservoir downstream catchment area development plans and the preparation of flood simulation.

Dam-break flow phenomena for the free surface of the problem contained, while the free surface in the method of calculating the movement of fluid interface, usually divided into Eulerian description and Lagrangian description. Euler's description on behalf of all computing grid is fixed in space, a fixed-point observation of fluid particle motion. The pull is observed moving description of the fluid particles, due to the fluid motion of the free surface will therefore flow field grid computing movement must follow immediately, namely mobile grid. This section provides a brief introduction to the free surface of the processing method, comprising: a marked grid method (MAC), the volume of fluid method (VOF), level set method (LSM). Also listed in recent years, many scholars and research results of the free surface.

Stay (1988) in order to deal with change, not the free surface boundary fixed by the coordinates conversion method, containing free surface boundary changes ilk field, into a fixed border area, and then be parsed to the finite element method. Solving the pressure field is concerned, the use of class Simple speed correction method. Finally, we discuss the circulation field containing the free surface of the fluid container and observe the two-dimensional turbulence freedom movement. Liao (1994) to the incompressible Navier-Stokes equations with the boundary coordinates adhesion method for solving free surface containing ilk field for much of the change in the free surface flow situations, such as fluctuations in the reservoir water problem, there's a good result.

Huang (1998) studied the phenomenon of droplet collision and fusion, the idea of using multi-fluid system (multi-fluid) of the surface of the droplets regarded system density discotinuity, the use of surface capturing method to automatically calculate the position and shape of the droplet. The only effect of surface tension on the interface between different liquids, in theory, no thickness will cause computational difficulties, so this research to take continuous surface force model (continuum surface force, CSF), so that the free surface has a thickness, then the surface tension is expressed as of a continuous physical (body force) form, distributed in the volume percentage of the free surface.

Mark Sussman (2000) allelic combination function method and fluid volume method, developed couples level set/volume of fluid (CLSVOF), and calculate the free surface two-phase flow problems. Development of this algorithm design is to calculate the surface tension and the free surface, can produce a more accurate ratio of the volume of fluid method or methods allelic function method. This article discuss buoyant bubbles, the bubbles merge the two issues found in the treated surface tension than the volume of fluid method is good, because the surface is relatively simple to calculate, but also more accurate than the mass conservation issues such as potential function method. Euler equation viewpoint taken to a fixed grid space observed fluid changes. The free surface of the particle tracking method were used, the volume of fluid method. Finally, we discuss the shock wave of finite amplitude, transmission and reflection of solitary waves. Hung (2002) CIP (cubic interpolated profile) method to simulate the free surface and the flow field, focuses on the CIP method for different thickness of the free surface of the grid scenarios capture and study there, without affecting the flow field of the viscous force . In the case of water droplets falling to explore the ability to simulate the surface, the viscous force found that the shape of the free surface has its influence exists.

Guo (2002), the use of allelic function method for solving the two-dimensional free surface flows. And two-dimensional reservoir rippling problems dimensional dam-break flow field, the freedom to do validation or water and other cases. Numerical results for the initial discovery of the border merger, crushing the capture quite good results. Lu (2003) also allelic function method free surface of a two-dimensional flow problems. Also adding to verify Zalesak problem allelic function method, the weight of the correctness of the distance, and then within the convective flow field after field solution of the ladder reliability verification flow numerical model. Finally, after the free surface to simulate the ladder, jump water issues and other cases, for the consolidation of the free surface, crushing the capture also have good results. Chen (2004), the use of allelic function method for solving the three-dimensional free surface flows of. Will be extended to three-dimensional problems. Allelic function equation solving section, space, and time entries were used WENO France and third-order Runge-Kutta method to discrete. Finally, simulation examples include: dry bed dimensional dam-break issue, freedom or water and droplet collision.

The outline of this paper is as follows: In Section 2, the differential equations governing the motion of two fluids will be presented along with the transport equations for the fluid viscosity and density. In Section 3, the truly two-dimensional dispersion-relation-preserving advection scheme will be presented to dispersively more accurate advect the front of interface. Section 4 is addressed to investigate the dam-break, bubble rising, and Rayleigh-Taylor instability problems. Finally, we will draw some conclusions in Section 5.

Governing equations

Of the two immiscible fluids under current investigation, one is known as a liquid and the other is a gas. Both of them are considered to be incompressible. The resulting equations of motion for the gas and liquid fluids in a gravitational vector field g can be represented by the incompressible Navier-Stokes equations given below:

$$\frac{\partial \underline{u}}{\partial t} + (\underline{u} \cdot \nabla)\underline{u} = \frac{1}{\rho}(-\nabla p + \nabla \cdot (2 \ \underline{\underline{D}}) - \underline{T} + \rho \underline{g}) \quad (1)$$

$$\nabla \cdot \underline{u} = 0 \quad (2)$$

where the physical properties ρ and μ shown in equation (1) represent the fluid density and the fluid viscosity, respectively. Both of them are functions of the time and space, implying that $\rho = \rho(\underline{x}, t)$ and μ=$(\underline{x}, t)$. The tensor $\underline{\underline{D}}$ shown above denotes the rate of deformation, with the components denoted by $D_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i})$. In addition to the stress tensor given by $-p\underline{\underline{I}} + 2 \ \underline{\underline{D}}$, where $\underline{\underline{I}}$ is the identity matrix, the other source term capable of resulting in flow acceleration is the surface tension $\underline{T}$ concentrated solely on the two-fluid interface, which is denoted by the phase field function Φ.

In this study, the surface tension will be modified as the body force and is applied at the interface. In other words, the surface tension per unit interfacial area is given by

$$\underline{T} = \sigma \kappa \underline{n} \quad (3)$$

In the above, σ is denoted as the surface tension coefficient, κ is the curvature of the interface and the unit outward normal vector $\underline{n}$ along the interface is normally pointed to the surrounding liquid. One can express the normal and curvature of an interface in terms of Φ as $\underline{n} = \nabla\Phi/|\nabla\Phi|$ and $\kappa = \nabla \cdot \nabla\Phi/|\nabla\Phi|$. This clearly explains why the Navier-Stokes equations need to be formulated within the framework of level set method. In this study, the curvature term is approximated by the second-order accurate central scheme.

The above equations cast in the dimensional form will be normalized for the sake of general application. Taking u_r, ℓ_r, t_r, $\rho_r g_r \ell_r$, ρ_r, μ_r as the referenced values for the respective velocity, length, time, pressure, density and viscosity, the normalized (or dimensionless) continuity equation remains unchanged.

$$\frac{\partial \underline{u}}{\partial t} + (\underline{u} \cdot \nabla)\underline{u} = \frac{1}{\rho}(-\nabla p + \frac{1}{Re}\nabla \cdot (2\ \underline{\underline{D}}) + \frac{1}{We}\underline{F_s}) + \frac{1}{Fr^2}\underline{e_g} \qquad (4)$$

where $\underline{e_g}$ is the unit gravitational direction vector and the Reynolds number (Re) is given by Re=$\rho_r u_r \ell_r/\mu_r$. Another characteristic parameter We is known as the Weber number, which is defined as $\rho_r u_r^2 \ell_r/\sigma$ and $Fr = V_r/\sqrt{gL_r}$ is the Froude number. Both density and viscosity will be smoothly approximated by $\rho = \rho_1 + (\rho_2 - \rho_1)\Phi$ and μ=μ_1+$(\mu_2 - \mu_1)\Phi$, where ρ_i and μ (i=1, 2) are the dimensionless densities and viscosities of the two investigated fluids, respectively.

Numerical model

In this paper, the advection term in the level set equation is discretized using the dispersion- relation-preserving (DRP) dual-compact scheme [22], and the advection term in the momentum equation is discretized using the multi-dimensional DRP upwinding scheme [23].

The underlying idea in the DRP method is as follows: to physically predict the first derivative term accurately, the dispersive nature embedded in it must be retained as much as possible. The reason for this is that the dispersion relation governs the relationship between the angular frequency and the wavenumber of the first-order dispersive term [24]. In other words, it is possible to predict the solution accurately provided that the dispersion relation is well preserved. To achieve this, we combine the Taylor series expansion analysis with the Fourier transform analysis to derive the discretized coefficients. For details of the derivations, the interested reader is invited to refer to [22] and [23].

I. Dispersion-relation-preserving scheme

Assume that the first derivative term $\partial\phi/\partial x$, in equation (4), and the second derivative term $\partial^2\phi/\partial x^2$ are approximated within the following three-point compact framework

$$
\begin{aligned}
a_1 \frac{\partial\phi}{\partial x}|_{i-1} + \frac{\partial\phi}{\partial x}|_i &= \frac{1}{h}(c_1\phi_{i-1} + c_2\phi_i + c_3\phi_{i+1}) \\
&\quad -h\left(b_1 \frac{\partial^2\phi}{\partial x^2}|_{i-1} + b_2 \frac{\partial^2\phi}{\partial x^2}|_i + b_3 \frac{\partial^2\phi}{\partial x^2}|_{i+1}\right) \qquad (5)
\end{aligned}
$$

$$
\begin{aligned}
\overline{b}_1 \frac{\partial^2\phi}{\partial x^2}|_{i-1} + \frac{\partial^2\phi}{\partial x^2}|_i + \overline{b}_3 \frac{\partial^2\phi}{\partial x^2}|_{i+1} &= \frac{1}{h^2}(\overline{c}_1\phi_{i-1} + \overline{c}_2\phi_i \\
&\quad + \overline{c}_3\phi_{i+1}) - \frac{1}{h}(\overline{a}_1 \frac{\partial\phi}{\partial x}|_{i-1} + \overline{a}_2 \frac{\partial\phi}{\partial x}|_i + \overline{a}_3 \frac{\partial\phi}{\partial x}|_{i+1}) \qquad (6)
\end{aligned}
$$

For terms $\partial\phi/\partial y$ and $\partial^2\phi/\partial y^2$, they can be similarly expressed along the y-direction. Note that the compact schemes for $\partial\phi/\partial x|_i$ and $\partial^2\phi/\partial x^2|_i$ are not independent of each other. They are rather strongly coupled through terms $\partial\phi/\partial x|_{i-1}$, $\partial\phi/\partial x|_i$, $\partial\phi/\partial x|_{i+1}$, $\partial^2\phi/\partial x^2|_{i-1}$, $\partial^2\phi/\partial x^2|_i$, $\partial^2\phi/\partial x^2|_{i+1}$, ϕ_{i-1}, ϕ_i and ϕ_{i+1}. For the sake of description, we consider the above equations only for the case involving the upwind (backward) case.

Approximation of $\partial^2\phi/\partial x^2$can normally accomplished by applying the central schemes because discretization error tends to be dissipative. The weighting coefficients shown in equation (6) are then determined solely according to the modified equation analysis to provide higher spatial accuracy. Derivation of the coefficients $\overline{a}_1$~$\overline{a}_3$, $\overline{b}_1$, $\overline{b}_3$ and $\overline{c}_1$~$\overline{c}_3$ is as follows. We start by applying the Taylor series expansions for $\phi_{i\pm1}$, $\partial\phi/\partial x|_{i\pm1}$ and $\partial^2\phi/\partial x^2|_{i\pm1}$ with respect to ϕ_i, $\partial\phi/\partial x|_i$ and $\partial^2\phi/\partial x^2|_i$. This is followed by elimination of the leading error terms derived in the modified equation. The coefficients then can be derived for Eq. (6) as $\overline{a}_1$=−9/8, $\overline{a}_2$=0, $\overline{a}_3$=9/8, $\overline{b}_1$=1/8, $\overline{b}_3$=−1/8, $\overline{c}_1$=3, $\overline{c}_2$=−6, $\overline{c}_3$=3.

Dispersion-relation-preserving governs the relationship between angular frequency and the wavenumber of the first-order dispersive term [24]. The dispersive nature embedded in $\partial\phi/\partial x|_i$ can largely be retained if the first derivative term from equation (9) is modeled suitably. To preserve the dispersion relation, we applied the Fourier transform and its inverse for ϕ, as presented below:

$$\phi(\alpha) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \phi(x)\exp(-\mathbf{i}\alpha x)dx,$$
$$\phi(x) = \int_{-\infty}^{+\infty} \phi(\alpha)\exp(\mathbf{i}\alpha x)d\alpha \qquad (7)$$

Note that notation $\mathbf{i}$ is equal to $\sqrt{-1}$. By performing a Fourier transform on each term shown in equations (6) and (7), the expressions of the actual wave number α for these two equations can be derived as

$$\begin{aligned}\mathbf{i}\alpha h\ (a_1\exp(-\mathbf{i}\alpha h)+1) &\simeq c_1\exp(-\mathbf{i}\alpha h)+c_2+c_3\exp(\mathbf{i}\alpha h)\\ &-(\mathbf{i}\alpha h)^2(b_1\exp(-\mathbf{i}\alpha h)+b_2+b_3\exp(\mathbf{i}\alpha h))\end{aligned}$$

$$\begin{aligned}(\mathbf{i}\alpha h)^2(-\frac{1}{8}\exp(-\mathbf{i}\alpha h)+1-\frac{1}{8}\exp(\mathbf{i}\alpha h)) &\simeq 3\exp(-\mathbf{i}\alpha h)\\ -6+3\exp(\mathbf{i}\alpha h)-\mathbf{i}\alpha h\ (-\frac{8}{9}\exp(-\mathbf{i}\alpha h)+\frac{8}{9}\exp(\mathbf{i}\alpha h)) &\quad (8)\end{aligned}$$

In an approximate sense, the effective wavenumbers α', α'' have the same expressions as those shown on the right-hand sides of equation (8) [23]. Therefore, we can express α' and α'' as follows:

$$\begin{aligned}\mathbf{i}\alpha' h\ (a_1\exp(-\mathbf{i}\alpha h)+1) &= c_1\exp(-\mathbf{i}\alpha h)+c_2+c_3\exp(\mathbf{i}\alpha h)\\ &-(\mathbf{i}\alpha'' h)^2(b_1\exp(-\mathbf{i}\alpha h)+b_2+b_3\exp(\mathbf{i}\alpha h))\end{aligned}$$

$$\begin{aligned}\mathbf{i}\alpha' h\ (-\frac{8}{9}\exp(-\mathbf{i}\alpha h)+\frac{8}{9}\exp(\mathbf{i}\alpha h)) &= 3\exp(-\mathbf{i}\alpha h)-6\\ +3\exp(\mathbf{i}\alpha h)-(\mathbf{i}\alpha'' h)^2(-\frac{1}{8}\exp(-\mathbf{i}\alpha h)+1-\frac{1}{8}\exp(\mathbf{i}\alpha h)) &\qquad (9)\end{aligned}$$

After solving equation (9), α' and α'' can be derived as

$$\begin{aligned}\alpha' h = &-\mathbf{i}(24b_1\exp(-2\mathbf{i}\alpha h)+c_1\exp(-2\mathbf{i}\alpha h)+c_3+c1+24b_1\\ &+c_2\exp(-\mathbf{i}\alpha h)+24b_2\exp(-\mathbf{i}\alpha h)+24b_3-48b_1\exp(-\mathbf{i}\alpha h)\\ &-8c_1\exp(-\mathbf{i}\alpha h)-48b_3\exp(\mathbf{i}\alpha h)+24b_2\exp(\mathbf{i}\alpha h)\\ &+24b_3\exp(2\mathbf{i}\alpha h)-48b_2+c_2\exp(\mathbf{i}\alpha h)+c_3\exp(2\mathbf{i}\alpha h)\\ &-8c_3\exp(\mathbf{i}\alpha h)-8c_2)/(-8+\exp(\mathbf{i}\alpha h)-8a_1\exp(-\mathbf{i}\alpha h)\\ &+a_1\exp(-2\mathbf{i}\alpha h)-9b_1\exp(-2\mathbf{i}\alpha h)-9b_2\exp(-\mathbf{i}\alpha h)\\ &+9b_2\exp(\mathbf{i}\alpha h)+9b_3\exp(2\mathbf{i}\alpha h)+a_1+9b_1-9b_3+\exp(\mathbf{i}\alpha h))\end{aligned}$$

$$\begin{aligned}\alpha'' h = &[-(3\exp(-\mathbf{i}\alpha h)-6+3\exp(\mathbf{i}\alpha h)\\ &-\mathbf{i}\alpha' h(\frac{8}{9}\exp(-\mathbf{i}\alpha h)+\frac{8}{9}\exp(\mathbf{i}\alpha h))\\ &/(-\frac{1}{8}\exp(-\mathbf{i}\alpha h)+1-\frac{1}{8}\exp(\mathbf{i}\alpha h))]\end{aligned} \qquad (10)$$

To enhance the dispersive accuracy of α', it is required that $\mathrm{Re}[\alpha'\mathrm{h}] \approx \alpha\mathrm{h}$, where $\Re[\alpha' h]$ denotes the real part of $\alpha' h$. This implies that $E(\alpha)$ as defined below should have a very small, and positive value. Define

$$E(\alpha) = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left[W\left(\alpha h - \mathrm{Re}[\alpha' \mathrm{h}]\right)\right]^2 d(\alpha h)$$
$$= \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left[W\left(\gamma - \mathrm{Re}[\gamma']\right)\right]^2 d\gamma \qquad (11)$$

where $\gamma = \alpha h$, $\gamma' = \alpha' h$ and W is the weighting function which is selected to allow equation (11) to be analytically integrated. To make E the minimum, positive value, the following extreme condition is enforced

The solution of the above equation, in conjunction with the other six algebraic equations obtained using modified equations analysis, allows for the seven introduced unknowns (provided below) to be uniquely determined as a=0.875, b_1=0.125, b_2=−0.249, b_3=0.00013, c_1=−1.936, c_2=1.997, c_3=−0.061. It should be noted that the above upwinding scheme developed for $\partial\phi/\partial x$ can be shown to have spatial accuracy up to the fifth order from the following modified equations $\partial\phi/\partial x$= $\partial\phi/\partial x|_{\text{exact}}$− 0.0007 $h^5(\partial^6\phi/\partial x^6)$ + 0.0002 $h^6(\partial^7\phi/\partial x^7)$ + 0.00005 $h^7(\partial^8\phi/\partial x^8)$ + $O(h^8) + \cdots$. Please refer to [22] for details.

For the sake of completeness, we also present the dispersion and dissipation behavior for the present dual-compact scheme. The fundamental analysis begins with the definition of coefficients k_i and k_r for the dispersion and dissipation errors, respectively:

$$k_i = \mathrm{Re}[\gamma']$$
$$k_r = \mathrm{Im}[\gamma'] \qquad (12)$$

In the above, $\mathrm{Re}[\gamma']$ denotes the real part of γ' $(\equiv \alpha' h)$ and $\mathrm{Re}[\gamma']$ denotes the imaginary part of γ'. In Figure 1(a) to (b), the predicted values of k_i and k_r are plotted against the modified wavenumber αh for the proposed dual-compact upwind scheme. Figure 1(a) illustrates that the proposed scheme is capable of providing excellent dispersion, which is crucial to the simulation of the phase field equation. The k_r value derived from the current upwind dual-compact scheme, does not precisely match the exact solution, due to the addition of artificial viscosity to enhance stability.

II. Semi-implicit Gear scheme and projection method

In our present study, the two phase flow equations are discretized by the Gear scheme as follows:

$$\frac{3\underline{u}^{n+1,*} - 4\underline{u}^n + \underline{u}^{n-1}}{2\Delta t} = -2\,[(\underline{u}\cdot\nabla)\underline{u}]^n + [(\underline{u}\cdot\nabla)\underline{u}]^{n-1}$$
$$+2\frac{1}{\rho^{n+1}}[\frac{1}{Re}\nabla\cdot(2\ \underline{\underline{D}} - \nabla^2\underline{u})]^n$$
$$-\frac{1}{\rho^{n+1}}[\frac{1}{Re}\nabla\cdot(2\ \underline{\underline{D}} - \nabla^2\underline{u})]^{n-1}$$
$$+\left((\frac{1}{\rho}(-\nabla p + \frac{1}{Re}\nabla^2\underline{u} + \frac{1}{We}\underline{F_s}) + \frac{1}{Fr^2}\underline{e_g}\right)^{n+1,*} \quad (13)$$

Note that we compute $\nabla p^{n+1,*}$ using the second order backward difference:

$$\nabla p^{n+1,*} = 2\nabla p^n - \nabla p^{n-1} \qquad (14)$$

Equation (14) may be expressed as a Helmholtz equation in the form $(\mathbf{I}+\mathbf{A})\underline{u}^{n+1} = \mathbf{F}$. There is no need for non-linear iteration for the present semi-implicit scheme. The intermediate velocity $\underline{u}^{n+1,*}$ is generally not divergence-free.

$$\frac{3(\underline{u}^{n+1} - \underline{u}^{n+1,*})}{2\Delta t} = -\frac{1}{\rho}\nabla p' \qquad (15)$$
$$p^{n+1} = p^{n+1,*} + p' \qquad (16)$$

Considering the divergence in equation (15), we can derive the Poisson equation for pressure correction as follows:

$$\nabla\cdot(\frac{1}{\rho}\nabla p') = \frac{3(\nabla\cdot\underline{u}^{n+1,*})}{2\Delta t} \qquad (17)$$

Solving equation (17), one can compute the corrected velocity $\underline{u}^{n+1} = \underline{u}^{n+1,*} - 2/3\Delta t(1/\rho\nabla p')$, and the pressure $p^{n+1} = p^{n+1,*} + p'$.

III. Velocity-pressure coupling

When solving the incompressible flow equation, special care must be taken for the velocity and pressure coupling. While a staggered grid has been demonstrated to be able to eliminate the odd-even decoupling problem, the resulting program complexity is still a key task. For our purposes, we use a semi-staggered grid to couple the velocity and pressure [27]. The velocity vectors are stored at the edge of the cell, whereas pressure and other scalar fields are stored at the center, as shown in Figure 2. The programming complexity is much lower for this grid system, compared to the staggered grid, and the coupling may be easily achieved if one employs a pressure interpolation from cell center to edge.

Numerical results

In this section, we present results for our solution. For the benchmark problems, we list the order of accuracy, the conservation of total mass, and the contours for the computed results. Finally, we compare our results with experimental and numerical results for three two-phase flow benchmark problems.

I. Dam-break problem

The first problem without considering surface tension simulates the sudden collapse of a rectangular column of water onto a planar surface. This classical problem, known as the dam break problem, has been frequently employed to validate the code for predicting free surface hydrodynamics. In addition to the hydraulic importance of this problem, both experimental [31] and numerical results [32] are available for making a direct comparison.

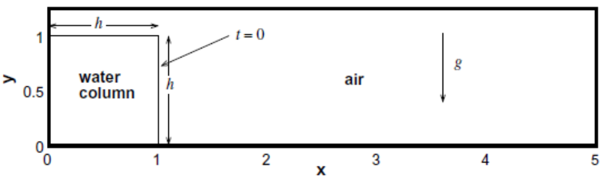


Fig. 1. Schematic of the initial water column for the dam break problem considered

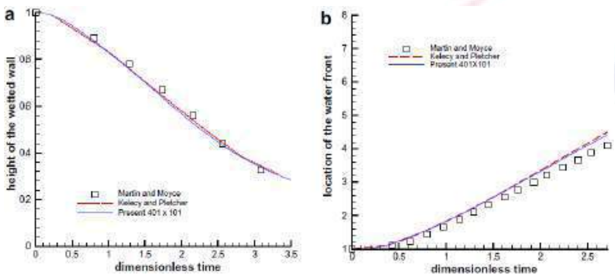


Fig. 2. Comparison of the predicted surge front location and the water column height with the experimental data and the numerical results of Kelecy and Pletcher.

(a) height of the wetted wall; (b) location of the water front.

In the current calculation, the fluid properties are considered to be the same as those given in [32]. The initially prescribed height of the water column schematic in Figure 1 is h=1. The results for the collapsed water will be predicted at Re=42792 in the domain containing 301×76 and 401×101 nodal points. The predicted heights of the collapsed water column will be plotted against the dimensionless time defined in [32]. Good agreement with the experimental result given in [31] is clearly demonstrated in Figure 2 for the predicted surge front location and the water column height. The predicted time–evolving free surfaces in Figure 3 are compared also favorably with the finite element solution of Kelecy and Pletcher [32]. As Figure 4 shows for the ratio of the temporal water against the initial water column, the conservative property built in the modified level set method is still retained quite well.

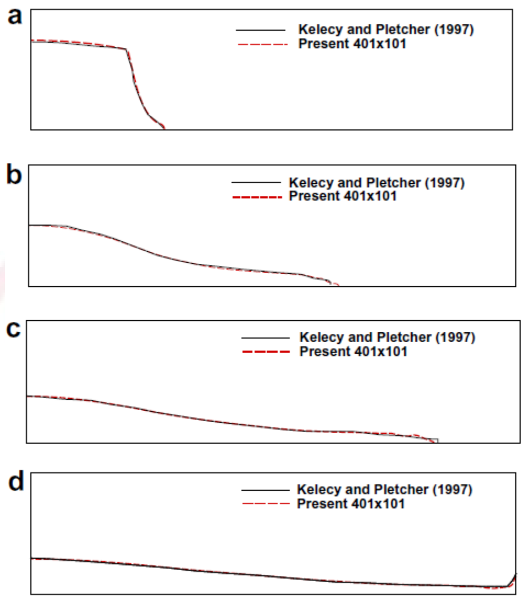


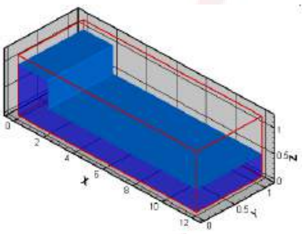
Fig. 3. Comparison of the predicted free surfaces, obtained at 401×101 grids, with those of Kelecy and Pletcher for the two-dimensional broken dam problem. (a) t=0.6; (b) t=1.8; (c) t=2.4; (d) t=3.0.

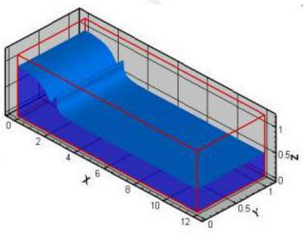
II. Bubble rising problem

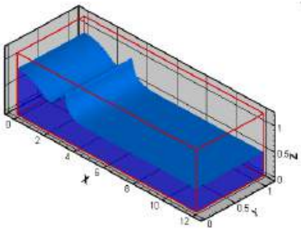
We then investigate the time-evolving interface problem where surface tension needs to be taken into account. The problem under investigation considers the evolution of a stationary bubble, that is driven by surface tension, in a container partially filled with the viscous fluid of height $3.5D$ and width $3.0D$, where D is the initial diameter of the bubble. The main reason for modeling the gas bubble rising from rest in the incompressible fluid flow under buoyancy is due to a considerable amount of available experimental results in the literature [33,34].

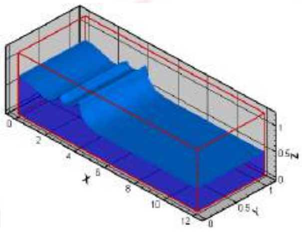
Modelling of a rising bubble, schematic in Figure 5, needs to specify the ratios of physical properties for the gas and liquid. The fluid-gas density and viscosity ratios are specified respectively as ρ_ℓ/ρ_g=2.0 and μ_ℓ/μ_g=2.0. In addition, the problem under investigation is characterized by another two dimensionless parameters, namely, $Re(D)^{3/2}\sqrt{g}\rho_\ell/\mu_\ell$ and $We = \rho_\ell g D^2/\sigma$, where Re and We are denoted as the Reynolds and Weber numbers, respectively. The subscripts ℓ and g correspond to the fluid surrounding the bubble and the fluid inside the bubble, respectively. Initially, the bubble center is located stationarily at $(1.5D, 1.5D)$ in the flow, which is at rest everywhere. The whole domain will be considered rather than simply specifying the axially symmetric condition to avoid a possible development of Conda effect. As is usual, no-slip conditions are specified along the horizontal and vertical walls.

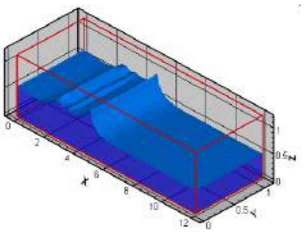
As the former test problem, the bubble area is excellently preserved. We have also conducted the analysis with the physical density ratio of 1000, considered by Sussman et al. [19], to simulate the bubble rising problem. The predicted time-evolving free surfaces and bubble interfaces, obtained in 144×144 grids with $Re = 100$ and $We = 200$, are plotted in Figure 6.


(a)


(b)


(c)


(d)


(e)

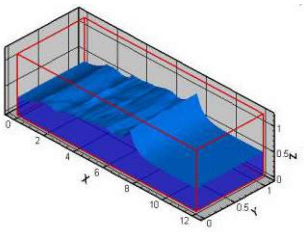
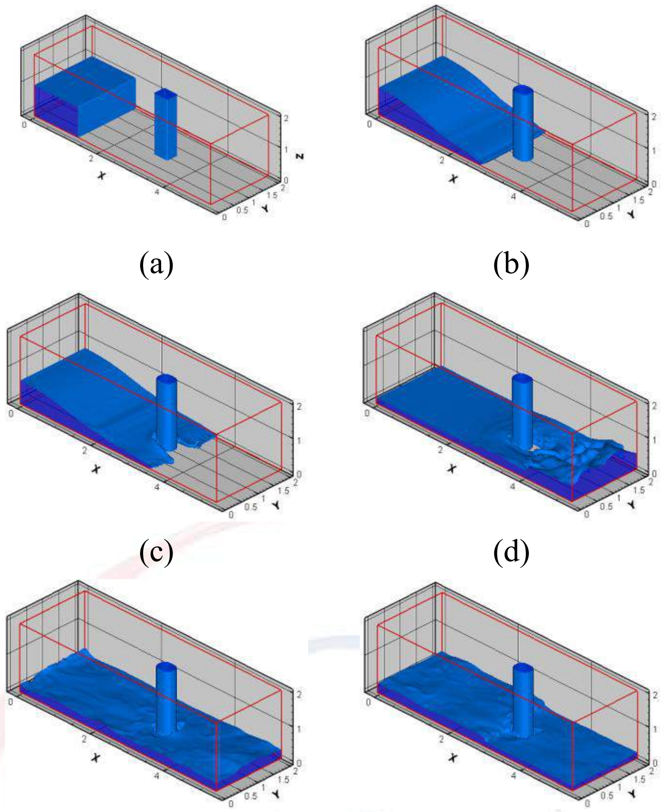

(f)

Fig. 4(a). Numerical simulation of dam-break wave surface change over time (downstream water depth is 0). (a) t=0s; (b) t=1.0s; (c) t=2.0s; (d) t=3.0s; (e) t=4.0s; (f) t=7.0s.



(a) (b)

(c) (d)

(e) (f)

(f)

Fig. 4(b). Numerical simulation of the downstream side of the dam-break wave impulse column. (a) t=0s; (b) t=1.5s; (c) t=2.0s; (d) t=7.s; (e) t=14.0s; (f) t=20.0s.

III. Water droplet falling problem

We also investigate a water droplet falling through the air and hitting the originally planar free surface. The dimensionless physical properties under current investigation are set to be the same as those given in Sussman et al. [36], namely, μ_1=1, μ_2=0.0141, ρ_1=1, ρ_2=0.00123. The drop is initially accelerated with a fictitious gravitational force $1/Fr^2 = 1/2$ for a total dimensionless time of 2. Afterwards, three dimensionless parameters for characterizing the flow motion are chosen as *Re*=3518, *Fr*=1633 and *We*=220, where the characteristic length and velocity are chosen as 10^{-3}m and 4 m/s, respectively. All the calculations will be carried out at $\Delta x = \Delta y$ =0.03125 and Δt =5.0×10^{-4} for the droplet with the dimensionless radius of 1.

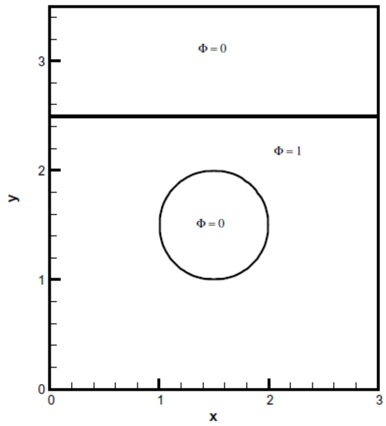


Fig. 5. Schematic of the initial condition for the bubble rising problem.

For the sake of enlightening the effect of surface tension, the case with consideration of surface tension is investigated for studying the interaction between the water droplet and the originally stationary water bounded by the free surface. The predimensionless dicted time-evolving droplet interface and free surface in Figure 21, plotted at the dimensionless times t=0.0, t=2.4 and t=3.5, are compared with those given in Sussman et al. [36]. As Figure 22 shows, the area-preserving feature remains also quite well for the case with consideration of surface tension.

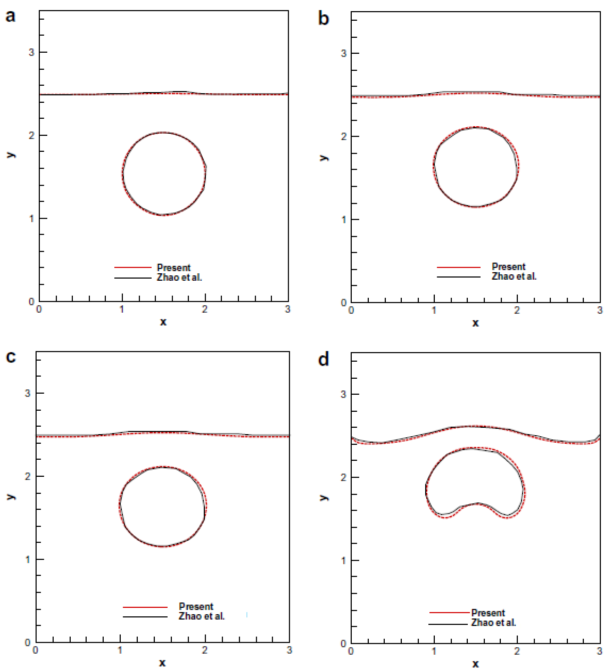
V. The actual terrain simulation

Finally, the study of the actual terrain of the development model in this paper. In the northern part of Taiwan freshwater Triple River area as an example, this section describes the geographic information system (GIS) and the actual DTM terrain apply in this mode, the final simulation results illustrate how GIS intussusception were Application integration (reference Wu, 2005).

Numerical terrain model DTM data set covering the whole island, its mesh size of 40 square meters in Taiwan. Chelungpu fault along the Taipei area has a higher resolution of about 5 meters square grid of DTM data. Taiwan in 2006, Taiwan has completed DTM resolution of five meters square, since the information is not easy to build, general or special purposes higher resolution DTM data subject or purchase made by the applicant, DTM data system used in the present study through Feng Chia University (FCU) camp Infrastructure and Disaster Prevention Center achieved. The DTM data in accordance with the purpose or use of different methods of which have different sources of information, therefore, generally purchased in addition to the civil society, will also apply to land information system or purchase. Using ArcGIS software is based on the main shown in Figures 9-10.

Three simulated conditions assumed a sudden flood areas affected by the invasion, embankment or dike embankment overflow due to excessive upstream inflow, caused by a dike or notches to triple flooded areas. To penetrate the downstream boundary (outflow boundary), the basic depth of the river channel is set to 1.0 m, the number of simulated conditions set grid 108^2, $\Delta x=\Delta y=40$m. Then the numerical topographic data (DTM) construct a triple-area numerical model will want to simulate the terrain, DTM accuracy of 40m×40m, is shown to simulate the actual terrain elevation schematic in Figure 11. Analog range is $4320\times4320\text{m}^2$ computational domain, including irregular terrain and meandering channels. The initial conditions for the simulation Manning n=0.095, CFL=0.01, simulation time from 0 seconds to 10,800 seconds.

Due to lack of information Tamsui triple section, under this part to Typhoon aera in Taipei Bridge water line calendar for simulated conditions. Inflows to the two-dimensional variable Hager (1985) empirical formula proposed rewrite stream design flow line calendar to comply under the bridge in Taipei Typhoon aera calendar water line, and then to the peak flow into the design flow line as the simulation calendar start. Where the bridge is located in the middle of the triple Taipei area, but is tentatively scheduled for inflow conditions, future data collection more complete good, if correct flow calendar line, after substituting the calculated results can show the triple area flooded condition.



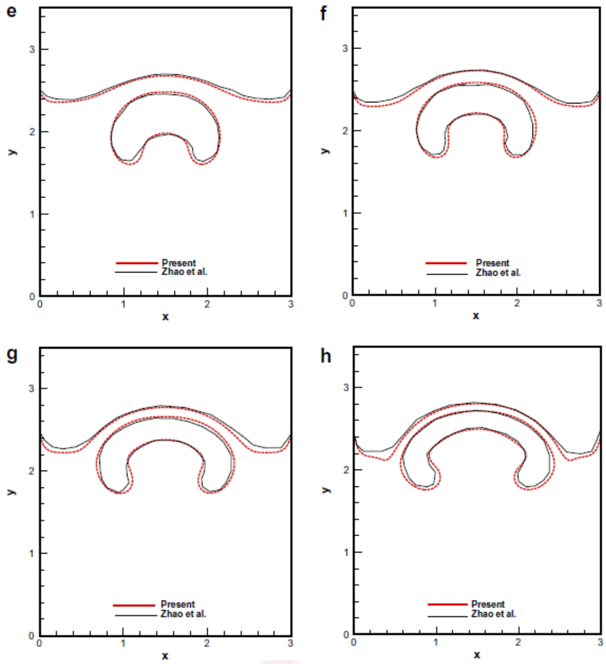
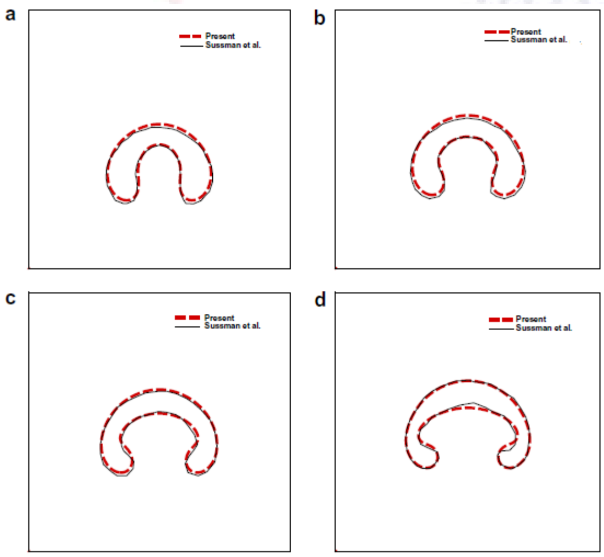


Fig. 6. Comparison of the predicted time-evolving free surfaces and bubble interfaces, obtained at 241×281 grids, with those of [35] for the case without considering surface tension. (a) t=0.5; (b) t=1.0; (c) t=1.5; (d) t=2.0 (e) t=2.5; (f) t=3.0; (g) t=3.5; (h) t=4.0.



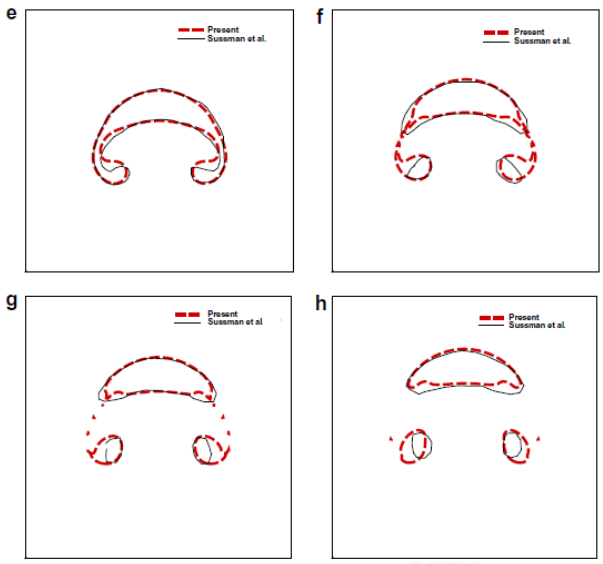


Fig. 7. Comparison of the predicted time-evolving free surfaces and bubble interfaces, obtained at 144×144 grids, with those of [19] for the case considering surface tension. (a) t=2.8; (b) t=3.2; (c) t=3.6; (d) t=4.0 (e) t=4.4; (f) t=4.8; (g) t=5.2; (h) t=5.6.

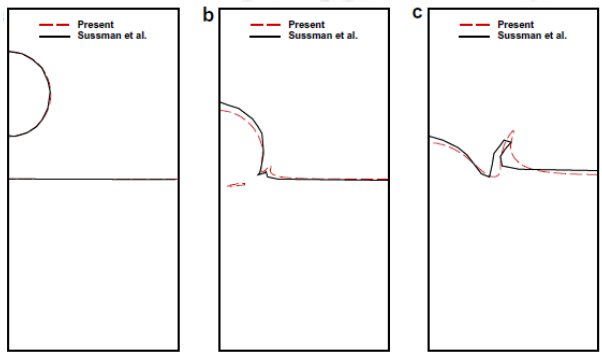


Fig. 8. Comparison of the predicted interfaces with those of Sussman et al. [36] for the droplet problem investigated in 257×257 grids. (a) t=0.0; (b) t=2.4; (c) t=3.5.

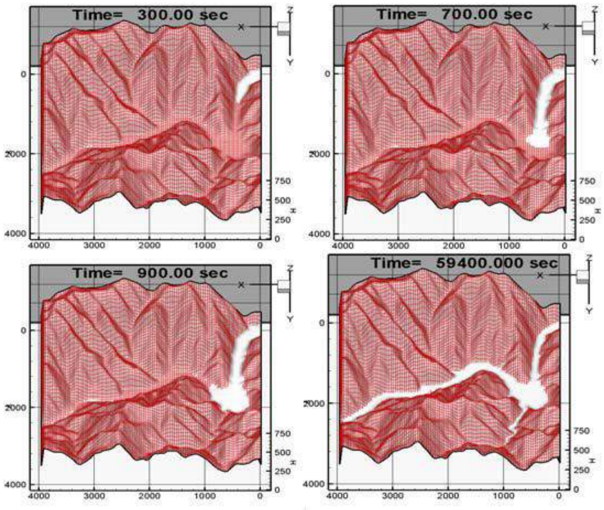


Fig. 9. Flooding flow simulation of the actual terrain conditions change (Reference Wu, 2005)

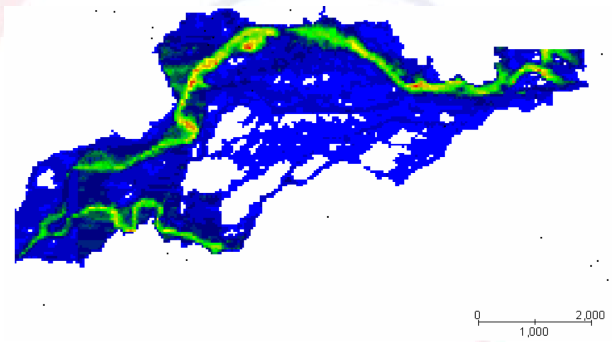
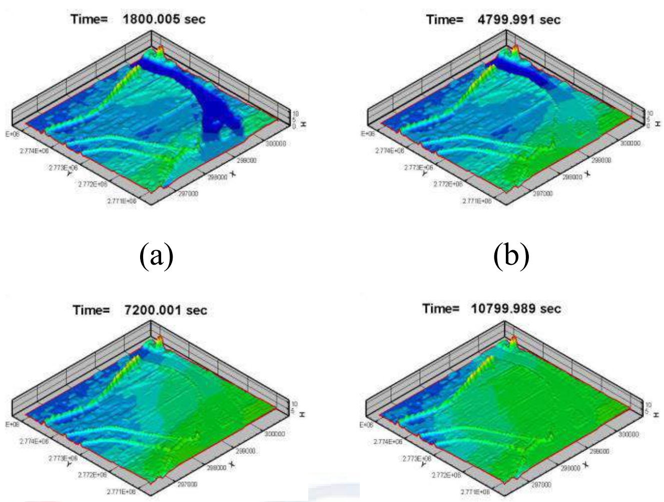


Fig. 10. Flooding potential analysis indicate (Wu, 2005)

Conclusion remarks

The differential equation employed to model the evolving interface should accommodate the conservative interface property. This underlying transport equation should also have the ability to compress the level set function and can, therefore, sharpen the interface. For the stabilization reason, an artificial viscosity that is sufficient to suppress the oscillations in the vicinity of interface, at which a fairly high gradient solution may be present, is explicitly added to the formulation. The derived conservative level set method will be split into the conventional level set method for the advection of the level set function and the other inhomogeneous equation, with the compressive flux and source terms being nonlinear with respect to the level set function, for compressing the interface profile. The finite volume advection scheme implemented in the advection step of the conservative level set method should yield a predicted solution that is dispersively very accurate. Both of the proposed DRP advection scheme and compact pressure gradient scheme applied in non-staggered grids have been verified analytically.



(a) (b)

(c) (d)

Fig. 11. Simulate the actual terrain level changes (a) t=1800s; (b) t=4800s; (c) t=7200s; (d) t=10800.

Acknowledgements

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Developing Lifecycle Inventory Indices for Estimating the Carbon Sequestration of Artificially Engineered Soils and Plants

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Abstract
Recent research into soil engineering indicates that increased carbon sequestration through the conversion of atmospheric CO_2 to a pedogenic carbonate mineral (calcite, $CaCO_3$) may help mitigate global warming through artificially engineering a variety of soils with selected materials and vegetation so that they have a photosynthesis-driven carbon capture function. Non-biological processes of carbonation also occur, at high pH. In both cases, CO_2 partitions into soil porewaters as dissolved carbonate, and precipitates by combining with Ca derived from portlandite ($Ca(OH)_2$) and weathered cement-derived calcium silicates, derived from materials generated by the demolition process. This paper aims to illustrate a method for capturing lifecycle data by quantifying the stocks and flows of the process through a series of possible experiments which if proved successful will allow a deeper understanding of the ability of soil calcite to act as a stable CO_2 sink. The challenge is to identify non-calcined (i.e. calcium silicate) rocks, that weather sufficiently rapidly to provide a net sink for CO_2, taking into account all emissions during production. The results will lead to normalised impact assessment data which can be applied globally within the fields of soil science and civil engineering. Furthermore, if the results indicate a strong uptake in terms of CO_2 sequestration there is the potential to assist the United Kingdom's 80% CO_2 reduction target by 2050 through widespread adoption of the technology, provided that there is a positive cost-benefit ratio.

Keywords: Climate change, Soil science, Carbon sequestration, Environmental policy

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1 Introduction

The potential of urban plants and soils to store C has long been recognised (IPCC, 1996; Lal et al., 2007) however, the magnitude and significance of this store with regard to climate change have only recently been quantitatively estimated (Smith, 2004; Smith et al., 1997). In a global context, soils are now recognised as an important potential tool for mitigation of rising atmospheric CO_2 concentrations. The 1997 Kyoto Protocol highlighted soils as a 'major carbon store' and recognised that processes underlying soil function should be considered in CO_2 emissions accounting.

In the UK, the Department for Environment, Food and Rural Affairs (DEFRA, 2009) highlighted a pressing need to 'develop a better understanding of steps that can be taken to protect or enhance levels of soil carbon'. Given that there is an 80% emissions reduction target by 2050 in the UK, it is imperative that further research into the development of engineered soils with a carbon function is maintained. The scale of the problem of compensating for anthropogenic emissions of CO_2 is clear: by 2050, global emissions will exceed 2000 levels by 7 Gt CO_2. There is no single process or activity that could compensate for this, and it has been suggested that 7 different approaches or carbon wedges, each accounting for 1 Gt C (approx. 3.7 Gt CO_2), might be a reasonable target (Pacala & Socolow, 2004). Current UK emissions are 456 mt CO_2 (590 mt CO_2 in 1990; www.decc.gov.uk), and so the UK's target for CO_2 emissions reduction, whilst ambitious, is small compared with potential global targets.

The aim of this paper is to report the design and development of an indexed inventory-based lifecycle assessment (LCA) framework that results in the creation of normalised impact assessment data. This also involves expanding initial embedded lifecycle CO_2 anthropogenic estimates into Global Warming Potentials (GWP) through CO_2 equivalency (CO_2e). It is the first lifecycle assessment that addresses organic and inorganic soil carbon sequestration; no primary lifecycle inventory data on carbon sequestration rates for minerals exist, possibly due to the wide variability in site location, the quantity of non-calcined rock types as well as logistical and production based dimensions. Following a short overview of current engineered and mineral based carbon sequestration methods, the paper is then illustrated focusing on the scope of the field study, data collection and comparison of rock types from brownfield sites and an illustration of the study location.

2 Carbon Sequestration of Engineered Soils

Recent evidence of soil based chemical processes indicate a rapid carbon sequestration function, removing CO_2 from the atmosphere and storing it as organic (soil organic matter) and inorganic (pedogenic) forms of carbon (C). During silicate weathering, calcium (Ca) and magnesium (Mg) silicate minerals naturally react with dissolved carbon dioxide (CO_2) to form carbonates (Berner et al., 1983) effectively capturing and fixing atmospheric C. Weathering involves leaching and transport of Ca^{2+} and Mg^{2+} in solution, some of which reacts with carbonate anions formed by CO_2 dissolution in soil pore waters to precipitate pedogenic (soil-formed) carbonates. This process contributes to the stabilisation of atmospheric CO_2 concentrations over various geological timescales (Berner & Lasaga, 1989; Berner et al., 1983) and forms pedogenic carbonates in both natural (Nettleton, 1991) and artificial soils (Renforth &

Manning, 2011). A simplified version of the carbonation reaction for artificial calcium silicates is given in Reaction 1.

$$CaSiO_3 + CO_2 + 2H_2O \rightarrow CaCO_3 + H_4SiO_4 \qquad (1)$$

2.1 Mineral Carbonation for Carbon Capture and Storage
Reaction (1) involves passive capture and storage of C. The addition of Ca and Mg-rich silicates to soils may promote the accelerated draw-down and storage of CO_2 from the atmosphere as relatively stable carbonate minerals (Manning, 2008; Schuiling & Krijgsman, 2006). Recently investigations into the role of urban soils as a sink for atmospheric CO_2 have shown that pedogenic carbonate minerals, normally regarded as a phenomenon of natural arid soils (Landi et al., 2003) form in *artificial* urban soils in the UK and North America (Manning & Renforth, 2012). For example, work at the 10 ha Newcastle Science Central site (Figure 1) formerly occupied by the Newcastle Brewery, has shown that the **soils onsite remove 85 t of CO_2/ha annually** (Washbourne et al., 2015). Overall, the $CaCO_3$ content to 100 mm depth over 18 months (2010−2012) increases from 22.0 to 39.0 wt %. Assuming that the UK has 1.7 million ha of urban land, only 12,000 ha of land in a similar state to that of Science Central will remove 1 Mt CO_2 annually.

Figure 1: Science Central; St James Park in background (Newcastle upon Tyne, UK)

Isotopic analysis of carbonate C and oxygen (O) shows that pedogenic carbonates in urban soils have similar isotopic compositions to carbonates from natural soils in which photosynthesis contributed to their formation (Cerling, 1984), and confirms that a significant proportion of the C has been captured from the atmosphere (Renforth et al., 2009; Wilson et al., 2009). This may be a characteristic phenomenon of urban brownfield sites and other anthropogenic soils, as construction activities in urban soils usually involve the addition of Ca/Mg-rich substrates. If added to such soils, construction and demolition (C&D) waste, fly ashes, iron and steel slag etc. may enhance C capture and storage in the urban environment (Morales-Flórez et al., 2011; Renforth et al., 2011a; Renforth et al., 2009; Renforth et al., 2011b) thus the value of materials which may otherwise be regarded as 'wastes' is increased. In principle, carbonation of these materials could be used to offset the C emissions associated with their production. There is potential for C capture and storage to become a routine design consideration in the engineering of anthropogenic soils, with minimal additional energy input, little change in current management practise and minimal translocation of materials. Figure 2 illustrates recently completed trial plots at Cockle Park Farm in Northumberland, UK, which use a mixture of different materials to test carbon capture.

Figure 2: Carbon Capture Trial Plots at Cockle Park Farm (Northumberland, UK)

2.2 Organic and Plant-Based Reactions

A number of organic chemical reactions exist which have an effect on soil's ability to act as a carbon sink (Schmidt et al., 2011). According to Davidson and Janssens (2006) the decomposition of microbial matter in soil along with root respiration almost entirely leads to expulsion of CO_2 to the atmosphere leading to a positive feedback loop on climate change. This so called C fluxing must be managed in order to reduce its exposure in the atmosphere as much as possible. Carbonation of minerals in soil breaks this feedback loop. Soil stores up to four times as much carbon as plant biomass (Stocker et al., 2013) and soil microbial respiration releases about 60 Gt of carbon per year as carbon dioxide (Shao et al., 2013). While initial experiments have shown that soil microbial respiration increases exponentially with temperature (Davidson & Janssens, 2006) more recent work has attempted to predict the magnitude of this reactivity. Karhu et al (2014) studied a range of different ecosystems from the Arctic to the Amazon to determine how microbial community responses affect the typical 90 day mid to long-term sensitivity to temperature change. They discovered that at colder climates the sensitivity is enhanced by a factor of 1.4 compared to instantaneous responses. While the assessment of carbon flux is out of scope for this initial study, subsequent experiments will attempt to take such reactions into account in order to determine its impact on carbon sequestration.

3 Methodology

The methodology consists of an approach which enables the design of an LCA inventory index to determine the ‘default’ carbon sequestration rates of calcium carbonate in brownfield sites. In addition, a lifecycle assessment of one of the key plots within the SUCCESS carbon capture site is simulated using dolerite (diabase) and basalt as calcium silicate additives to soil.

3.1 Scope of the Study

The scope of the study is based around maximizing the effectiveness of carbon sequestration and $CaCO_3$ formation within brownfield sites or engineered soils associated with construction activity, by adding artificial or natural calcium silicate materials. The reason for using this type of material as described earlier is the abundance of calcium and magnesium substrates, which in part is a direct consequence of the construction and demolition process. In order for this to happen a variety of different experiments consisting of soil types and vegetation is being explored. Figure 3 illustrates a comparison of a typical carbon cyclic process of C between greenfield lands and the artificially engineered experimental soils at Cockle Park Farm using crushed concrete and dolerite, collected locally, to maximize sequestration effectiveness. It should be noted that a combination of feedback processes in both greenfield and carbon capture sites will be occurring such as photosynthesis in the plot trials etc.

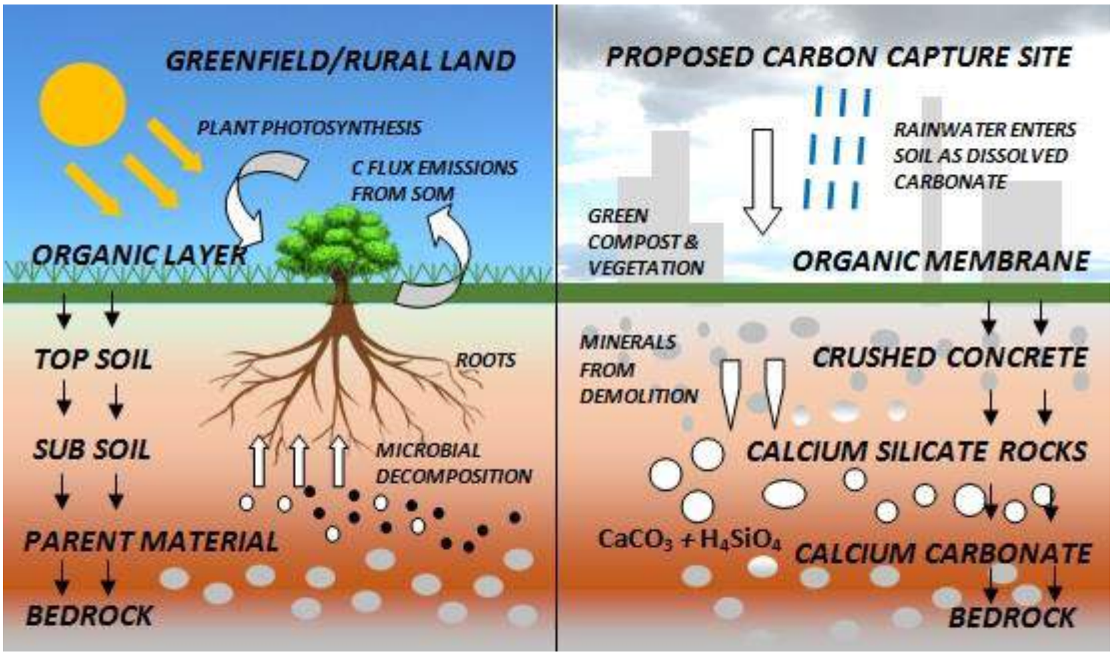

Figure 3: Comparison of dominant carbon cyclic processes in greenfield/rural land and the carbon capture site

Figure 4 outlines the scope (system boundary) of the LCA model. The model considers the initial supply of raw material including natural rock and crushed concrete fines in which they both have their individual collection process. The concrete fines for this study are classified as a waste product from crushing associated with demolition. These are sourced from the same locations as the natural rock. Logistical transport, excavating and mixing is measured in CO_2 equivalency using the

Global Warming Potential (GWP) characterisation factor. The so-called global warming potential (GWP_i) of GHG emission i measures its relative global warming strength in terms of its absorbed radiation in comparison to a CO_2 emission (Solomon, 2007). To obtain a global warming impact score GW for all GHG emissions m_i along a life cycle, the amounts m_i of all GHG emissions i are multiplied by their characterization factors GWP_i and summed:

$$GW = \sum_i m_i GWP_i \qquad (1)$$

The distinction between GWP_i and GW is essential: GW describes the actual global warming impact of a product's lifecycle (also known as Carbon Footprint), whereas GWP_i characterizes the radiation absorption of a single GHG emission independently from any product life cycle. Within the life cycle, material processing includes the mechanical handling (excavation) and mixing of the material at site which leads to the eventual application to the soil plots. The CO_2 release of the soil organic matter due to microbial and vegetation respiration while out of scope for this analysis should be estimated in future, based upon previous studies.

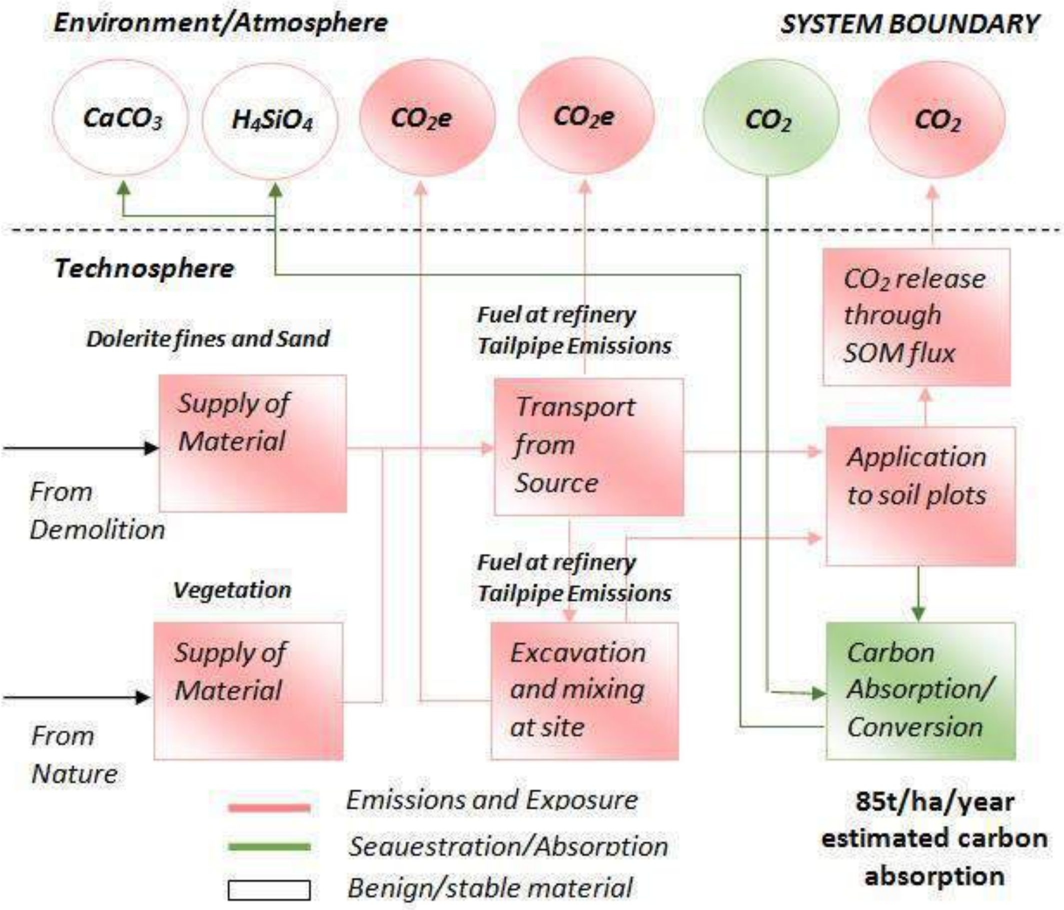

Figure 4: LCA Boundary Analysis

3.2 Data collection

The trial at Cockle Park Farm consists of 14 distinct plots each with a mixture of different types of material, mainly dolerite, sand and crushed concrete. In order to select the appropriate plot to simulate it was first necessary to perform a comparison of materials between several source quarries in the region. Figure 5 illustrates the sample region and collection.

Figure 5: Left – A map illustrating quarries in Northumberland (Source: Simkin, 2012), UK; Top-Right –'Disturbed' samples (Site A); Middle-Right – Site B (possible calcium carbonate visible on surface); Bottom-Right – 'Disturbed' samples (Site B) of 100mm applied substrate depth; Bottom-Left - SUCCESS team on-site collecting samples from 'Site B'

The initial data collection consisted of collecting a variety of 'disturbed' test samples from site A (UK Grid Reference NY 92643 75682). 6 random 'disturbed' samples were also taken at site B (Grid Reference NU 13163 34162). Figure 5 illustrates the site locations and sample collection process. The estimated rate of C sequestration (85t/ha/year) for demolition/waste material is derived from the study undertaken at Science Central (concrete-based) by Washbourne et al (2015). Site B plot trials have been operating for around 4 years while Site A is estimated to have remained untouched for 15 years. Figure 6 illustrates the layout of the plots as well as the different treatments that were given (Simkin, 2012). A disturbed sample was taken from each plot in order to estimate the current level of carbonization of CO_2 into calcium carbonate. The collected samples would assist in providing an understanding of which types of soil material perform best at absorbing carbon and therefore estimating the carbon sequestration rate without the addition of other materials.

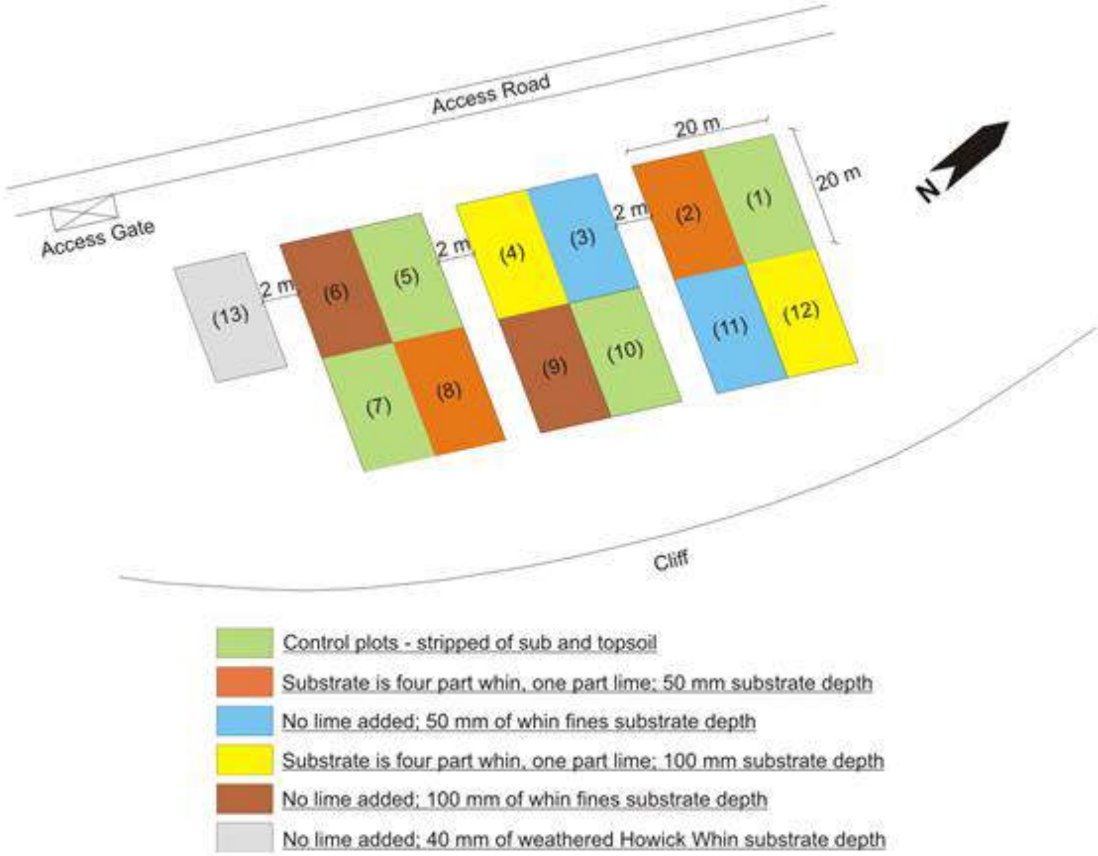

Figure 6: 'Site B' plot layout and treatments (Source: Simkin, 2012)

The first set of results consist of an organic and inorganic sequestered carbon comparison of local quarries i.e. site A and site B. As the two locations feature carbonation at different time scales, a time series analysis was applied to the results. An LCA of the SUCCESS carbon capture plot that theoretically has the most potential to absorb carbon was then performed using a mixture of materials that is considered to be optimal for sequestration. This is based on past studies of basalt showing a rapid carbon absorption rate. Table 1 and Figure 7 illustrates a carbon analysis of the Site A quarry sampling. Two samples were collected for each specific location within the quarry. From field observation, the quarry floor indicates a rough mix of clay, crushed concrete and dolerite/basalt fines.

Table 1: Site A Quarry Carbon Analysis (Organic/Inorganic)

Sample ID	Sample Description	TOC per 100mg (%)	TIC per 100mg (%)	TC per 100mg (%)
Qu Si Su	Quarry Side Surface	0.38	0.48	0.87
		0.43	0.39	0.83
Qu Fi To	Quarry Fines Top	0.86	0.19	1.05
		1.02	0.04	1.07
Bu 6”	Bund 6”	0.18	0.10	0.28
		0.17	0.09	0.26
La Ed	Lagoon Edge	0.16	0.11	0.27
		0.17	0.10	0.27
Bu Su	Bund Surface	0.28	0.24	0.52
		0.27	0.28	0.56
Qu Fl	Quarry Floor	0.30	0.16	0.47
		0.29	0.12	0.42

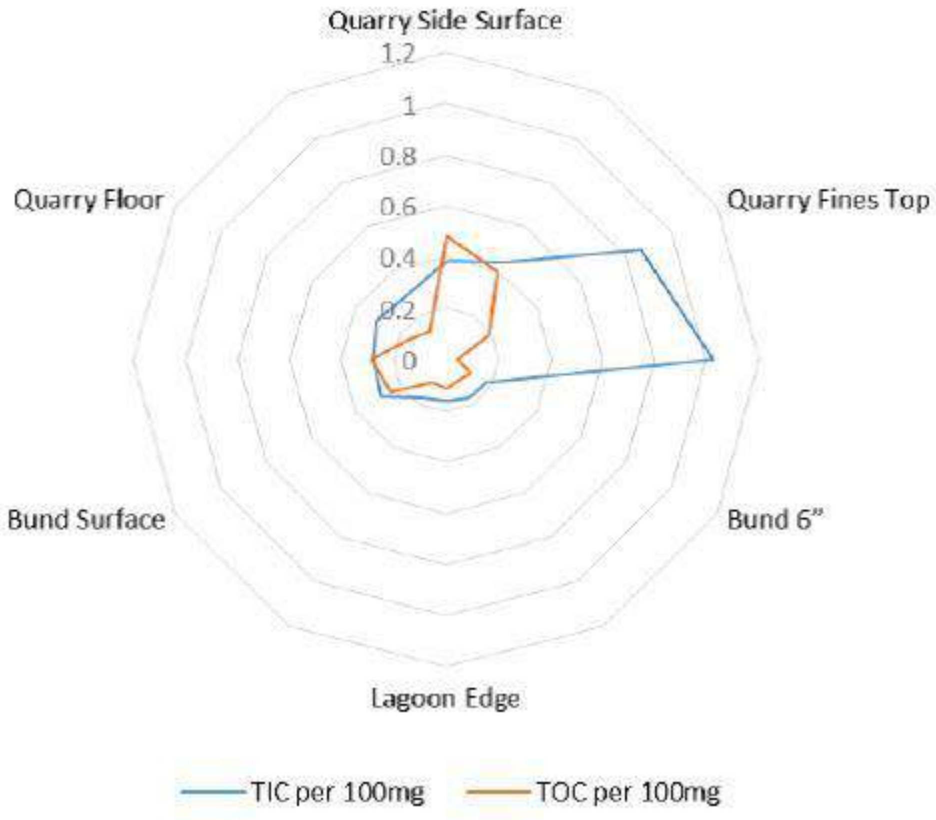

Figure 7: Comparison of Site A carbon analysis

Table 2 and Figure 8 illustrate the analysis of the site B carbon content. Three samples in total from each plot were analysed with the mean TOC/TIC illustrated in the table.

From the results it appears that the plots which feature significant levels of carbon also feature a large quantity of dolerite material (Plots 2, 4, 8 and 12) in addition to 20% of these plots also containing lime. All of the materials originate from the site.

Table 2: Site B Carbon Analysis (Organic/Inorganic)

Sample ID	Sample Description	TOC per 100mg (%)	TIC per 100mg (%)	TC per 100mg (%)
1	Control Plot – Stripped of sub and topsoil	1.06	0.72	1.78
2	Four part Dolerite, one part lime, 50mm substrate depth	0.17	8.62	8.80
3	No lime added; 50 mm of Dolerite fines substrate depth	0.70	1.16	1.86
4	Substrate is four part Dolerite; one part lime; 100 mm substrate depth	0.20	8.22	8.43
5	Control Plot – Stripped of sub and topsoil	1.20	0.49	1.70
6	No lime added; 100 mm of Dolerite fines substrate depth	0.12	0.48	0.60
7	Control Plot – Stripped of sub and topsoil	0.74	0.91	1.65
8	Four part Dolerite; one part lime; 50 mm substrate depth	0.25	8.09	8.35
9	No lime added; 100mm of Dolerite fines substrate depth	0.03	0.47	0.50
10	Control plot – Stripped of sub and topsoil	0.71	0.68	1.39
11	No lime added; 50mm of Dolerite fines substrate depth	0.46	0.57	1.04
12	Four part Dolerite, one part lime	0.36	8.08	8.44
13	No lime added; 40mm of weathered Howick Dolerite substrate depth	1.06	0.09	1.16

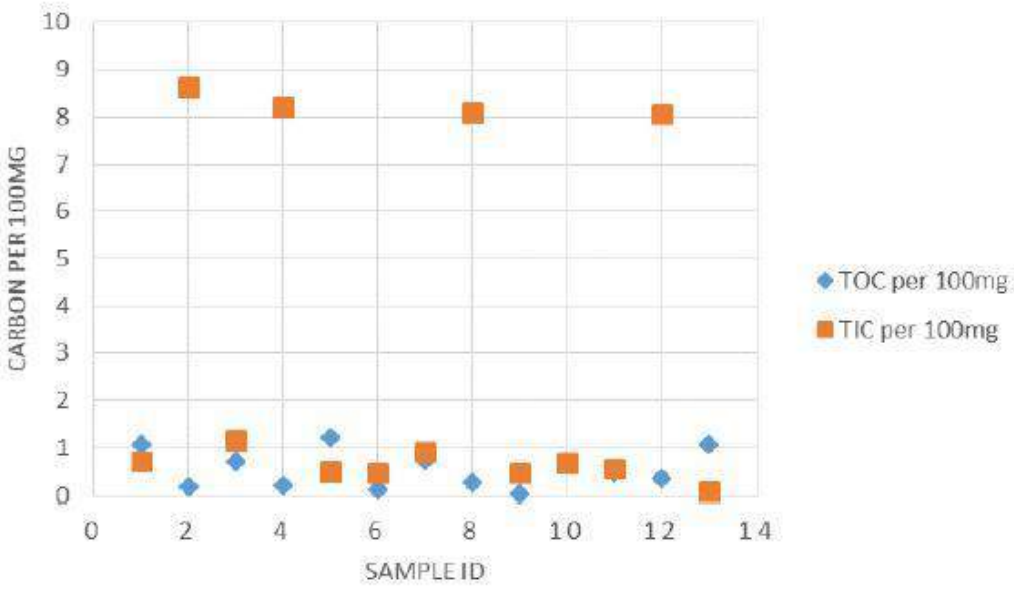

Figure 8: Comparison of Site B plot samples illustrating both total organic and inorganic carbon

Figure 8 illustrates the difference between total organic and inorganic carbon. For Site B, the inorganic carbon results for plots with added lime (limestone) include the carbon that is part of the lime used to build the plots, but the maximum TIC contribution from this source is 2.4%. The excess above this is due to the absorption of CO_2 from air into the soil.

3.3 Inventory Analysis and Key Assumptions

SimaPro v8.1 was used in the analysis of the estimated embedded emissions of the plot trials using a combination of previous studies and general assumption. SimaPro is a dedicated LCA software tool for undertaking LCA studies according to EN ISO 14040 (International Standards Organisation, 2006) and EN ISO 14044 (International Standards Organisation, 2006). The Ecoinvent inventory database (v3) was used to derive emission factors for each stage of the lifecycle. Table 3 shows the inventory analysis as input to the LCA, extrapolated to 1 ha ground area. The supply of raw material consists of dolerite, sand and compost from green waste. Sand was used as an unreactive mineral base, analogous to the sand fraction found in soils. Compost from green waste sources were added and sowed with a wildflower seed mix in order to encourage vegetation to growth and therefore allow increased absorption of CO_2 through photosynthesis to occur.

Table 3: Plot trial sub processes and inputs extrapolated to 1 ha.

Categories	Factors considered	Input
Supply of Raw Material	Dolerite (30% composition)	5,291.3 tonnes (weight)
	Sand (70% composition)	9,078.5 tonnes (weight)
	Compost from green waste (Top soil – 4% composition)	169.2 tonnes (weight)
Transport to site	Dolerite from Site B using Truck >20 tonnes	tkm = 338,066.2 (max load of 20 * total distance of 16903.31 km)
	Sand from Thrislington using Truck >20 tonnes	tkm = 664,774.5 (max load of 20 * total distance of 33238.7271)
	Compost from Newcastle upon Tyne using Truck >20 tonnes	tkm = 5,718.2 (max load of 20 * total distance of 285.91)
Excavation	Excavator	16,000 tonnes (weight)
Mixing at site	Loader	416.6 hours loader is active (time)

The input for each material is based upon the total material composition for a proposed trial plot of volume 10,000*1m^3 (1ha). The weighting of the material was calculated by multiplying the density of each material with the volume of the plots and their composition. The estimated transport of the materials to the site was calculated in tkm (tonnes * total kilometres driven) with a max load of 20 tonnes for each trip (return journeys with an empty load were automatically calculated using the appropriate Ecoinvent dataset). The excavation of the area requires 16,000 tonnes of Holocene sand to be removed. This area was once again calculated using the density of the land to be excavated. Emissions of the excavator were calculated with an engine rating of 100kw. Diesel consumption is .000556 kg per kg of excavated material. Finally, the mixing at the site was carried out by a standard loader with front facing bucket. As the vehicle remains stationary during the mixing process the engine is in an idle state, therefore this dataset is based upon duration of mixing where baseline emissions are calculated from the engine remaining active but on standby.

4 Lifecycle Impact Assessment Results

4.1 Analysis

The use of impact categories gives the ability to compare the environmental impacts of the different options. Characterization factors, or equivalency factors, describe the relative impact of the different environmental flows (ISO 2006). A larger characterization factor means a larger impact for that flow. Characterization factors are multiplied by each of the environmental flows to convert all them into an equivalent amount of the category indicator. The category indicator is the flow that is usually associated with that particular impact category (CO_2 equivalency for global warming). The environmental impact categories which are required for LCI inventory involve SimaPro V. 8.1; this study used the category to assess the environmental impacts from the creation of passive carbon capture trial plots in the north-east of England.

In order to interpret the results, a characterisation method was selected. As only global warming potential was appropriate for this study there was no particular requirement to display the results of all the characterisation factors, therefore the

GWP factor from the CML baseline method was chosen. This method is an update of the CML 2 baseline 2000 and was released by CML in April 2013 (version 4.2).

4.2 Main results

The results of the LCA are illustrated in Figure 9. The diagram shows the embedded GHG emissions from the selected plot construction. As anticipated, carbon dioxide has a total share of 85% global warming potential, primarily from the logistics and transport requirements of the materials to the plot site. The other highest emission is the combustion of fuel required to run the trucks and loaders (marked as fossil). The majority of CO_2, methane, and dinitrogen monoxide emissions derive from the exhaust of the trucks used to transport the materials to the site. The middle row consists of the estimated take back of carbon against the embedded emissions after 1 year of carbon sequestration. The left pie chart illustrates the comparison between embedded and absorbed CO_2 while the right hand pie chart illustrates absorption against total GWP. The bottom row illustrates carbon sequestration after 2 years where the plot is estimated to become CO_2 negative.

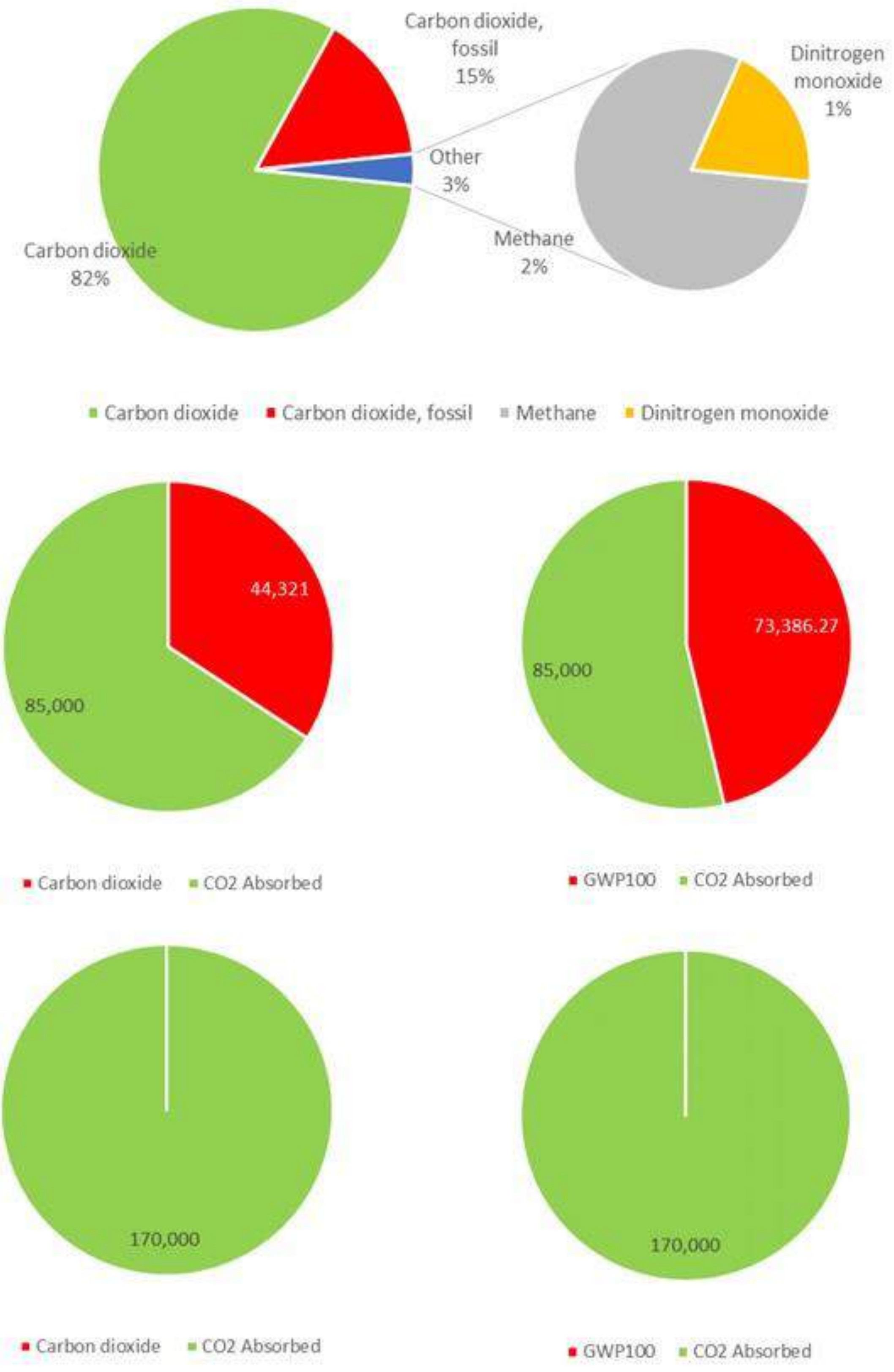

Figure 9: Top row: Embedded GHG emissions from selected plot construction (extrapolated to 1 ha); Middle row Estimated carbon sequestration level after 1 year compared to total embedded CO_2 (left) and total GWP100 (right); Bottom row:

projected carbon absorption after 2 years - experiment becomes carbon negative.
The mixing of materials, excavation of the area and the transport materials are illustrated below. All four areas of analysis illustrate the levels of GHG emissions based upon the functional unit of 1 hectare/10,000m^2 of carbon capture land per 1 year's operation. A cut off of 0.036% has been applied in order to illustrate only the most prominent emissions within the lifecycle. Note that the carbon sequestration function is shown here to compare with the total negative lifecycle emissions (i.e. 85t/ha/annum). From these results, it would take roughly around 18 months to offset the embedded emissions of 1 hectare of carbon capture plot using the materials provided.

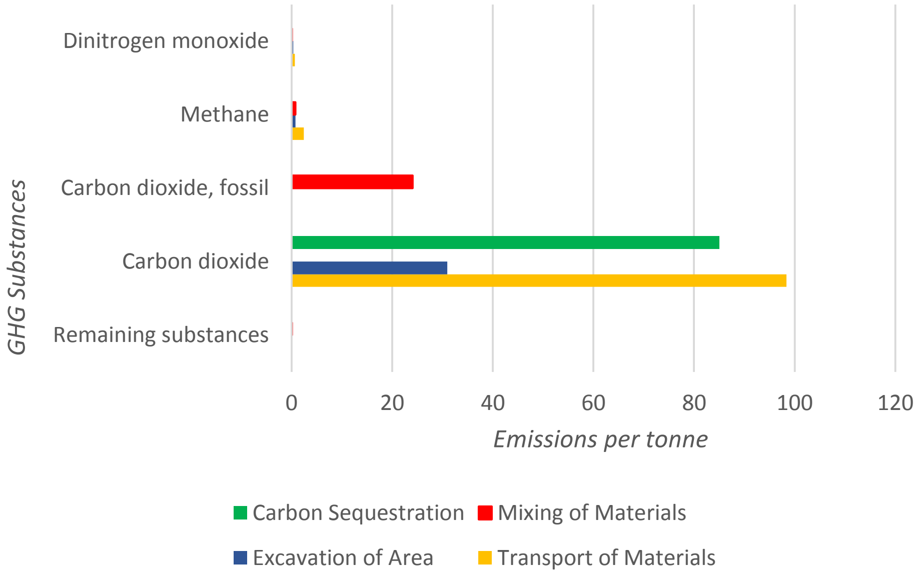

Figure 10: GHG contribution to the extrapolation of a SUCCESS trial plot to 1 hectare

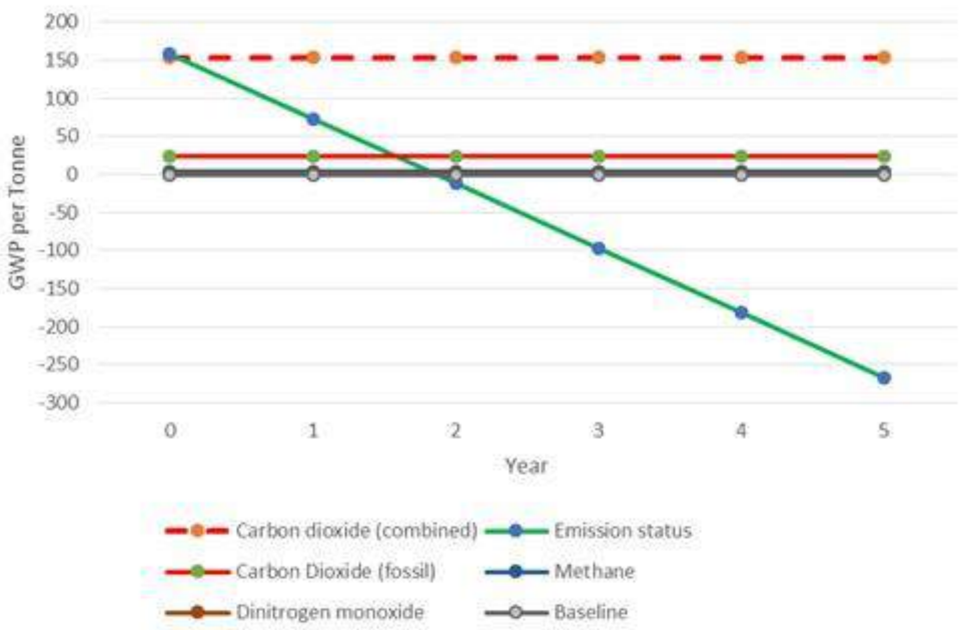

Figure 11: Embedded GWP and captured carbon over time

4.3 Discussion and Interpretation

From the results, it appears that the lifecycle scenario is highly sensitive towards the placement of the suppliers and the actual location of the carbon capture site. This is due to the high levels of emissions arising from transport of the material to the site. In order to achieve 85t carbon sequestration per year, it is necessary for $CaCO_3$ production in the soil to be approx. 39% present within the soil based on previous studies in Washbourne et al (2015) . However, using a dolerite material as opposed to crushed concrete effectively allows CO_2 absorption based upon past studies of using this material (Manning et al., 2013). It appears the material dolerite has a very high potential to capture carbon, particularly when the material is crushed and processed into fines.

In order to keep embedded CO_2 emissions to a minimum the placement of the site with regard to the suppliers should be at its shortest distance (no longer than 200 km each way), otherwise the duration of the plots to become CO_2 negative in a reasonable time will increase drastically

The logistical chain should use environmentally friendly vehicles in order to reduce the payback rate of the embedded emissions within the lifecycle.

An additional carbon capture component should be installed in order to provide extra sequestration support in the form of vegetation.

Any additional mixing should be carried out on-site and thereby avoiding carbon intensive processes. This is due to industrial mixing processes being more carbon intensive due to the additional energy requirements as opposed to mobile loaders which require less power, and produce less emissions due to improvement in recent euro 5 emission standards.

5 Conclusions and Future Work

The paper has applied a lifecycle assessment to a trial plot as part of the SUCCESS projects primary carbon capture experiment. It was important to illustrate the embedded emissions burden during the initial construction to determine the level of offset required for the plot lifecycle to become carbon negative.

Future work includes the continued monitoring of the SUCCESS carbon plot trials over an 18 month period in order to determine the actual rate of sequestration and the capacity of the material. However, what is unknown is the point where the soil becomes saturated with calcium carbonate such that CO_2 absorption ceases. This is important, as when this occurs intervention is necessary though either ploughing the trial or replacing the calcite-saturated material with minimal $CaCO_3$ so that the process can begin again. Work is ongoing in also adapting the carbon capture trial plots to a possible highway based setting where plot trials are implemented on road-side verges. Finally, a more in-depth study on carbon fluxes, in particular the role of microbe decomposition and respiration will be explored in order to fully capture the carbon cycle.

Acknowledgments

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Management of Sustainability Activities in Projects: The Perspective of Project Managers

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Abstract
Managing project sustainability is becoming important in the last two decades. An increasing number of projects have built in sustainability considerations into project design and implementation. For instance, the "Equator Principles" as adopted by the Equator Principles Financial Institutions (EPFI) since 2003 have urged projects seeking project financing to meet the requirements of determining, assessing and managing social and environmental risks on top of economic analysis. Recent research findings show that lack of sustainability knowledge for project managers is a key barrier to drive projects contributing towards a sustainable society. This paper reports the results of a judgmental survey on project managers with 101 completed questionnaires. Four key messages are identified: 1) 61.4% of project managers are of the opinion that integration of economic, environmental and social criteria into project development would have either significant or critical impacts on project success; 2) they rank the relative importance of sustainability impacts in the order of economic; environmental and social; 3) 59.5% of project managers do not agree that care of project sustainability activities are the responsibility of sustainability managers (professional specialized in sustainability activities). In other words, project managers should be accountable for the sustainability activities in projects; and 4) project managers amounting to 74.2% of the sample agree that sustainability as essential knowledge area shall be included in the published guidebook of project management body of knowledge. This paper contributes to understanding project manager accountability in managing project sustainability activities and the significance of such sustainability impacts on project success.

Keywords: project, project management, project management success, project success, project manager, project sustainability, sustainable development, economic sustainability, environmental sustainability, social sustainability

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Introduction

Project management being an evolving academic discipline and professional practice is continuously developing in response to the needs of society (Bredillet, 2006, 2007a, 2007b, 2007c, 2008; Kloppenborg & Opfer, 2002; Kwak & Anbari, 2008; Shenhar & Dvir, 2004). Project exists in a relatively turbulent environment and change is the purpose of the project itself with uncertainty being inherent into the objectives of that project. As defined in the PMBoK Guide (A Guide to the Project Management Body of Knowledge) (4^{th} edition), project is "*a temporary endeavor undertaken to create a unique product, service, or result*". PMBoK Guide published by the Project Management Institute (PMI) in the United States recognizes "*... Projects can also have social, economic, and environmental impacts that far outlast the projects themselves*" (PMI, 2008). Munier (2005, p.21) in his book "*Introduction to Sustainability: Road to a Better Future*" mentions that "*Sustainability as a process often involves making an analysis to determine the best course of action when several projects, plans, programs, and options are considered*" (Munier, 2005). The Association for Project Management (APM) in the UK supports sustainability. In the "*APM Supports Sustainability Outlooks*" (APM, 2006), they recognize that many people involved in projects and programmes have the ability and capacity to be involved and influence at personnel, corporate, government and project level. Projects and sustainability are intertwined to serve a higher purpose towards a sustainable society that Brundtland Report (Brundtland, 1987) urges. Since project management is becoming a common way of managing business (Bredillet, 2000; Turner, 2009), the awareness of project manager and his/her team members to meeting the challenges of sustainability in project delivery would have made contributions to mankind.

The meaning of project success has also been changing from focusing on time, cost and quality ('Iron Triangle' by Dr. Martin Barnes in 1969) in early development stage of modern project management to recently having a framework to assess efficiency; impact on customer; impact on team, business and direct success; and preparation for future (Shenhar & Dvir, 2007). Literature review shows that sustainability whether taken as externality or interaction to project development basically made little influence on historical development of modern project management until the 1990s. Daniel (1961), as a pioneer researcher working on success factor for business, describes the necessity to collect environmental information to satisfy management information gap which includes social, political, and economic aspects of the climate in which a business operates or may operate in the future (Daniel, 1961). About forty years after Daniel's (1961) recommendation, Belassi and Tukel (1996) and Atkinson (1999) have brought in project externality considerations into their framework for systematically assessing the success/failure of a project. Belassi et al. (1996) consider political environment, economical environment, social environment and technological environment as part of the external environmental factor group. These external environmental factors affect the implementation of project leading to success/failure (Belassi & Tukel, 1996). Atkinson (1999) in "*The Square Route*" model (see Figure 1 and Table 1) recognizes the importance of considering social and environmental impacts; as well as economic impact to surrounding stakeholder community towards establishing success criteria for project management success (Atkinson, 1999).

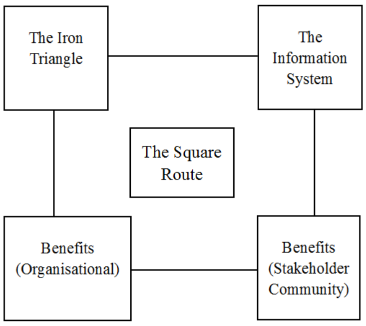

Figure 1 Atkinson's Square Route (Atkinson, 1999)

Table 1 Square Route to understanding success criteria (Atkinson, 1999)

Iron Triangle	The Information System	Benefits (Organisation)	Benefits (Stakeholder Community)
Cost;	Maintainability;	Improved efficiency; Improved effectiveness;	Satisfied users; Social and environmental impact;
Quality;	Reliability;		
Time.	Validity; Information - quality;	Increased profits;	Personal development;
		Strategic goals; Organisational-learning;	Professional learning;
	Use.		Contractors profits;
		Reduced waste.	Capital suppliers;
			Content project team; Economic impact to surrounding community.

Collins and Baccarini (2004) in a survey of 150 Australian project managers on the subject of project success criteria indicates that twenty-three (23) criteria are identified important to product success and project management success in the Baccarini suggested Logical Framework Method (LFM) to project success (Baccarini, 1999). As expected, time (84.7%), cost (78.0%) and quality/meeting specification (55.3%) are most recognized by project managers as criteria for project management success. However, two sustainability related criteria are suggested by respondents in the study. They are "Community Acceptance" (5.3%) – a criterion important to product success about meeting the social objectives, standards and expectations of the community; and "Environmental" (3.3%) – a criterion important to project management success about meeting environmental obligations and regulatory compliance. Although these criteria rank the bottom in the list of project success criteria, they have confirmed Atkinson's (1999) thinking in an empirical manner (Collins & Baccarini, 2004). The above links project management to sustainability. Belassi et al. (1996), Atkinson (1999) and Collins et al. (2004), etc. become supporters to considering sustainability as requirements in project development and project management success.

In the sections below, system perspective of managing project sustainability and sustainability competence of project managers are discussed. These two elements constitute critical ingredients in managing projects sustainably. To understand how project management community views the criticality of sustainability in project management, a web based survey targeting on industry practitioners was conducted. It serves to explore the views of project managers about 1) degree of importance on integration of sustainability related criteria (economic, environmental, social) as part of project success requirements; 2) rank the relative importance of each sustainability aspect on project success under the three pillars approach; 3) project managers' view on management accountability; and 4) inclusion of sustainability as essential knowledge area in the guide book of project management body of knowledge. Based on 101 samples obtained from judgmental sampling, this paper contributes to better understanding about sustainability issues from project manager's perspective. Based on the result of this survey, further study on factors of respective sustainability dimension leading to project management success is recommended.

System perspective of managing project sustainability

Morgese (2014) distinguishes sustainable projects into three (3) categories by their different levels of sustainability, namely: 1) projects that are sustainable because of their own nature (e.g. wind farm project); 2) projects that create sustainable products, results, or services (e.g. building a solar panel production line); and 3) projects that are managed sustainably (e.g. building a coal fired power station with down to earth sustainability considerations) (Morgese, 2014). Whatever the category that a sustainable project falls, balancing the system of economic sustainability, environmental sustainability and social sustainability in the project management process remains important. The Shen, Tam, Tam and Ji (2010) study shows that incorporation of sustainable development principles in conducting project feasibility study (an important stage governing the success of a project) is not effectively understood by project stakeholders. Research results suggest that economic performance is given the most concern in the current project practice, whilst less attention is given to environmental and social performance (Shen, Tam, Tam, & Ji, 2010). Understanding sustainability from a system perspective helps project managers in decision making.

The concept of sustainability can be viewed as a system or a particular system state where the system's inputs and outputs remain sufficiently balanced over time to avoid system collapse or disruptive change (Peattie, 2011). By analogy to students learning physics in their experiment class testing electricity relationship of voltage (V) and current (I) (Ohm's Law: I = V/R) in an electric circuit consisting of resistor (R), students would find that there is a linear relationship between voltage and current in a linear electric circuit up till a state where linear relationship is becoming non-linear and eventually the resistor is burnt. It happens when the resistor is operating at a state beyond its limit. It is no longer to sustain with increased pressure (voltage applied). In other words, a system can only be sustainable within its limit. A system can be vulnerable and be destroyed fast, for example, a giant corporation (Enron) can be collapsed within a short period of time. Maintaining system sustainability whether it is a physical or social system needs to understand its inherent architecture.

Sustainability is about integrating economic, environmental and social aspects. It is about integrating short term and long term aspects; and about consuming the income and not the capital (Dyllick & Hockerts, 2002). The integration of both social and natural (or physical) systems as a whole is important to understand key sustainability issues. The notion of a system incorporates a number of components that interrelate with each other. The components can be grouped together to be understood as a whole and in terms of how that whole interacts with its neighborhood environment. For a sustainable system, the relationships among its components must be sustainable and the relationship between the system and its environment must not be destabilizing (Peattie, 2011). Project manager is a key member in the team for project design, planning, executing, monitor and control. Their views and understanding of the concept of sustainability and their attitudes towards managing project would greatly impact on project success sustainably. Integrating the concept of sustainability in project management would stretch the "system boundaries" of project management (Silvius & Schipper, 2010).

Having discussed with some project managers about barriers to managing project sustainability in a recent study, some of them reflect that barriers are related to mentality of project managers and sponsors, etc. For example, one responds that "*to me, sustainability is the responsibility of the sponsor and customer, not the project manager nor a sustainability expert*." Another mention about economic benefits: "*there is a growing awareness of Sustainability but the project sponsor will only consider these issues if there is increase in ROI (Return on Investment). The only factor that mitigates the above is where the sponsor wishes to show his 'green' credentials and is not concerned with ROI. This usually happens where the project is 'iconic' and a 'statement' is being made either with government sanction or on a personal level by the sponsor/ owner*".

In the same study, I have identified several major hurdles in project sustainability system. Not surprisingly, "lack of sustainability knowledge and expertise" ranks top barrier. It is followed by two barriers having the same votes each on "lack of interest from project sponsor/investor" and "managers' mindsets". The barrier of "lack of interest from customers" ranks third in the study. There are other barriers such as "organizational culture", "absence of appropriate tools and processes (e.g. guidelines)" and "government regulatory support". The study shows that barriers to managing project sustainability do exist. It is necessary to strengthen knowledge of sustainability (top barrier) to project managers and sponsors. Some project managers do not find themselves involved in building a sustainable society through their contributions in project development. Others still think that project economic benefit is more significant than other benefits such as environmental or social (Shen, Tam, Tam & Ji, 2010). Their chosen views reflect the fact that enhancement of sustainability competence for project managers is required.

Sustainability competence of project manager

When it comes to project management, it is the people that matter (Lechler, 1998) because the people side of success factor is woven into their very fabric (Cooke-Davies, 2002). Lock raises concern about sustainability of humankind (Lock, 2007). He is well aware that project managers need to face the kind of challenges like climate change and lack of fossil fuel in the days to come and that "*We shall need* *effective project managers to deal with these challenges if humankind is to survive*" (Lock, 2007). Project managers are becoming part of the solution to human survival or sustainable development. Morris (1997) points out 'knowledge and awareness of project environment' being one of the principal competency requirements of a project manager (Morris, 1997). However, Turner and Müller (2005), after reviewing the contributions of project manager's competence and leadership style on project success, have concluded that "*the literature has largely ignored the impact of the project manager, and his/her leadership style and competence, on project success*" (Turner & Müller, 2005). Previous studies on the people issues of project management impacting on project success are mostly linked to leadership (Müller & Turner, 2007; Turner, 2007; Turner & Müller, 2006), intrinsic and extrinsic rewards (Mahaney & Lederer, 2006), cultural impacts (Henrie & Sousa-Poza, 2005), and project manager competence (Crawford, 2000), etc.

Nonetheless, Mui and Sankaran (2004) opine that sustainability development (e.g. urban renewal project) requires project managers to adopt a holistic perspective and a cradle-to-grave approach in managing projects. Mui et al. identify that current project management body of knowledge ignores the professional knowledge on sustainability issues and the suitability of generalizing specialist (project manager) or specializing generalist (sustainability manager) in the role of project leader. Mui et al. suggest to include such essential knowledge area into project management body of knowledge and put emphasis on the importance of a multi-disciplinary and integrated approach (Mui & Sankaran, 2004). In their research on an urban renewal project, Mui et al. suggest that "*individuals who are generalizing specialists – who have appropriate technical and management skills, a system approach perspective, and an ability to create an open culture in teams – are the preferred choice to serve as team leaders*" (Mui et al., 2004, p.31). Project manager needs to identify sustainability impacts due to the project, develop mitigation plan within the project life cycle process to which project manager makes a balance or even trade-off on chosen solutions with a target to maximize overall positive sustainability effects.

Since project sustainability impact is context dependent, project managers working on nuclear power station, for instance, choose to focus on certain sustainability competence requirements that others project managers (e.g. new product development project) may choose to develop a different set of competence requirements. However, the basic needs of a sound environment, a just society and a healthy economy (Brundtland, 1987; Diesendorf, 2000) towards building a sustainable society by way of project development are the same. These basic needs drive project managers in identifying sustainability requirements during project reviews and that project managers exercise their sustainability competence in promoting positive impacts and minimizing negative impacts overall whether adopting pillars approach (Zainul Abidin, 2005) or core generic criteria (Gibson, 2006) for assessing sustainability. Project managers make reference to previous project experience including the nature of project and its context (sector specific) to identify appropriate potential sustainability impacts for review (Tam, 2013).

Unfortunately, sustainability knowledge area (economic, environmental and social) as part of project manager competence requirement is not clearly established. The views of project management community about criticality of sustainability impacts on project success have not been fully understood. Although the Equator Principles

Financial Institutions in the project finance sector have urged projects seeking project financing to meet the requirements of determining, assessing and managing social and environmental risks on top of economic analysis since 2003 (EPFI, 2013), the lack of research and discussion within project management community about sustainability has caused a gap in knowledge creation and dissemination. To bridge the knowledge gap, a web based survey on project managers was conducted.

Survey on managing project sustainability

In this survey study, population refers to project managers in the project management community worldwide. Project manager is used as an all-encompassing term to describe the role of those managers that are tasked with managing project team and such person may be addressed by a different title depending on the structure of their organization. Other respondents whom are member of project team without taking the project manager role are taken as project participants with their responses discounted in the study. Exact population of project managers in the community is not known and that it is impossible to identify a complete list. A systematic or probabilistic sample for generalization of findings cannot be processed. Less desirable process is a non-probabilistic sampling (or judgmental sampling), in which respondents are chosen based on their convenience and availability. The non-probability samples serve the purpose of understanding what respondents are thinking (Czaja & Blair, 2005) which is useful for subsequent studies (a follow up pilot study was conducted to test the correlation of environmental sustainability criteria leading to project environmental success). In this cross-sectional exploratory study, non-probabilistic judgmental sampling is adopted.

As infrastructure and other large scale projects are seen to have larger sustainability impacts, it is naturally to identify and compare the opinions of project managers who are working on great sustainability impact projects against others in this survey. To this end, it is necessary to exercise judgment in gaining sufficient responses (purposive without quota) from project managers who are managing infrastructure or large scale projects. Based on direct and indirect contacts in the project management community (e.g. some contacts in the Project Management Institute, IPMA International Expert Seminar 2010 – Survival and Sustainability, etc.) and engineering institution (e.g. The Institution of Engineering and Technology, UK, etc.), 957 practitioners from the contact list were invited to participate into the survey. Web-based survey tool was adopted to facilitate data collection. One hundred and one (101) respondents from 26 countries and regions form the samples (see Table 2 below). The response rate is 10.55%. We have a full picture about where the respondents are based. Majority respondents are coming from the U.K. and Hong Kong. Male project managers (94) represent majority (93.1%) of the respondents and 52.5% of survey participants hold professional project management qualifications, such as PMP, PRINCE2 and IPMA – A, B, C or D levels. There are 79 project managers who are having more than 10 years' experience in managing projects which represents 78.2% of the samples.

Table 2 Country of respondents based

Country (# of Respondents)				
Angola (1)	France (5)	Italy (2)	Omen (1)	UK (29)
Australia (3)	Germany (3)	Japan (1)	Spain (1)	USA (9)
Bahrain (1)	Hong Kong (13)	Kuwait (1)	Suriname (1)	
Brazil (1)	Iceland (1)	Netherlands (5)	Sweden (1)	
Canada (2)	India (1)	Nigeria (3)	Switzerland (2)	
China (8)	Ireland (3)	Norway (2)	Thailand (1)	

Results and discussion

Using a five-point Likert Scale (1 = No Impact, 2 = Little Impact, 3 = Some Impact, 4 = Significant Impact, 5 = Critical Impact), respondents were asked about the degree of impact on project success by integrating economic, environmental and social sustainability criteria into project development. Table 3 shows the results. There are 62 project managers (61.4%) of the opinion that these sustainability criteria would have made either significant or critical impacts on project success. Average rating of the responses is 3.62, which means that, in general, respondents concern about the performance of sustainability requirements in delivering project results. It echoes to Belassi et al. (1996), Atkinson (1999) and Collins et al. (2004) that sustainability criteria, be it within the pillar of economic, environmental or social, should be taken into project performance assessment.

Table 3 Summary results on opinion of sustainability impacts on project success

No Impact	Little Impact	Some Impact	Significant Impact	Critical Impact	Rating Average
2	7	30	50	12	3.62

To a further extent, the respondents were asked to rank the relative importance of the three sustainability success criteria (1 = most important; 2 = important; 3 = least important). The results are indicated in Table 4 below. The ranking obtained is Economic Sustainability (58/101 ranked 1st), Environmental Sustainability (27/101 ranked 2nd), and Social Sustainability (23/101 ranked 3rd). If the responses of “Most Important” combine with “Important”, the ranking remains the same. The results agree with Shen et al. (2010) study. It indicates that project managers still concern economic impact over others. Moreover, the vote on economic sustainability (58) as “Most Important” is twice of respective environmental sustainability (27) and social sustainability (23).

To answer Mui and Sankaran (2004) questions on the suitability of generalizing specialist (project manager) or specializing generalist (sustainability manager – professional specialized in sustainability activities) in taking a project leading role in handling such sustainability activities in the development process and the lack of knowledge tools to support (e.g. inclusion of sustainability knowledge area in the PMBoK Guide or APM BoK), respondents were asked to express their opinions in these respects. The results of the two aforesaid questions are shown in Table 5 below.

Table 4 Summary results on relative importance of sustainability as success criteria on project success

	Most Important (1)	Important (2)	Least Important (3)	Total Count
Economic sustainability	58 (Ranked 1st)	29	14	101
Environmental sustainability	27 (Ranked 2nd)	48	26	101
Social sustainability	23 (Ranked 3rd)	41	37	101

Table 5 Summary results on leading role and sustainability knowledge tool

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Rating Average
Care of project sustainability activities is the job of sustainability manager and not the job of project manager	15	45	20	16	5	2.51
Sustainability as essential knowledge area shall be included in the published guidebook of project management body of knowledge	1	3	22	49	26	3.95

Many respondents in the project management community (59.4%) prefer project manager to take charge of project sustainability activities; and that most respondents (74.3%) agree to include sustainability as essential knowledge area in the published guidebook of project management body of knowledge.

Lock (2007) concerns about sustainability of humankind and believes that project managers by managing project sustainably can be part of solution to building a sustainable society. Although Shen et al. (2010) find that some project managers in their study do not find themselves contributing to a sustainable world, imminent trend of managing project sustainability is, nevertheless, emerging. Following Brundtland Report in 1987, some project management researchers and practitioners engaging in delivering project success aim not only to fulfilling economic terms but require to meeting environmental and social requirements, such as requirements by the Equator Principles Financial Institutions (EPFI) in the project finance sector, that infrastructure projects and other high sustainability impact developments seeking project financing are unavoidable to follow more stringent practice.

Working on conceptual framework, Belassi et al. (1996) and Atkinson (1999) suggest that there is a need to plan, execute, monitor and control project holistically by considering economic, environmental and social impacts. Collins et al. (2004) identify from their Australian project managers study that environmental and social sustainability are criteria for project success though ranked bottom in the list. In this survey, a clear message is obtained from the project management community that integrating of economic sustainability, environmental sustainability and social sustainability criteria form either significant or critical impacts on project success. Though the message is clear but there is no measurement in this survey about individual sustainability impact on project success. Hence, it is necessary to differentiate the nature arising from individual sustainability impact.

Further study

As discussed above, a pilot study after the said survey for preparation of upcoming comprehensive study was conducted to differentiate the impact of individual sustainability factor on the meaning of project success. In this pilot study, the same group of survey respondents were asked to answer further questions, however, only fifty (50) project managers responded to my request. Factors on environmental sustainability criteria making reference to Hill and Bowen (Hill & Bowen, 1997), Maldonado-Fortunet (Maldonado-Fortunet, 2002) and Tam (Tam, 2010) were given to participants such that they could indicate the degree of impact on project environmental success.

Hill et al. (1997), Maldonado-Fortunet (2002) and Tam (2010) suggest that use of renewable resources as preferred choice (Q1); employ practice of environmental resource minimization (Q2); create a healthy and non-toxic environment (Q3) and maintenance of Earth’s vitality, ecological diversity and landscapes (Q4) by the project help delivering environmental sustainability. Corresponding four questions are constructed to seek opinion of respondents on the item(s) of environmental sustainability that impacts on project environmental success. Q5 is being constructed to check with project managers if environmental sustainability is a criterion for project success.

Four items from literature review as shown above within the environmental sustainability dimension are taken as independent variable for building up a list of questions. Dependent variable is project environmental success dimension of project success. In other words, with more positive impact exerted on environmental sustainability independent variable item(s), a higher project environmental success as dependent variable is expected. The questionnaire contains closed-end questions and that 5 points Likert scale is used to measure project managers’ opinion about the impacts of environmental sustainability on project environmental success (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree). Due to time limitation in this pilot study, 5 questions are constructed without collecting demographic details of the respondents for further analysis.

Table 6 Summary on number of responses in the survey

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1: Chosen of renewable resources (energy and material) as preferred choice will have positive impact on project success.	0	3	23	17	7
Q2: The practice of environmental resource minimization (including reuse and recycling of resources) will improve the chance of project success.	1	0	18	25	6
Q3: Project creating a healthy and non-toxic environment to stakeholders will have positive impact on project success.	0	1	9	32	8
Q4: Construction project considering maintenance of Earth's vitality (e.g. ecological diversity, landscapes) will have positive impact on project success.	1	0	21	21	7
Q5: Project environmental sustainability is a criterion for project success.	0	1	13	27	9

Fifty (50) respondents (project managers) out of 101 potential participants responded to the pilot study by completing the questionnaire. Table 6 above shows the summary on number of the responses. In doing analysis, SPSS 18.0 version has been employed to carry out stepwise multiple linear regressions in constructing a model relating environmental sustainability to project environmental success. Details of the analysis will be reported separately.

In this pilot quantitative study, a three-pillar approach has been adopted to investigate the impact of environmental sustainability on project environmental success. The SPSS outputs of the pilot study suggest that, in the four independent environmental factors, it is only Project Maintaining Earth's Vitality constitutes environmental sustainability impact on project environmental success. This factor explains 39.6% of the variance of the success on project environmental sustainability and that there may have other factor(s) influenced on the same. We need to increase the sample size later in the comprehensive study to test whether other factor(s) (e.g. Practice of Environmental Resource Minimisation) would be included in the model. Inference can be made that some factors are having significant effect while others shall have less impact on project environmental success. Nevertheless, the regression equation generated from this pilot study has confirmed empirically that factor in environmental sustainability would have impact on project environmental success. A comprehensive study on each sustainability dimension is recommended such that the knowledge base developed helps project managers in managing project sustainability in their project planning and execution process. Criteria on economic sustainability, environmental sustainability and social sustainability identified in empirical comprehensive study would have made contributions to knowledge in building a sustainable society.

Conclusion

Project management and sustainability are two subjects but closely intertwined leading to building a sustainable society. The system perspective of managing project sustainability and the sustainability competence of project managers are discussed. They are critical ingredients in managing project sustainably. Project managers in this survey offer the view that integrating sustainability criteria (economic, environmental and social) into project development would have made either significant or critical impact on project success. Survey results also show that economic sustainability is the most important success criterion to project managers on project success while social sustainability is found to be least important to survey participants. Project managers find themselves accountable in managing project sustainability activities. In other words, it is project manager whom is responsible for managing the whole development process including any activities linked to external environment and the social community. To facilitate their work and enhance capability in delivering sustainability related performance, project managers would like to have related essential knowledge area to be included in the published guide book of the project management body of knowledge, such as PMBoK published by the Project Management Institute (PMI) in the United States. The survey did not differentiate individual impact but a follow up pilot study to measure the correlation of environmental sustainability criteria on project environmental success show that "Project Maintaining Earth's Vitality" explains 39.6% of the variance to project environmental success. The pilot study provides a good preparation for later comprehensive study covering factors of each dimension of respective sustainability pillars on project success.

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Sustainable Urban Transportation with Travel Demand Management Methods: A Case Study for Istanbul

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Abstract

In order to achieve sustainable cities, in addition to smart use of land, intelligent transportation systems, clean and green vehicles, it is vital to achieve social behavioral change for shifting our modes from motorized means to greener, healthier and more economic means such as walking, cycling, and public transportation. Economic, environmental, and social concerns about growth of traffic congestion have caused several mega-cities in the world and academics towards investigation and introduction of different policies and measures in urban areas. Among many options, Travel Demand Management (TDM) policies mainly aim to promote sustainable modes and increase an effective use of existing infrastructure by voluntarily controlling demand. With such circumstances, objectives of this study are as follows: (1) review existing academic, industry, governmental and non-governmental literature to examine and understand various sustainable society, sustainable development, sustainable mobility concepts, mechanisms and policies developed and tested in other parts of the world; (2) establish a framework of social behavioral change policies particularly developed and tested for urban mobility; (3) compare various mega-cities on different indicators to better understand the case of Istanbul. As a result, it was revealed that traffic congestion is worse in Istanbul compared to similar cities and management of traffic within the city implies mistakes. However, it was also seen that TDM policies offers noteworthy potential to increase use of sustainable modes and help reducing congestion levels in the city.

Keywords: TDM, Congestion, Istanbul

Introduction

High levels of traffic congestion in urban areas like Istanbul caused cities in the world and academics towards investigations and introduction of timely and effective solutions to mitigate traffic congestion levels. Travel Demand Management (TDM) policies are one such solution. TDM policies mainly aim to promote sustainable modes such as walking, cycling, and public transportation, to eliminate the need for travel for particular trips, and to increase effective use of existing infrastructure by voluntarily controlling demand.

This paper is divided into two parts; (1) Transportation in Istanbul and (2) Mobility and Access Management. The first part overviews selected case city, Istanbul, on general highlights, transportation infrastructure, urbanization and motorization trends, and make comparisons between Istanbul and various cities in different parts of the world on different indicators to better understand the case of Istanbul. The second part establishes a framework for mobility and access management and gives brief descriptions of its components, then explain TDM as part of Mobility and Access management and provide various policies of TDM in different groups which are developed and tested in other parts of the world. Since TDM policies are very new to Istanbul, this study mainly aims to demonstrate the gap for TDM policies potential in the city to alleviate high traffic congestion levels and keep up pace with increasing motorization levels in last decades.

2. Transportation in Istanbul

As the economic, financial, and industrial center of modern Turkey, Istanbul is currently one of the largest cities in the world with a population of approximately 14 million inhabitants [4]. Istanbul is divided into two parts by the Bosporus channel which also connects the Black Sea and Mediterranean Sea through the Marmara Sea and the Aegean Sea. The channel forms the natural boundary between Europe and Asia. In addition to this, Europe's easternmost or Asia's westernmost city, Istanbul is one of the most important gateways for trade routes between Europe and Asia from past to present. Despite of the Bosporus channel's positive impacts on the city from many perspectives, it also complicates mobility and access within the city.
Likewise other mega-cities in developing countries, Istanbul has faced rapid urbanization and motorization in last decades in conjunction with economic growth. Population of Istanbul was just 4,7 million in 1980, it has increased to 10 million in 2000, and finally to 14 million in 2014, while the number of registered vehicles in 1980 in Istanbul was 0,2 million, it has dramatically increased to 1,25 million in 2000 and finally to 3,3 million in 2014 [12]. Although motorization rate is still low in Istanbul where there are 232 vehicles registered for 1000 people as compared with other megacities in developed world (400-500 vehicles per 1000 population), trend of motorization rates in last 10 years is alarming [36]. Figure 2.1 takes the year 1980 as base year for illustration rate of rise to show this dramatic difference in rise of population and motorization levels. It is also projected that population will increase to 17,2 million, number of vehicles in the city will increase to 4,3 million, and number of vehicles per 1000 population will increase to 252 in 2023 [14].

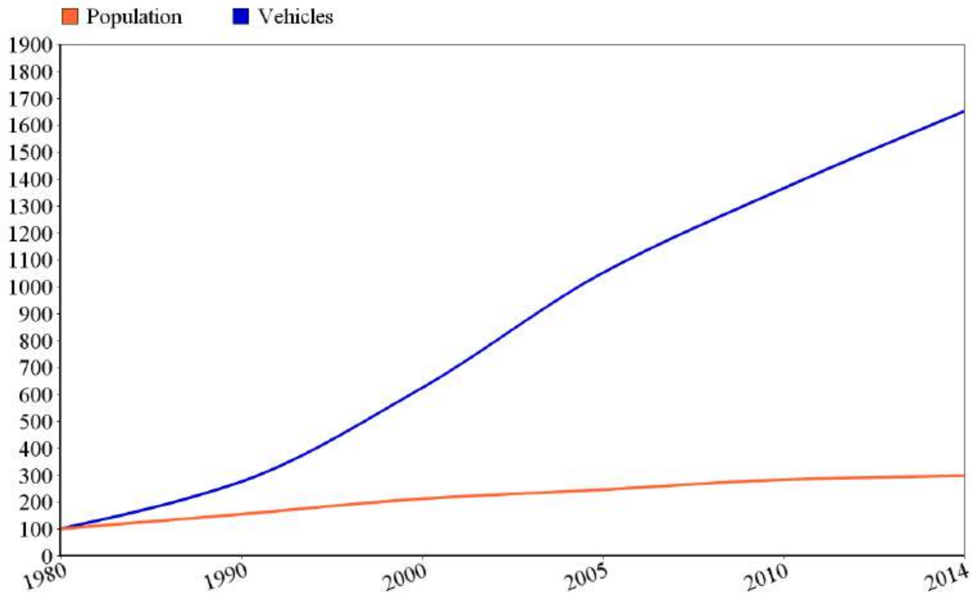

Figure 2.1: Population and Motorization Growth in Istanbul between 1980-2014 (1980=100) [12,36]

Based on the 2006 Household Travel Survey conducted by the Istanbul Metropolitan Planning and Urban Design Center (IMP) in Istanbul, the change in modal split of urban motorized travel in the period of 1987 to 2006 has been estimated and shown in Figure 2.2. According to the figure, it can be seen that the share of car has risen from %19 in 1987 to %26 in 2006 together with Company/School shuttles which has increased from 10 in 1987 to 21 in 2006. On the other hand, the share of buses has dropped from %35 in 1987 to 24 in 2006 together with respectable decrease in rate of taxi, shared taxi and minibuses. Share of railway and sea lines range at a low level between %2 and %5.

As a result, the dramatic increase in motorization rates resulted in big traffic congestion problem in Istanbul. According to a survey undertaken in 2011, participants have replied the question “What is the biggest problem in Istanbul” as traffic congestion by %31 and it is followed by population density by %21 and security by %15 [29]. Another survey as part of the Urban Age research has been undertaken to look at what residents really think about the quality of life in Istanbul [26]. According to that survey, participants have been asked “What concerns most about the city”, the result is that %55 of participants think it is traffic congestion.

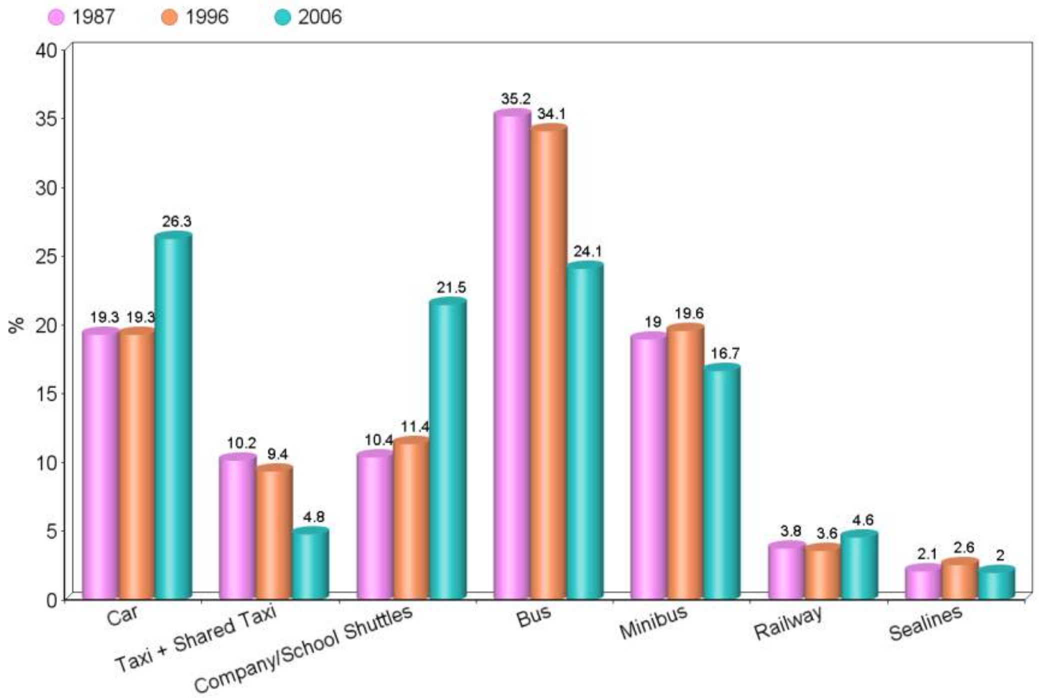

Figure 2.2 modal split of urban motorized travel in the period of 1987 to 2006 [12]

2.1. Comparisons of Istanbul and Other Megacities

As one might expect that all megacities share similarities due to extreme globalization trends, however, each city draw different patterns of urbanization and motorization with diverse spatial, economical, and social characteristics that result in specific urban experience for each city. A preliminary assessment and comparisons of various world cities on different key indicators is important to get the bottom of this urban experience. New York City from North America, Mexico City from Central America, Sao Paulo from South America, Shanghai and Singapore from Asia, London and Barcelona from Europe and finally Johannesburg from Africa have been selected in comparisons to Istanbul. The selection has been made due to representation of all parts of the world and each city sharing different spatial, economic and social characteristics. First, they have been compared on basic indicators like population, central area density and GDP (See Table 2.1). Second, they have compared on transportation related indicators such as congestion index, total infrastructure network, motorization level (See Table 2.2). Finally, they have been compared on more comprehensive indicators such as minimum wage, transport related cost indicators, and transport related purchasing power of minimum wage (See Table 2.3).
The range of population of these nine cities vary from 3,2 million (Barcelona) to 24,2 million (Shanghai) while Istanbul (298,6 %) and Johannesburg (%285,4%) has faced the highest population increase since 1980. Patterns of central area densities also differ significantly. The cities representing highest densities are Shanghai (24.673 people per km^2) and Istanbul (20.116 people per km^2) which nearly tripled London (7.805 people per km^2), and Singapore (7.418 people per km^2). On the other hand, the city indicating lowest central area density, which might be considered as being more dangerous places to live, is Johannesburg (2.270 people per km^2). Despite of New York City (1.210 billion $) having the highest weight in terms of GDP, its share in the

US GDP is only %7,5 which is the second lowest in the nine cities. Cities contributing most in country GDP are Istanbul (301,1 billion $) with percentage of 38,1 and Mexico City (411,4 billion $) with share of %34,7. (See Table 2.1)

Table 2.1: General comparisons of various cities [13, 17, 18, 28]

City	Population in 1980 (million)	Current Population (million)	Population increase since 1980 (%)	Density (people per km^2)	GDP (billion $)	% share in Country GDP
Istanbul	4,74	14,16	298,6	20.116	301,1	38,1
New York City	7,07	8,40	118,9	15.361	1.210,0	7,5
Mexico City	13,88	21,17	152,7	12.541	411,4	34,7
Sao Paolo	12,49	20,82	166,6	10.299	473,0	21,0
Shanghai	11,73	24,15	205,7	24.673	516,5	6,2
London	7,74	9,78	126,4	7.805	731,2	29,6
Barcelona	3,07	3,23	105,5	7.866	171,0	12,9
Johannesburg	1,55	4,43	285,4	2.270	76,0	19,8
Singapore	2,41	5,31	220,1	7.418	327,2	100,0

As mentioned in previous sections, the number of vehicles in Istanbul has increased in a more rapid trend than the population, thanks to the economic developments. The number of automobiles in Istanbul has experienced an 8-fold increase since 1980, compared to 5-fold increase in the population [12]. Although the number of cars per thousand populations is significantly lower than the most of the other large world cities, the scope of congestion problem has increased in the last years (see Table 2.2). In this manner, congestion index gives a good estimate of the degree of congestion on a normalized scale, which is calculated as follows:

$$congestion = \frac{t_{normal} - t_{free}}{t_{free}} \qquad (1)$$

Where t_{free} is the amount of time spent when the roads are free (e.g., during night), and $t_{normal}$is the amount of time spent during a usual scenario (e.g., averaged over a large number of times sampled from various instants) over a predefined route. Looking at Table 2.2, it can be seen that Istanbul has the highest congestion index, compared to the other cities. Strikingly, number of cars per 1000 residents in Istanbul is lower than all the cities given in the table, except Shanghai and Singapore. Infrastructure comparison of these cities is made on the indicators of total metro network and total road network. While cities having the longest road network are New York City (56.516 km), Mexico City (52.749 km) and London (47.287), they also have the longest railway networks, which are London (402 km), New York City (373), and Mexico City (226,5 km), except Shanghai with total road network of 20.082 km but 538 km rail network. On the other hand, Istanbul is in the mid-range on both indicator with total road network of 32.535 km and 142 km total railway network. The unexpected relationship between the congestion index, road and rail network and the number of cars compared to the other cities implies mistakes related to the management of the traffic.

Table 2.2: Infrastructure, life quality and congestion comparisons [7, 15, 28, 30, 35]

City	Mercer Life Quality Rank.	Congestio n Index	Car ownership per 1000 residents	Total Metro Network (km)	Total Road Network (km)
Istanbul	117	0,62	152	141	32.535
New York City	44	0,26	215	373	56.516
Mexico City	120	0,54	360	226,5	52.749
Sao Paolo	115	0,46	368	74,8	28.956
Shanghai	95	0,38	73	538	20.082
London	38	0,34	645	402	47.287
Barcelona	40	0,25	470	102,6	4.551
Johannesburg	94	0,31	206	NA	2.280
Singapore	25	NA	120	152,9	NA

The comparison of the cities on quality life is also significant to analyze social welfare and life satisfactions of individuals and societies in those cities. Mercer life quality index has been used to evaluate the cities (See Table 2.2). The index consists of evaluating cities on more than 39 factors including political, social, economic environment, education, health and sanitation, natural environment, housing, consumer goods etc. which is determined according to surveys conducted in 420 different cities all over the world. The index reveals that the most livable cities among these nine cities are Singapore (ranked as 25th), London (38), Barcelona (40) and New York City (44), while the worst livable cities are Mexico City (120), Istanbul (117) and Sao Paulo (115).

Table 2.3 reveals purchasing power of minimum wage in the cities according to different mobility related indicators, while it also provide comparisons of prices of an average car, gasoline, and one way metro ticket. However, comparisons only between prices is inadequate to draw objective comparisons between cities on mobility related indicators, therefore, purchasing power of minimum wage in different cities have also been provided in the table. For example, one can purchase a new car in 138 months in Mexico City, or 141liters of gasoline, or 342 one way metro ticket by minimum wage, while in London a new car can be purchased in 14 months by minimum wage or 826 liters of gasoline or 409 one way metro tickets. On the other hand, it can be seen that one can purchase a new car in 61 month, or 172 liters of gasoline, or 397 one way metro tickets.

Table 2.3: Comparisons based on mobility indicators related to purchasing power of minimum wage [24, 28, 30]

City	Minimum wage ($)	VW Golf or eq. car price	Gasoline ($ per lt)	Metro ticket price ($)	Car price / Min. wage	Min. wage / Gasoline	Min. wage / Metro ticket
Istanbul	393	24.123	2,29	0,99	61	172	397
New York City	1.400	23.000	1,05	2,67	16	1.333	524
Mexico	130	17.982	0,92	0,38	138	141	342
Sao Paolo	310	23.914	1,25	1,38	77	248	225
Shanghai	295	25.175	1,3	0,57	85	227	518
London	1.925	26.895	2,33	4,71	14	826	409
Barcelona	620	25.462	1,97	2,67	41	315	232
Johannesbu	174	20.496	1,25	0,02	118	139	8.700
Singapore	1.000	111.865	1,71	1,44	112	585	694

As a result, Istanbul has faced uncontrollable growth at a higher rate than was anticipated in the last 30 years and this has resulted unplanned urban settlements and chronicle traffic problems unlikely from other metropolitan regions. In this manner, it was important to take a picture of Istanbul regarding traffic congestion and make comparisons with similar urban areas to find out the differences and similarities between cities. This can help to manage traffic growth in the city. Within this framework, it is also important to find appropriate successful approaches which have already been successful in other parts of the world.

3. Mobility and Access Management

There are various measurements available worldwide for any transportation management programs to meet transportations needs of an area such as building new roads, transit facilities, or managing demand, or increasing access conditions. Meyer (1998) has properly categorized these measures into three groups include supply management, land use management, and demand management [20]. Instead of developing and implementing measures from single category, applying a coordinated program including a combination of measures from three groups is necessary as a formidable solution to address long-term transport problems of urban areas, particularly mega-cities [21].

Supply Management

Of the three groups, supply management measures and strategies are the most common response policy makers and city managements have taken to come up with solutions for traffic related problems simply by supplying more. Supply management methods such as widening of existing roads, building new highways and transit facilities aim to increase the capacity of transportation infrastructure to meet the growth of traffic and transport needs. Technological solutions are also considered in this category such as more fuel efficient, cleaner engines or new forms of road surfaces to reduce the level of traffic noise and friction related energy losses to reduce air pollution. However, these supply side measures, both building more and technology side improvements, are only effective in short-term requiring expensive investments and, in fact, generating further transport, social and economic related problems, and they are not be able to meet long-term sustainable urban mobility goals. Because it has been realized that the added road capacity makes driving more attractive, thus it increases demand to use the roads leading to further traffic related problems again [27, 19, 23].

Land-use Management

Land use means simply how the land is used, in other words, what human activities are conducted and what location is allowed for constructions. From the perspective of transportation management, knowledge of the geographical settlement patterns of social and economic activities is crucial at planning stage of transportation policies. To put simply, trip-making patterns, volumes, frequency and modal distributions are simply related to spatial distribution and use of land. It has the answers for supply management questions: how much, what type and where to supply when increasing transport capacity of a city. It is also critical for demand management when exercising control over the trip generating characteristics of the land use in an area to use for providing the resultant demand being consistent with the existing transportation infrastructure and the desired level of service.

Travel Demand Management

As discussed in previous sections of this study, automobile use has been steadily increasing at a growing rate during the past few decades. In addition, the number of passenger kilometers by private car per capita has been increasing due to aggressive growing of cities and consequently longer, more frequent working and personal trips. On the other hand, the average number of passengers traveling in the same car has been decreasing at the same time. As a result, problems related to this uncontrollable growth such as congestion, air pollution, noise, traffic accidents are continuing to rise. Besides, vehicles take up much space in urban areas, which narrow down people's living spaces. For example, many streets, which are assumed to be a habitat for many activities, are captured by traffic along with its associated problems. To arrive at a more sustainable urban transport system in the future, however, cleaner fuels and reduced car use will be necessary [32]. Technological solutions are effective at reducing the impact per vehicle and per kilometer. However, the mitigating effects of new technological solutions are not expected to keep up with the increasing growth of mobility and accessibility needs and use of various vehicle use [34]. Reduced car usage strategies are aimed at influencing people to change their behaviors to more sustainable transport modes to improve urban quality of life. Such behavioral change strategies are known as Travel Demand Management (TDM) policies.

Travel Demand Management (TDM) was defined as *"any action or set of actions intended to influence the intensity, timing, and spatial distribution of transportation for the purpose of reducing the impact of traffic*"[20]. In other respects, the primary objective of TDM policies was explained as *"to reduce the number of private vehicle* *trips while providing a wide variety of mobility options to those who wish to travel*"[6]. TDM includes a broad set of policies designed to increase the attractiveness of sustainable transport modes including walking, cycling and public transport as an alternatives to travel by automobile. In other words, TDM policies aim to maximize efficiency of existing transportation system by increasing the number of passengers in a vehicle, or by influencing the time of, or need to, travel. TDM instruments rely on incentives and disincentives to accomplish these types of behavioral change by making unsustainable modes less attractive and sustainable modes more attractive.

Among many different categorization of TDM measures such as *physical* and *behavioral* or *push* and *pull* or *hard* and *soft*, we have used *push* in similar meaning with *hard* and *pull* in similar meaning with *soft* categories [33]. "Push" (hard) policies aim to decrease attractiveness of car by economic disincentives, laws and regulations, as well as modifying the objective physical environment. Examples are road tolls, congestion charging, traffic calming, increased prices of fuel and vehicle ownership, and reduction of road capacity. "Pull" (soft) policies aim to increase benefits from using other modes of travel more than car, influence individual's awareness of the problems related to cars, and increase their knowledge for more sustainable modes of travel as alternative to car by providing economic incentives, information, education, public campaigns as well as improving physical infrastructure and service levels of sustainable modes [33,11]. Because of resulting high public opposition, being politically unfeasible and having only short-term effects, previous researches show that hard policies, that enforce change, alone do not lead to meet reduced car use targets in long-terms [10]. To illustrate this, it was found that during the world oil crisis of the mid-1970s the substantial rise in fuel prices had only a marginal effect on car use in short term [25]. In long term, higher prices have lead people to purchase smaller and more economical cars and consequently lower petrol consumption.

Thus, transportation planners, scholars, and other stakeholders have started paying serious attention to applying "soft" policies to meet desired sustainable urban transport objectives [16]. Mainstay of "soft" policy applications are an economic paradigm "utility based theory" in which travelers are generally assumed to be rational decision makers, who make choices for their travel based on how much net utility they can get out of their journey[16]. On the other hand, there are rationale advantages of car such as speed, comfort, flexibility, carrying capacity, however, there are also some subjective or emotional factors, which play significant role for charging travel behaviors through sustainable modes (public transportation, walking, and cycling) such as expressing feelings of power or superiority, or deriving enjoyment from driving, expressing their personality through type and color of car [32]. These two important aspects, utility theory and rationale and emotional advantages of car form groundings of soft policies. Different soft policy measures were identified and grouped into 10 different soft policy measures in literature which are explained below [3]. The first policy types (workplace travel plans, school travel plans, personalized travel planning, information and marketing, awareness campaigns) have been the most frequently implemented and evaluated to impact upon car use in the last decade. Although there is lack of evidence for the last categories (car clubs, car sharing, teleworking, teleconferencing, home shopping) having remarkable impacts on reducing traffic, they offer a great potential in the future to affect traveler's behaviors as technology evolves [2]. To obtain favorable results from these measures, they should be combined in designing, policy development and implementation in order to amplify the effectiveness [9].

Workplace Travel Plan (WTP)

Nobody doubts that commuting to work by car accounts for vast majority of all car traffic in every mega-city, particularly at peak times. However, growing experience of employer travel planning programs from different countries such as the UK, Netherlands, the US, Australia etc. demonstrate that workplace travel plans offers a great potential for sustainable urban transportation as they can be highly effective at cutting the number of cars driven to work totally or at peak times, through a combination of incentives for alternative sustainable travel modes [31]. From this point of view, a work place travel plan can be described as a package of measures developed by an organization or combination or organizations, companies, municipalities and governments to accomplish more sustainable travel as making getting to and from the workplace easier, faster, more inexpensive and less harmful for employees, and reducing dependence on private vehicles and parking space [2]. Although measures would vary depending on the number of employees and stakeholders, main measures used in a typical workplace travel plan include: (1) Discounts on public transport, (2) Increased and effective spending on public transport infrastructure by offering new public bus or rail services to linking to the sites of interests such as business quarters; (3) Providing all staff with public transportation information and available promotions and discounts, (4) Offering personalized journey plans to staffs, (5) Cycling and walking initiatives (secure cycle parking, promoting cycling and walking, changing facilities and showers), (6) Co-ordinated car-sharing schemes and incentives, (7) Management of parking (restrictions to essential users, parking charges, parking 'cash out' for non-users), (8) Encouraging teleworking and teleconferencing, (9) Variations and working hour arrangements on the five day week, e.g. compressed working hours [5].

School Travel Plans (STP)

In mega-cities, millions of students and their parents go from home to school in the mornings and return home in the afternoons every day during school terms and substantial proportion of students are driven. Consequently, traffic congestion around schools has increased dramatically at peak times. This proportion has tended to increase steadily as motorization level of megacities increase at last decades. Hence, it is important to focus on these trips to make them more sustainable as promoting walking and cycling for short distances, and public transportation or dedicated school buses for longer distances through developing school travel plans (STP). In this respect, a STP can be defined as a travel plan which aims to decrease problems related to school related-congestion and traffic and to support pupils who are already travelling by more sustainable means (DfT n.d.). On the other hand, not only school travel plans are significant for reducing traffic related problems in mega-cities, but also they are helpful and crucial for children's health and wellbeing as it is desired for children to walk or cycle, which helps them to increase their daily physical activity. Well-designed school travel plans (STP) concentrate on measures to make school runs safer for walking and cycling together with awareness-raising education and campaigns, and incentives to walk or cycle such as cycle parking, fare cuts etc. A typical STP include measurements: (1) Special walking or cycling days, (2) Walking buses or cycle trains (see Figure 3.1), (3) program for pedestrian and cycling training for children, (4) Dedicated school buses, (5) Improvement to public transportation for children, (6) Fare cuts, (7)Traffic calming, pedestrian crossing and cycle lanes around schools, (8) Offering lockers at schools [5].

Figure 3.1: A Typical Walking Bus

Personalized Travel Planning (PTP)

Recently, personalized marketing, also known as individualized marketing or one-to-one marketing has become one of the most practical strategies in the market. Basically, it means differentiating products to specific customers or customer segments according to his/her/their preferences rather than mass-marketing campaigns. The assumption behind personalized travel planning is that drivers generally have limited and inaccurate information about alternative modes, and would like to switch or use more sustainable transportation modes if they had known the available services were better. In a typical personalized travel planning application, first, all households within a target area are contacted to offer alternative travel modes, and classified in three main groups whether they are interested or they are already a user or not interested. After that, pre-surveys are conducted with interested customers to learn their current travel behaviors and sometimes (in travel blending applications) also asking them keeping travel diary for generally a week. After receiving individualized information from the travel diaries and pre-surveys, personalized information packages designed to modify behaviors have been offered to each participant. Personalized marketing strategies have been applied successfully in various fields with positive results as well as in the field of TDM under the name of personalized or individualized travel planning (PTP) at the household level and for all types of trips [1]. A typical personalized information packages may include ideal tools (ideas for changing current travel activities or time of activities), travel blending, personalized journey plans, public transportation schedules, brochures (dealing with saving money, reducing environmental impact, making travel less stressful), Local activity guides, Loan-a-bike, free public transport tickets, and information regarding CO2 emissions their car produced, wasted time in traffic, how much money they spent etc. [2]. After a participant received his/her customized information package, participant is asked to keep post-travel diary for identifying change in travel behavior, facilitate feedback to participant and monitors program's total impact.

Marketing, Information and Travel Awareness (MITA)

Marketing, information and travel awareness applications based on targeted marketing techniques providing advice and information for alternative transport modes, and increasing public awareness for problems resulted from travel choices through campaigns. At the last decades, the concept of de-marketing emerged as a particular specialism in marketing field. While conventional marketing practices based on encouragement of demand for a product or service, on the other hand de-marketing concept based on discouragement of demand for a product or service [37]. Both marketing and de-marketing applications in the transportation field is as old as Second World War (See Figure 3.2). Marketing applications in transportation field can be easily separated into two category. First category is mainly focused on marketing of alternative transportations modes in substitution for automobile, while the second category consists of de-marketing applications for discouraging people for car usage. Applications from both categories reported evidence of reductions in car usage [2].

Figure 3.2: 'Is Your Journey Really Necessary' the UK Awareness Campaign during Second World War

Car Clubs and Car Cooperatives or Car Sharing Schemes (CC-CS)

Car clubs (in the UK) or US name 'car sharing' is a model of car rental where people rent cars for short period of time by the minute, by the hour as well as by the day [8]. Car clubs also differs from traditional car rentals in some points: 7/24 renting is available; reservation, pick up and return is all self-service; fuel costs included in the rates; users are members and pre-approved to drive; the locations of vehicles are very easy to reach by public transportation, walking and cycling; reservation can be made by phone, websites, mobile applications or even text messages depending on company. Car clubs required membership with fees from USD30 to USD200 annually and charge by time used and distance travelled [22]. They are mostly attractive to people whose main travel modes are public transportation, walking and cycling and they only need car occasionally. Car clubs are also an alternative for owning second car for households with more than one driver. Because car clubs offers less car intensive means of urban transport by leading its members to make only necessary trips and increase usage of alternative transport modes, it has the potential for reducing car owning rates at an estimated rate of that one rental car can take the place of 15 owned vehicles (Economist 2012). In the longer term, it is estimated that growth of car clubs might reduce national car travel demand by 1.6 per cent [31].

Teleworking (Telecommuting, Teleconferencing, and Shopping from Home)

New developments within the fields of computer and telecommunication technology in recent years, -including computer networks and data systems, telephone, fax and scanner machines, electronic mail, online payment, online calling, websites, video connections etc.- offers new work and social habits to people especially workers so they can work or shop or communicate socially wherever these tools are available including home. These opportunities have led many companies, organizations and government agencies to adopt these technologies for improving services, reducing costs, reducing vehicle trips, or to achieve other objectives. In this manner, a general term, *teleworking,* has been defined as use of telecommunications to replace physical travel [5]. Specific examples of teleworking are as follows: (1) Telecommuting, (2) Satellite office or local work center, (3) Video-conferencing and Video presentations, (4) Distance Learning, (5) Tele shopping or Internet-shopping, (6) Online-Banking, (7) Electronic Government, (8) Internet Business-to-Business (B2B) [5].

Conclusion

On one hand, transportation of goods and people is vital for economic development and social life. On the other hand its negative effects, such as congestion and air pollution, risks economic development, social well-being, and most importantly sustainability of our world. Since building more roads makes driving more attractive and automobiles are unsustainable mode of mobility, it is significant to change our travel modes towards sustainable modes like public transportation, walking and cycling to mitigate this effects especially resulting from traffic congestion. Besides, increasing urbanization and motorization rates make the problem much more complicated especially in megacities. In this direction, Istanbul’s traffic congestion problem is also alarming. Investments on road network and PT network do not keep up pace with traffic demand due to increasing urbanization and motorization levels. Especially during last decade, it became more chronic. In this sense, the first part overviews Istanbul on general highlights, and continue with making comparisons between Istanbul and various cities in different parts of the world on different indicators to better understand the case of Istanbul. While, the second part of this study highlights TDM policies to use existing infrastructure more efficiently, canalize people to social behavioral change for sustainable modes and alleviate unnecessary travel demand. As a result, The unexpected relationship between the congestion index, road and rail network and the number of cars compared to the other cities implies mistakes related to the management of the traffic in Istanbul, therefore, it is suggested in this study that TDM policies should be taken into account in management level to eliminate these mistakes and to keep up pace with increasing urbanization and motorization levels in the city.

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Exploration of Bacteria Symbionts Pocillopora Damicornis Coral for the Production of Sanitary Hand Gel

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Abstract

The purpose of research was to determine potential anti-bacterial symbiont bacteria from coral *Pocillopora damicornis* and would be used to produce an hand antiseptic. Research includes the isolation of bacterial symbionts, screening bacterial symbionts that has potential as anti-bacterial, DNA extraction using High Pure PCR Template Preparation Kit (Roche), DNA amplification by PCR of 16S rDNA and DNA sequencing. Result of 16S r-DNA sequences were analyzed and edited using Genetix program and sequence analysis of 16S rDNA. Bacterial extracts were obtained by separation using a separating funnel and then evaporated at low temperature. Several experiment had been done such as bioactivity test of extracts, solubility, the sensitivity of bacteria to solvents test assay of each concentration, producing of antiseptic gel with Carbopol 940 base until final evaluation and antiseptic test of bacterial extracts. Results on isolation of bacterial symbionts of coral *Pocillopora damicornis* had obtained 9 isolates with isolates 5.A.4 has potential as an antibacterial. BLAST analysis using the isolate had showed that bacterial isolates 5.A.4. has similarities with the species of *Bacillus subtilis* strain A2 with sequence homology of 99%. Based on the test results were known that antiseptic gel from gel of 1% 5A4 bacterial extracts have antiseptic power almost similar to the potitive control or Detol. Conclusion, antiseptic gel preparations made from extracts of bacterial symbiont bacteria coral *Pocillopora damicornis* performs effectively as an antibacterial in the form of hand sanitary antiseptic gel.

Keyword: Coral *Pocillopora damicornis*, bacterial symbionts, *Bacillus subtilis*, sanitary hand

INTRODUCTION

Almost of 70% of thearth surface were covered by the ocean, thus it is important to explore the potentials of the ocean or marine resources sustainably. High biodiversity of marine resources implies for the great possibility for the use of marine resources. This was such as coral reef organisms which was also as the host of so many symbiont. Micro organism or symbotic bacteria and host coral reef was believed with very diverse bioactive compounds. Some symbiotic bacteria found in mollusc (Pringgenies, 2010a) had been explred as antibacterial-agent for *Multi Drug Resistant* strains (Pringgenies, 2010b) such as *Pleuroploca trapezium* (Gastropods). Pringgenies (2009) in isolation of 20 Gastropods genera revealled that about 10 genera of Gastropod had shown an antibacterial-activity potential for new material of antibiotic, such as found in *Conus miles.*

As symbiotic bacteria in mollusc had shown a significant otential use as antibacteria agent then it wasassumed also from coral reef. *Pocillopora damicornis* was one genera of coral found in Jepara waters Java sea. In the collection of symbiotic bacteria from coral have no destructive samplings so that would be no harm to environment. Based on that the aim of the study was to explore the symbiotic bacteria of *Pocillopora damicornis* to produce anti-bacterial agent for hand sanitary.

METHODS

Sample collection and symbiotic bacteria isolation

Sample of *Pocillopora damicornis* tissue weight 5 grams were collected from Awur bay – Jepara Java sea Indonesia. Sample were directly put into sample bottle with seawater and stored in a cool box. Samples of coral tissue were rinsed with sterile seawater, destructed and add 5 ml steril seawater, so that 10 fold dilution (10^0) were obtained. Take 0.5 ml of the solution with sterile pippete put into a reaction tube with 4.5 ml sterile seawater so that 10^{-1} was obtained and so the next same steps so that dilution of 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} were obtained. Take out 100 µl out of each dilution and spread onto the surface of Zobell 2216E medium and incubated for 3 days with 30°C temperature (Radjasa, 2003). Yellow and orange coloni (5.A.4) was selected and purified.

Bacteria Identification

DNA of the cultured bacteria incubated for 24 hours was then exctracted using *High Pure* PCR *Template Preparation* Kit (Roche). DNA amplification using PCR 16S rDNA with denaturation at 94°C temperature for 5 minute as preliminary heating, with 30 cycles (*annealing* at 94°C temperature for 30 seconds, *extension* at 54°C temperature for 60 second and denaturalised at 72°C temperature for 120 second) and finally at 4°C temperature incubation. Primer used for PCR 16S rDNA was universal primer 27F (5'-AGAGTTTGATCMTGGCTCAG-3') and specific eubacteria primer 1492R (5' TACGGYTACCTTGTTACGACTT-3') (Isnansetyo and Kamei, 2003). Electrophoresis was done using agarose gel with 1 % concentration, running with 100 Volt for 45 minute. Result of electrophoresis was observed using UV Illuminator. Sequencing were done with PCR cycles using *Big Dye Terminator* v.3.1 and result were comparred with DNA sequence database at *Basic Local Alignment Search Tool* (BLAST) at *National Center for Biotechnology Information, National Institute for Health*, USA (www.ncbi.nlm.nih.gov) (Altschul *et al*., 1997). Main material in the study were isolate and extrcat of symbiotic bacteria from coral *Pocillopora damicornis* from Jepara waters Java sea. Tested bacteria was *Salmonella thyposa* from Microbiology Laboratory – Health Office Semarang City Indonesia.

Bacteria Extraction

Procedure to obtain crude extract of symbiotic bacteria was using 5 days culture then soaking 250 ml of sample with N – hexan, ethile acetate and methanol solvent simultaneously and followed orbital shaker until separation of the two solution was obtained (Burgess *et al.*, 2003). Minimum resistance concentration test of was using end product as anticeptic gel evaluation parameters of pH, colour and odor (Table.1). Production of symbiotic bacteria extract in the form of gel. Where carbopol-940 was soaked and mixed thoroughly with warm aquadest then mixed with bacteria extract and glycerin. Add drop by drop of TEA (trietanolamin) to the mixture until the formation of a clear gel was obtained.

Tabel 1. Matrix of gel parameter test

Material	Compound Dosage/Volume		
	F1	F2	F3
Bactria exctract	0.00%	0.5 %	1 %
Carbopol 940	0.50%	0.50%	0.50%
TEA	0.50%	0.50%	0.50%
Glicerine	1%	1%	1%
Lemon Esence	0.5 ml	0.5 ml	0.5 ml
Aquadest	100 ml	100 ml	100 ml

Antiseptic Test of Antibacterial Exctract Gel

Antiseptic test of the antibacterial extract (antiseptic) gel was done with procedure : hand palm was thoroughly washed in a running water and air dried for 1 minute. Some drops of antiseptic gel onto hand spread and hold for 1 minute. Make dilution of antiseptic gel from 10^1 up to 10^9 and make a gentle contact of the anticepted hand palm with with solid *Zobell's 2216 E* medium in a petri disc. These series of three replicates each dilution of medium were then incubated in 37^0 C temperature for 24 hours. Bacterial colony counting using magnifying lense and colony counter (Sari, 2006).

RESULT AND DISCUSSIONS

Isolation of Symbiotic Bacteria

Result of *Pocillopora damicornis* symbiotic bacteria exctraction had yielded 9 isolates. Most of isolates with white or transpaterent white andonly one with orange carotenoid pigment (bacteria sample 5.A.4) as Nugraheni (2010), elaborate that most of carotenoid pigments ere found in the range colour of yellow, orange until red. Result of morphological (bacterial code, colour, form and tecture) observation of symbiotic bacteria isolates as presented in Tabel 2.

Table 2. Result of morphological observation of symbiotic bacteria *Pocillopora damicornis*

No.	Bactery code	Colour	Form	Texture
1	5.A.1	Milky white	Round	Flat
2	5.A.2	Transparent white	Ellipse	Flat
3	5.A3.	Milky white	Irregular	Flat
4	**5.A.4**	**Orange**	Round	**Convex**
5	5.A.5	Light yellow	Round	Flat
6	5.A.6	Transparent white	Round	Convex
7	5.A.7	Milky white	Round barbed	Flat
8	5.A.8	Light yellow	Round	Convex
9	5.A.9	Light yellow	Round barbed	Convex

Symbiotic Bacteria Identification

Based on the amplification of 16S rDNA had showed that bacteria isolate 5.A.4. yield a alkaline tape of 1500 bp according to the ratio of DNA marker. Sabdono (2001), mention that 1500-1600 bp was the typical size of 16S rDNA bacterial sequence. Result of DNA visualisation using electrophoretic analysis as presented in Figure 1.

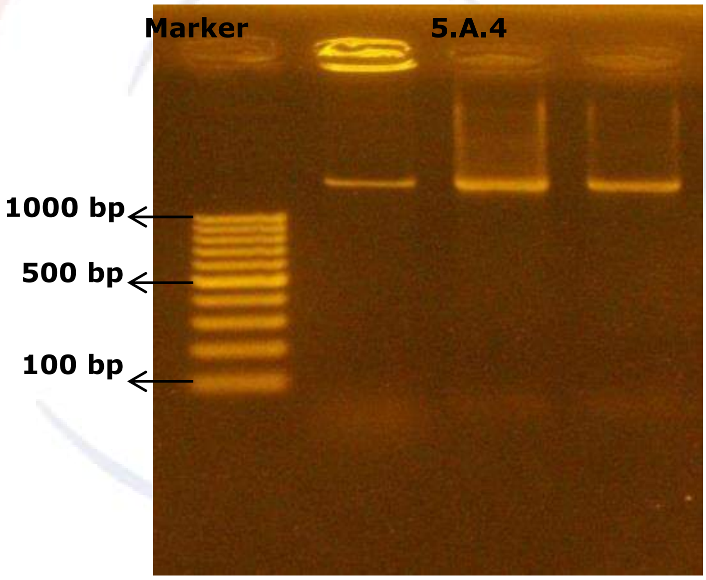


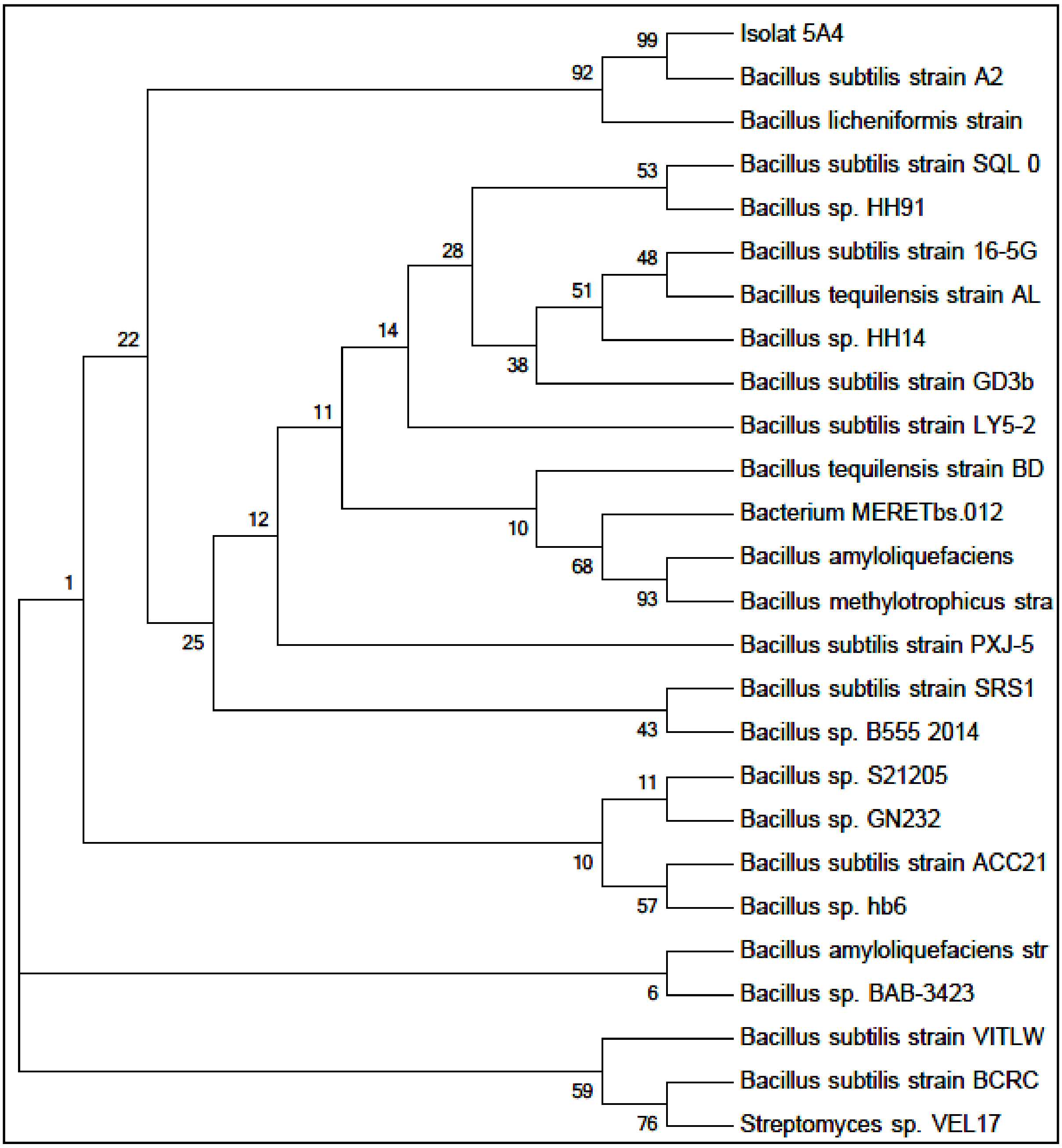
Figure 1. PCR Band Visualisation of 16S rDNA on Isolate 5.A.4 symbiotic bacteria of coral *Pocillopora damicornis*

BLAST analysis of bacteria isolate 5.A.4. had shown 99% homological sequence with *Bacillus subtilis* strain A2 with futher homological tracing using BLAST Searching as presented in Table 3. With definition that homological sequence of isolate 16S rDNA between 93%-97% will representing identification at genera level with different species and homological sequence above 97% will represent for similar species (Hagstrom *et al.*, 2000). Result of philogenetic tree for the 5.A.4 isolate using MEGA *software version* 5.05 (Molecular Evolutionary Genetics Analysis) and ClustalX as presented in Figure 3 had conformed that isolate 5.A.4 the symbiotic bacteria at coral *Pocillopora damicornis* was *Bacillus subtilis* Strain A2. *Bacillus subtilis* was a gram positif bacteria, aerobic obligate belongs to Kingdom Bacteria, Phyllum Firmicutes, Class Bacilli, Ordo Bacillales, Famili Bacillaceae, Genus Bacillus and Spesies *B. subtilis* (Madigan, 2005). Morphologically *B. subtilis* was rod type of bacteria (thick or thin), with or without chain structure with ability to produce endospore and motile with the flagella.

Table 3. Homological tracing of Isolat 5.A.4 using BLAST

No.	Description	Max score	Total score	Query cover	E value	Ident	Accession
1	Bacillus subtilis strain A2 16S ribosomal RNA gene, partial sequence	2111	2111	100%	0.0	99%	KC433738.1

Figure 3. Philogenetic tree 16S rDNA sequence of symbiotic bacteria Islote 5.A.4



B. subtilis was usually found in the soil, water, air, and decomposing plant materials (Graumann, 2007) but as well as in the seawater. Ashwinkumar and Karutha (2012) had succed in isolating *B. subtilis* from the coastal seawater. Bacillus was know as pigment producing bacteria. Rashid *et.al* (2014) found that *B. subtilis* with orange pycosianin pigment but also can produce pigmen of melanin, quinones, prodigiosin,violacein and phenazine (Yoshida *et al*., 2009;).

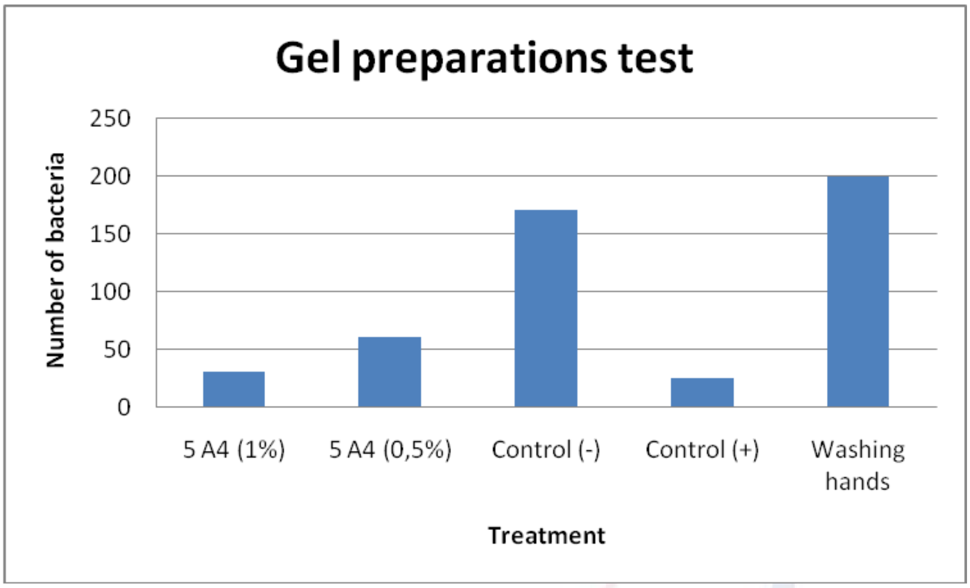
Antiseptic Gel. Result of antiseptic gel from symbiotic bacteria exctract of 5A4 isolate related to the concentration were as presented in Figure 4, where 0% (gel without exctract) with very clear gel, gel with 0.5% exctract with very light yellowish white and as well as with gel with 1% exctract but more solid state.

Figure 4. Exctract of 5A4 gel with concentration of 0%; *0.5* %; *1*%

Several character of 5A4 exctract gel with lemon like odour, light yellow white and pH was eight. Antiseptic test of exctract *5A4* gel on washed hand palms with 0.5% gel exctract had been contaminated with 61 bacterial colony and 1% gel exctract continated with 31 bcaterial colony as in Table 3 and diagram as in Figure 5. Based on the test confirmed that exctract of the symbiotic bacteria had a significant inhibition power to pathogenic bacteria. Where 1% concentration of the exctract had almost the same effect to the positive control using a commonly use antiseptic Detol.

Table 3. Resultof antiseptic test of 5A4 exctract

No	Treatment	No of colony		Average colony	Standart deviation
		Test-1	Test-2		
1	5A4 1 %	38	24	31	9.899494937
2	5A4 0,5 %	52	71	61.5	13.43502884
3	Control (-)	168	175	171.5	4.949747468
4	Control (+)	27	25	26	1.414213562
5	Washing hands	198	201	199.5	2.121320344



Control test without treatment of gel (only washing hands) and contact to agar plate produce 199 bacterial colony. Test of gel with 0% exctract had produce 171 colony, and test of antiseptic gel with concentration of 0.5 % produce 61 bacterial contaminant colony and 1 % produce 31 colony. Means that with the treatment of antiseptic gel of symbiotic bacteria exctract had significantly decrease the number of bacterial contaminant colony. Comparison with a patent antiseptic gel with active compound of ethanole (Detol) reult with 26 colny of bacterial contaminant. The effect would be much better, since only up to 1% exctract concentration treatment had been used, and if the exctract concentration increased will be effective in suppressing the bacterial contaminant, mean that exctract of symbiotic bacteria *B. subtilis* from coral *Pocillopora damicornis* was found to be effective as an antiseptic gel and can be classified as sanitizer. As conformed with APUA/*Alliance for the Prudent Use of Antibiotics* (2011) with definition of sanitizer are biocative compound that can kill pathogenic bacteria in a given concentration. Pringgenies *et.al* (2011) revealed that exctract of symbiotic bacteria from marine Gastropods with concentration of 25 % of *Pseudoalteromonas* sp have ability to decrease 77.17 % and *Vibrio* sp decrease 85.84 % bacterial contaminant. While test with concentration of 50 % have ability to decrease up to 91.04 % colony of bacterial contaminant. Comparison with antiseptic gel with active compound of Triclosan and ethanol have the same effect of 50% symbiotic exctract. The ability of Vibrio sp . as antibacterial is an interesting information because it is a natural material . Information about the potential of bacterial symbionts as an anti- bacterial already stout known as already done by bacterial symbionts mollusc *Conus miles*. Based on the research that has been done that the bacterial symbionts gastropod Conus Miles able to inhibit the growth of bacterial MDR (Multi Drug Resistant) more than one type of bacteria including Klebsiella , Staphylococcus , Pseudomonas , Enterobacter and E. coli Pringgenies (2009) . Active compounds which inhibit the growth of bacteria can not be known in detail because of bioactive compounds isolated are still at the level of crude extract .

The world problem of sanitation getting more and more urgent where 850 million world population have limited acces to clean water and about 2.5 billion have no access to standard sanitation services. With assumsion that desease and mortality can be reduced by 9.1% and 6.3% with better access to to clean water and sanitation. Most of desease was caused by diarhea with 1.9 milion death and 4 billion case for children under 5 yeras old. The World Health Statistics 2009 review shows that 386,000 diarhea mortality in India and 13.9% mortality in Egipt under five years old (A Joshi and C Amadi, 2013). The future prospect of the use exctract of symbiotic bactera such as *B. subtilis*. a antiseptic gel was inevitable.

SUMMARY

Symbiotic bacteria of *Bacillus subtilis* from coral *Pocillopora damicornis* had confirmed as antiseptic. Concentration of 1 % exctract of *Bacillus subtilis* have the same effectivity with ethanol based common antiseptic in the market.

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Deltas of the World: A Possible Comparison

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Abstract.
Wetlands are a key point of the environmental conservation agenda. Some of the ecological reasons include a high biodiversity, including rare and endangered species, their vulnerability and importance in global mass and energy flows. Moreover, wetlands are ecotone areas, accounting for the biodiversity of land and water species. The ecosystem services provide an excellent framework for assessing their benefits. Among wetlands, deltas are far away the largest one from a geographical standpoint; for this reason, deltas represent a protection priority. This paper looks at several particular deltas, attempting to find common grounds, despite of the geographical and ecological elements, using sustainability-based criteria accounting for environmental, social, economic, and cultural issues. The results suggest that the lack of accessibility is a warrant of protecting biodiversity by limiting access, but at the same time prevents their economic development, generating social issues. Tourism is a potential way of valorizing their potential, but could conflict with protecting the values of the local culture. Among the instruments aimed at their protection, WWF, the Ramsar Convention, World Heritage and Man and Biosphere Programs offer important management principles. Ecological restoration also represents an instrument for enhancing the environmental quality of these areas.

Key words: wetland, biodiversity, sustainability, conservation, restoration.

1. Introduction

The term ‘wetland’ is used to name the transitional ecosystem type between the aquatic (water) and terrestrial (upland) environment, exhibiting features of both types of ecosystems separated or joined (Apostolov et al., 2004). The definition emphasizes the fact that, from an ecological standpoint, wetlands are ecotone areas, accounting for the biodiversity of land and water species. Their ecological typology is diverse; authors distinguish mineral and organic wetlands; according to the type of vegetation, grasses dominate marshes, while trees dominate swamps (Apostolov et al., 2004). A more detailed typology is displayed in Table 1.

The importance of wetlands is often stressed out by their inclusion as key points of the environmental conservation agendas. From an ecological standpoint, the main reasons are, from an ecological standpoint, their high biodiversity, including the presence of rare and endangered species, and importance in global mass and energy flows. More exactly, wetlands are among the most biologically productive ecosystems in the world (Heinl, 2001); for example, they were found to be important sources of methyl mercury to the boreal forest ecosystem (St. Louis et al., 2004). They absorb and slow down floodwaters from coastal storms, hurricanes, filter and degrade toxic substances, reduce flooding and erosion by absorbing storm water and releasing it slowly, and by absorbing overflows from streams and lakes, and helping to replenish stream flows during the dry periods, to recharge the groundwater, and to preserve biodiversity by providing habitats for a variety of species (Tyler Miller and Spoolman, 2009), provide valuable feeding sites and migration staging (McCulloch et al., 2003). Furthermore, wetlands support diverse and unique species assemblages (Russel et al., 2002), and play a greater role in the metapopulation dynamics of certain animal species (Gibbs, 1993). In economic terms, they have value because many of their functions have proved to be useful to humans. Their perceived values come out of the fact that functional ecological processes, but are also determined by human perceptions, the particular location, the human pressures on it, and the extent of the resources (Mitsch and Gosselink, 2000).

Another reason for stressing out the importance of wetlands is that they are among the most vulnerable and most threatened habitats (Williams and Dodd, 1979). Not all threats are due to the humans; natural causes affect them too. In summary, the main impacts are due to drainage and filling to provide more agricultural lands and as an anti-malaria measure, building of huge dams to store water for agricultural purposes, straightening and straightening the course of riverbeds with dikes as a flood protection measure, water pollution, overexploitation/ unwise use of wetlands resources, species composition alteration/ damage – removal of plant cover, overgrazing by domestic animals, introduction of non-indigenous (nonnative) species (Williams and Dodd, 1979; Apostolov et al., 2004). In more details, dams, and canals fragment rivers, alter and destroy terrestrial and aquatic habitats by reducing water flow and increasing damage due coastal storms; flood control levees and dikes disconnect the rivers from their adjacent floodplains, destroy aquatic habitats, and alter or reduce the functions of neighboring wetlands. Most anthropogenic impacts come from cities and farms, which add pollutants and excess plant nutrients. Last but not least, many inland wetlands have been drained or filled to grow crops or have been covered with concrete, asphalt, and buildings (Tyler Miller and Spoolman, 2009). As a consequence of these impacts, wetlands are disappearing globally at an alarming rate (Heinl, 2001).

Table 1. Ramsar Classification System for Wetland Type (Apostolov et al., 2004)

Marine/Coastal Wetlands	Inland Wetlands	Human-made wetlands
• Permanent shallow marine waters • Marine subtidal aquatic beds • Coral reefs • Rocky marine shores • Sand, shingle or pebble shores • Estuarine waters • Intertidal mud, sand or salt flats • Intertidal marshes • Intertidal forested wetlands • Coastal brackish/saline lagoons • Coastal freshwater lagoons • Karst and other subterranean hydrological systems	• Permanent inland deltas • Permanent rivers/streams/creeks • Seasonal/intermittent/irregular rivers/streams/creeks • Permanent freshwater lakes • Seasonal/intermittent freshwater lakes • Permanent saline/brackish/alkaline lakes • Seasonal/intermittent saline/brackish/alkaline lakes and flats • Permanent saline/brackish/alkaline marshes/pools • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Permanent freshwater marshes/pools • Seasonal/intermittent freshwater marshes/pools • Non-forested peatlands • Alpine wetlands • Tundra wetlands • Shrub-dominated wetlands • Freshwater, tree-dominated wetlands • Forested peatlands • Freshwater springs; oases • Geothermal wetlands • Karst and other subterranean hydrological systems	• Aquaculture ponds • Ponds • Irrigated land • Seasonally flooded agricultural land • Salt exploitation sites • Water storage areas • Excavations • Wastewater treatment areas • Canals and drainage channels, ditches

The ecosystem services provide an excellent framework for assessing the benefits of wetlands. Starting with the Millennium Ecosystem Approach from the early 2000's, the classical capital-based approach (i.e., the natural capital provides environmental goods and services to human society) was replaced with the ecosystem services perspective; these are the benefits provided by ecosystems to human society, classified as: (1) supply (food, water), (2) regulation (flood and disease control), (3) cultural (spiritual, recreational, and cultural benefits), and (4) support (nutrient cycling) (Zakri and Watson, 2003; Watson and Zakri, 2005). This perspective is related with the previous one, since a normally functioning ecological system has a biological yield, which is turned into goods and services, provided to the human society (Ianoş et al., 2009).

2. Deltas are a particular type of wetland

According to Hori and Saito (2007), deltas are discrete shoreline protuberances formed where rivers enter oceans, semi-enclosed seas, lakes, or lagoons and supply sediment more rapidly than it can be redistributed by the basinal processes. They need to be particularly distinguished from estuaries; from a geomorphologic viewpoint, deltas are regressive/pro-grading systems, while estuaries are transgressive coastal depositional systems (Hori and Saito, 2007). Among wetlands, deltas are far away the largest one from a geographical standpoint; for this reason, they represent a protection priority. Furthermore, a delta is an integral part of a larger total river system and, to be adequately understood, must be considered in that context (Coleman and Huh, 2004.

Authors distinguish several types, based on their morphology – Gilbert-type delta; fluvial-dominated delta; tide-dominated delta / high-constructive and high-destructive / morphology: elongate, lobate, cuspate, estuarine (Hori and Saito, 2007), or formation – river dominated, tide dominated, wave dominated (Syvitski and Saito, 2007). Despite of their type, all deltas were formed over thousands of years some 6000-8000 years ago Renaud et al., 2013, and exhibit distributary channels, sand bars, mudflats, and lakes, and all give evidence of broadly similar evolutionary changes (Walker and Grabau, 1999). Their morphology depends on the location, morphology of the basin, fluvial and sediment discharge, ocean energy, and shelf depth reached by the sub-aqueous delta (Syvitski and Saito, 2007). In terms of inhabitance, many deltas are densely populated, and constitute important economic hubs (Renaud et al., 2013); although river deltas only contribute to 5% of the global land mass, over 500 million people live in these areas (Kuenzer and Renaud, 2012). Some deltas are sparsely populated but might have outstanding ecosystem and biodiversity value, such as the Rufiji Delta, which has only about 150,000 inhabitants (Kuenzer and Renaud, 2012), or Mekong Delta, where 16 million people make it the most densely populated part, nearly 85% rural (White, 2002); the main economic activities are traditional subsistence strategies (Bock, 1998). In general, deltas have evolved in close relationship to human activities and climate changes (Li et al., 2006).

Among the instruments aimed at their protection, WWF, the Ramsar Convention, World Heritage and Man and Biosphere Programs offer important management principles (Stan, 2013a, b). While the lack of accessibility is a warrant of protecting biodiversity by limiting access to many wetlands and deltas, it prevents the same time their economic development, generating social issues (Petrişor et al., 2014). Tourism is a potential way of valorizing their potential (Stan et al., 2014), but could conflict with protecting the values of the local culture (Meiţă et al., 2014; Petrişor et al., 2014).

This paper looks at several particular deltas, attempting to find common grounds. Obviously, provided the theoretical considerations presented above, it is easier to find differences due to the geographical and ecological elements. The analysis is focused on their value and on the main impacts affecting them, using sustainability-based criteria accounting for environmental, social, economic, and cultural issues; in addition, a special section is dedicated to the core principles supporting their strategies of development.

3. Deltas are valuable ecological systems

Deltas provide important benefits to society, often supporting large populations (Saito, 2005). Their benefits include highly fertile soils for agricultural development, good transportation provided by waterways and the nearby coast, fresh and salt water resources, and rich biodiversity and recreational value (Coleman and Wright, 1971; Ibeanu, 2000; White, 2002; Reker et al., 2006; Kuenzer and Renaud, 2012; Buhociu et al., 2013a, b; Renaud et al., 2013), including important and rare species (Wolfe et al., 2002). Deltas are among the most productive natural systems (Saad, 2003); for example, the Mekong Delta produces about half of the national food volume, 51% of total rice-paddy production, 55% of the national fisheries and fruit production, 60% of country’s exported aquacultural goods, and 61% of the total national export value (Käkönen, 2008). Their services include food, fuel, transportation, climate regulation, water purification, natural hazards regulation, fishing, and recreation – e.g., birdwatching and cultural benefits (Rasleigh et al., 2011).

In more details, the goods and services provided by deltas include highly productive arable land, rich in fertile sediments and organic materials for the agriculture, marine and river resources for protein food security, frequent onshore and offshore oil and gas reserves nearby, flat topography, which provides a favorable environment for agriculture, for urban and industrial development, and for transport, a large area which allows for urban growth and multi-directional sprawl (in most cases), function as a transport hub for incoming goods from abroad or from inland, and for outgoing goods and manufacturing, usually ice free harbors due to river and ocean streams, fresh water from the river or aquifers, rich biodiversity of wetlands and protective ecosystems (e.g., mangroves or reed belts), health advantages (winds and tidal mixing dilute the solid, liquid and gaseous wastes), and recreation and eco-tourism options (Kuenzer and Renaud, 2012).

For example, the mangrove forest in the Tanzanian Rufiji Delta supports an extensive food web through its high production of detritus, broken down by fungi and bacteria. The delta and Mafia Island are important wintering grounds for migrant birds, including waders and terns. Many species (hippopotamus, crocodiles and monkeys) feed and shelter in the mangrove forest. The wetland provides food in the form of organic detritus and shelter in the form of flooded vegetation (Mwalyosi, 1993). Similarly, the importance of Botswanian Okavango Delta can be assessed from multiple standpoints; it is historically important, as it served as a refuge during politically troubled times in past centuries and as a guaranteed source of water in years of drought; ecologically important, concentrating a significant part of the wildlife, including 650 bird species identified; economically important as sources of tourist revenue and water; and scientifically important, as a rare association of abundant water in an otherwise arid environment, containing a magnificent record of past climates (Jansen and Madzwamuse, 2003; McCarthy, 2009).

Due to the advantages provided, civilizations were founded on deltas and populations have been concentrated within their perimeter (Coleman and Wright, 1971); consequently, deltas have evolved into important centers of human populations, where people carry on various economic development activities such as agriculture and building (Li et al., 2006). The economic importance of deltas varies from one continent to another, but as the population of the world increases rapidly rate, greater demands will be placed on these food producing areas (Coleman and Wright, 1971). However, despite of these economic considerations, the Niger Delta is the poorest, least developed and least reciprocicated for its contribution to national wealth (Ikelegbe, 2001).

4. Deltas are vulnerable and threatened

In general, deltas are considered the most endangered ecosystems with respect to societal, environmental and climate change (Frihy et al., 2003; Kuehl et al., 2005; Saito, 2005; Reker et al., 2006; Hori and Saito, 2007; Kuenzer and Renaud, 2012), as well as their consequences, including sea level rise, and by other natural hazards such as cyclones and storm surges (Coleman and Wright, 1971; Tanabe et al., 2003; Boştenaru Dan, 2006; Renaud et al., 2013). Although deltas are wetlands, many of them seem to be experiencing wetland loss and sinking at a significant rate (Coleman and Huh, 2004; Coleman et al., 2008; Syvitski, 2008); for example, in the Colorado River delta, wetlands have been reduced by 80 percent due to water management practices in the Colorado River basin (Hinojosa-Huerta et al., 2005). The vulnerability of deltas can be illustrated by the Red River Delta, considered so intensively managed, that it became highly vulnerable to even minor perturbations (Rambo and Cuc, 1993).

Attracting people from the early history, deltas have been transformed by human interventions such as agricultural intensification, modification of water and sediment fluxes, as well as urbanization and industrialization (Saito, 2005; Syvitski and Saito, 2007; Syvitski, 2008; Meyer and Nijhuis, 2010; Kuenzer and Renaud, 2012; Renaud et al., 2013; Dandekar and Thakkar, 2014; Giosan et al., 2014). All deltas, including even those in remote regions of the Arctic, have been modified to some very different degree by human activities (Walker and Grabau, 1999). Particular impacts result from such as dam construction and for the generation of hydroelectric power (Mwalyosi, 1993; Wolfe et al., 2002; Saad, 2003; Torab and Azab, 2006; Hori and Saito, 2007). These impacts have economic consequences; rapid changes of hydrographic networks and in coastal delta fronts cause many problems relating to navigation, fishing, flooding of coastal infrastructure, and even delimitation of state borders; rising sea level causes flooding of coastal lowlands and deltas and severely impacts ecosystems, negatively impacting living conditions for the inhabitants of deltas (Pupienis et al., 2012), putting hundreds of millions of humans at risk (Syvitski, 2008; Syvitski et al, 2009).

For example, Volga Delta has been affected by vegetation removal, grazing, fires, irrigation, pressure of tourism, and pollution (Barmin et al., 2005); in addition, the construction of irrigation systems was carried out on the site of spawning fish, and artificial reservoirs are located on the migration routes of terrestrial animals (Chujkov, 2012). Arsenic pollution seems to be common to Asian deltas, such as Ganges-Brahmaputra-Meghna Delta, Red River Delta, or Mekong Delta (Thanh, 2003; Stanger et al., 2005; Datta et al., 2015). However, arsenic was found in Volga, Rhine and Danube Deltas, in addition to heavy metals, PAHs and PCBs, Hg, Cd and PCBs (Winkels et al., 1996). In addition to pollution, Asian deltas confront massive urbanization (Chen et al., 2008); the results indicate that urban areas have increased by more than 300% between 1988 and 1996, with potentially serious implications for a number of issues, including regional food supply and biogeochemistry (Seto et al., 2002). In addition to urbanization, intensifying agriculture resulted into the conversion of marshes and forests of Mekong Delta into a landscape dominated by highly productive rice paddies (Käkönen, 2008). In the Yangtze Delta, the paddy area decreased by 22% during 1942-2002, coupled with an 8% net increase of the built area, a 14% increase in aquaculture area, and a 5% net increase in land cover by closed canopy woody vegetation; these changes were caused by the growth of rural population combined with changes in land policy, agricultural technology and increasingly, by market-oriented land management (Wu et al., 2009). The Rufiji Delta was affected by damming, pollution with biocides drained from agricultural areas, and overexploitation of resources (Mwalyosi, 1993), while fire has caused impacts in the Okavango Delta (Heinl, 2009).

Other causes, such as changing political regime, including the colonial status of Vietnam’s deltas, set their fingerprint on agricultural practices, inducing land use changes and fragmentation (Jerez, 2014); inter and intra country conflicts had massive, long-term social, economic and cultural impacts on the peoples of the lower basin and depleted populations, resources and institutional capacity, especially in resource management (White, 2002). When deltas are shared by more countries, accelerating, political, cultural, economic, and water and land use changes have the potential to both benefit individual countries and to disadvantage their downstream or upstream neighbors (White, 2002). Wars are a possible cause; damage to the Mekong Delta last since the Indochina War, when defoliants, bombing, land clearing and drainage destroyed wetlands and forests (White, 2002). Political changes were also an underlying cause of impacts in the Okavango Delta (Hasler, 2009) or Niger Delta (Ibeanu, 2000).

The drivers of change include human and natural factors: urbanization, groundwater and hydro-carbon extraction, agricultural intensification, anthropogenic alteration of flow path and floodplains, upstream water consumption, diversion and sediment trapping, climate change, extreme natural hazards in terms of river flooding and coastal storm surges. Changes occurred in sediment delivery, subsidence, coastal erosion, extreme events such as cyclones or tsunamis, inundation, salinity intrusion, pollution, increased resource scarcity, but also in social systems, policies, social perception and development prioritization (Renaud et al., 2013).

In general, according to Kuenzer and Renaud (2012) the most important causes are:

- Urban development: urban and industrial sprawl, and associated waste water and solid substance pollution, strong surface sealing, changes of land use, often resulting into erosion, deflation, and degradation, ground water pumping to cover the urban drinking water needs, often leading to land subsidence (and increased flood hazard), drilling of oil and gas, also leading to subsidence, higher pressure on remaining recreational or protected areas, and substance, noise and light pollution;
- Rural development: the intensification of agriculture, resulting into an increased application of fertilizers, pesticides, antibiotics, and consequently increased water pollution; shift towards most profitable monoculture crops or increase in the number of annual harvests often leading to a loss in biodiversity; shift from grain crops or mixed crops towards intensive aquaculture, and conversion of natural protective ecosystems into aquaculture areas, usually along with and increased use of antibiotics and chemicals; increased production of domestic animals, also associated with waste water- and solid substance pollution; changes in water flows, water availability and sediment dynamics, and simultaneous growth of urban centers and expansion of peri-urban environments;
- Upstream developments: lowered sediment rates further downstream and in the delta (impacting nutrient transfer and thus agricultural productivity), increased coastal erosion due to lowered sediment content, changed flood pulses and pulse variability across the year, downstream transfer of pollutants leading to water quality deterioration, changes in river ecology and biodiversity (composition, amount of fish catch and local communities depending on the river) due to changes in water quantity and quality, and changes in navigability due to changes in water quantity and barriers;
- International conflicts

Deltas do not face changes of the natural environment only; societal changes are present too, in the form of losing traditional lifestyles, language, and cultural traditions (Bock, 1998). Restrictions to the livestock, imposed by the protection status, along with a tremendous expansion of the tourism are sources of societal problems in the Okavango Delta (Jansen and Madzwamuse, 2003), while modernization affects the Red River Delta (Hirschman and Minh, 2002).

5. Instead of conclusions: planning for the future of the deltas

Although delta-areas have similar problems, they have different morphological and functional characteristics which must be considered in spatial planning (Meyer and Nijhuis, 2010). The means of mitigation and adaptation towards these negative impacts can be of educational, ecological, technological and political nature (Kuenzer and Renaud, 2012). The literature mentions several principles for managing the future of deltas (although most are not specific to them); the strategies must balance the conservation of ethnic and biological diversity and use of natural resources (Miloslavich et al., 2011), include measures for adapting to the climate changes (Kuenzer and Renaud, 2012), address issues such as national sovereignty, local needs, comparative advantages, increased security, food security, rural development, industrial development, protected areas management and tourism, ecological reserves and trading water (Jansen and Madzwamuse, 2003), and engage the locals in the elaboration process (Văidianu et al., 2014). Ecological restoration also represents an instrument for enhancing the environmental quality of these areas (Stan et al., 2013; Petrişor et al., 2014).

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Nowcasting of Global Horizontal Irradiance for an Equatorial-Based Location Using Artificial Neural Network and Machine Learning

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Abstract
This paper investigates the use of artificial intelligence and regressive techniques to forecast hourly solar irradiance for a tropical country. The hourly irradiance data was obtained from Sepang, Malaysia, recorded throughout 2011. The data is converted into corresponding clearness index values to facilitate model convergence. Five techniques are evaluated; Persistence Forecast, Support Vector Machine, Least Squares-Support Vector Machine, Multilayer Perceptron and Autoregressive Moving Average. Standardized datasets for training and testing are used for all the techniques to ensure result comparability. The evaluation metrics used to validate each model's performance are mean bias error, root mean square error, mean absolute error/average, and Kolmogorov-Smirnov integral test. Results show that the Least Squares-Support Vector Machine outperforms all the other techniques, followed closely by the original Support Vector Machine.

Keywords: solar irradiance forecasting, support vector machine, ANN, ARMA

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Introduction

The proliferation of grid-connected PV (GCPV) systems has increased extensively, with a total global operating capacity of approximately 99 GW by the end of 2012 (Secretariat), 2014). GCPV introduce a number of challenges to the existing grid, particularly due to their inherent variability and stochastic nature. Currently, ancillary generators are used to compensate fluctuations. However, it is a costly solution. Accurate and reliable solar forecasting is an essential supporting technology required in order to enable the ability to anticipate short, medium and long-term characteristics of the power fluctuation and prepare necessary mitigation measures optimally.

A significant amount of research has been dedicated to this field with varying degrees of success. Comprehensive reviews done by (Inman, Pedro, & Coimbra, 2013) and (Diagne, David, Lauret, Boland, & Schmutz, 2013) conclude that suitable forecasting models are dependent on the forecast time horizon, geographical location, and available data, with stochastic and artificial intelligence (AI) techniques having the highest adaptability compared to other methods.

Initially, solar forecasting using historical data is done using statistical regression methods. Arguably the most popular methods were Box-Jenkins' Auto-Regressive Moving Average (ARMA) and Auto-Regressive Integrated Moving Average (ARIMA) to handle linear stationary and non-stationary data respectively (Box, Jenkins, & Reinsel, 2008). Notable related research include (Reikard, 2009) for time horizons of 5 up to 60 minutes and (Bacher, Madsen, & Nielsen, 2009) for hourly irradiance values of up to 36 hours. However, this method is not fully capable of handling nonlinear data.

Meanwhile, the artificial neural network (ANN) technique has been verified as an established method in producing accurate irradiance forecasting results, analyzed in detail by (Adel Mellit & Kalogirou, 2008). Comparison done using various ANN and regressive techniques by (Paoli, Voyant, Muselli, & Nivet, 2010), (Fernandez-Jimenez et al., 2012), and (Pedro & Coimbra, 2012) also point to the same conclusion. (Chen, Duan, Cai, & Liu, 2011) used a radial basis function network (RBFN) to forecast PV power production 24-hour-ahead for a deregulated power market while (Marquez & Coimbra, 2011) used a feed-forward type neural network to forecast GHI using inputs from a total sky imager (TSI), infrared radiation measurement (IR) and pyranometer values.

Support vector machine (SVM) is a relatively new technique applied for irradiance forecasting. It has shown satisfactory results in other relevant forecasting research such as wind power. SVM was used to predict hourly power output of a 1 MW PV plant in Kitakyushu Japan (Silva Fonseca et al., 2012) with encouraging results. Apart from that (A Mellit, Pavan, & Benghanem, 2013) explored the use of LS-SVM compared to various ANN techniques in predicting various meteorological parameters in Madinah, Saudi Arabia, including solar irradiance. Results reveal that LS-SVM performed better than the other ANN architectures used.

For tropical countries, current research are promising. Daily and hourly forecast for specific locations in Malaysia using several ANN methods was done by (Khatib, Mohamed, Mahmoud, & Sopian, 2011) and (Khatib, Mohamed, Sopian, &

Mahmoud, 2012) respectively with good results, while (Almaktar, Abdul Rahman, Hassan, & Saeh, 2013) proposed an ANN algorithm to predict PV module temperature in a tropical climate that in turn, affects PV output. Apart from that, a series of studies done by the Solar Energy Research Institute Singapore explored short term solar forecasting using numerous statistical time series models such as ARMA model with additive seasonal decomposition (Yang et al., 2015), spatial-temporal covariance and time-forward kriging (Yang et al., 2013), and exponential smoothing state space model (Dong, Yang, Reindl, & Walsh, 2013). Research in Thailand studies the use of clearness index model (Waewsak & Chancham, 2010) and satellite data to forecast hourly GHI values. Although a substantial amount of research have evaluated numerous forecasting techniques, currently these studies focus on specific techniques and does not compare the applicability of each techniques for tropical conditions.

Therefore, the main aim of this paper is to evaluate the accuracy and reliability of the different prediction techniques to forecast hourly global horizontal irradiance (GHI) data for a tropical country, utilizing one year irradiance data from Sepang, Malaysia. The justification for selecting these techniques is because they are the dominant choices for forecasting based on their respective category. ARMA rely on manipulating statistical techniques to identify past patterns that can be projected into future values, while SVM and ANN rely on machine learning capabilities to learn from existing data and determine the underlying pattern that can be used.

The paper is organized according to the following format. Section 2 lays down the foundation of techniques deployed in this paper while section 3 presents the dataset measurement location and its characteristics. Section 4 explains the methodology of analysis and its respective evaluation metrics. Section 5 shows the result and relevant discussion. Finally, section 6 provides the conclusion.

Background

This section provides the background theory for persistence, SVM, LS-SVM, MLP and ARMA models.

Persistence Model

Persistence model is the simplest type of forecast. It assumes that the characteristics of irradiance today will be the same for tomorrow and onwards. It is often used as an indicator of the long term trend of the forecasted values and also as a benchmark to evaluate other forecasting techniques (Inman et al., 2013). Persistence method is intuitively relevant for locations with relatively consistent climate conditions such as in tropical countries. For clearness index persistence forecast, it can be defined as

$$K_{t+\Delta t} = K_t = \frac{G_t}{G_{ext}} \qquad (1)$$

Support Vector Machine

SVM is a supervised learning model used for classification and regression analysis. SVM is initially used for data classification by constructing hyperplanes separating different classes (Vapnik & Vapnik, 1998). The hyperplanes are optimized by maximizing their functional margin (i.e. distance) from the closest training data points from each class. The concept is extended to the introduction of soft margins to accommodate misclassifications (Cortes & Vapnik, 1995). For nonlinear data classification, the SVM algorithm is completed through the use of kernel trick, where data is mapped into higher dimensional space via kernel functions, where it is presumably easier to separate.

Least Squares Support Vector Machine

LS-SVM are reformulations of the classical SVM that categorizes and analyze regression by solving linear Karush-Kuhn-Tucker conditions instead of solving convex quadratic programming problems (Suykens et al., 1999).

Multilayer Perceptron (MLP)

MLP are essentially a subset model of ANN that emulates the learning process of the human brain, which is based on feed-forward NN model. This model has been the primary choice for a substantial amount of research due to its prediction accuracy and reliability (A. Mellit & Pavan, 2010), (Voyant, Muselli, Paoli, & Nivet, 2012) and (Paoli et al., 2010). For MLP, each layers are directly connected to other layers and each node, apart from the input nodes is a neuron with a nonlinear activation function. MLP utilizes backpropagation, a supervised learning method used that allow the model to recognize non-separable linear data (Hagan, Demuth, Beale, & others, 1996).

Autoregressive Moving Average (ARMA) models

ARMA models are essentially a combination of autoregressive (AR) and moving average (MA) applicable for linear stationary time series forecasting. Stationarity implies that the data fluctuation must be approximately horizontal along the time axis, fluctuating around a constant mean and variance. In this model, the time series to be predicted is expressed as a function of both previous values of the series (autoregressive terms) and previous error values from forecasting (moving average terms). It can be written as ARMA (p,q) or ARIMA (p,0,q), where p is the autoregressive model order and q is the moving average model order (Makridakis, Wheelwright, & Hyndman, 2008).

A general ARMA model can be written as

$$Y_t = c + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q} \quad (2)$$

In which ϕ and θ are the moving average and autoregressive parameters respectively.

Data Description

Peninsular Malaysia

Peninsular Malaysia is situated slightly above the equatorial line at coordinates of approximately between 1.48° to 6.50° N and 100° and 103°E. It is classified under the equatorial/ tropical rainforest climate which is characterized by high average of precipitation, almost equally distributed throughout the year. The peninsular also experience annual northwest and southeast monsoons.

Because of its location close to the equator, the annual climate condition does not have a distinct seasonal variation. It means that this location receives almost equal amount of sunshine daily throughout the year. This implies that theoretically Peninsular Malaysia has a high potential for harvesting solar energy. In spite of this, total irradiation produced is generally low due to high cloud cover. This is because Malaysia sits inside the Intertropical Convergence Zone where the north and south tradewinds come together. High amount of winds bring large bands of clouds inside the area continuously throughout the year.

Data

The data used in this paper is obtained from the Malaysian Meteorological Department, collected from Sepang weather station throughout the year of 2011. The coordinates of the station is 2° 44' N and 101° 42' E with an elevation of 16.1 m from sea level. The data used for this comparison comprised of 349 days of hourly global horizontal irradiance (GHI) taken at each hour interval from 9 am to 6 pm.

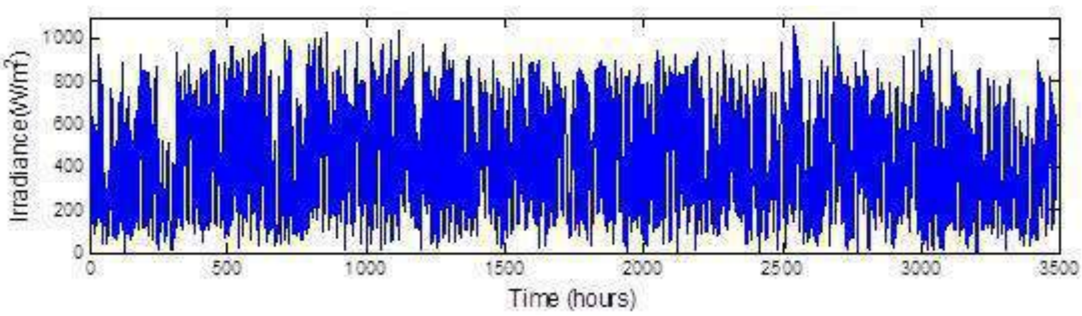

Figure 1: Hourly Irradiance for Sepang, Malaysia 2011

Figure 1 shows the dispersion of irradiance quality level throughout the year. Night time hours are omitted for clarity. High irradiance levels of above 800 W/m^2 are achieved only approximately 10% of the time, with a miniscule amount of 0.25% exceeding 1000 W/m^2. This data is consistent with the climate conditions of Malaysia which are characterized by high cloud cover throughout the year. Irradiance values are averagely lower during January to February and November to December due to the monsoon season.

In order to facilitate the convergence of model solutions these irradiance values are converted into clearness index K_t, which is given as

$$K_t = \frac{G_t}{G_{ext}} \qquad (3)$$

Meanwhile the formulation of G_{ext} is given in (Duffie & Beckman, 2013) as

$$G_{ext} = G_{sc}\left[1 + 0.033\left(\frac{360 \times n}{365}\right)\right] \qquad (4)$$

Where G_{sc} is the solar constant of 1367 W/m^2 and n is the number of days throughout the year. (i.e. 1 to 365). By preprocessing the data, all irradiance values are normalized to values within 0 to 1 with each value computed up to the 4th decimal.

Methodology

All training models are conducted in MATLAB R2012b environment. The training and testing of SVM and LS-SVM are executed using LIBSVM (Chang & Lin, 2011) LS-SVM Toolbox v1.8 (Pelckmans et al., 2002) respectively. All the dataset are standardized so that the results are comparable.

Persistence Model

This model assumes that the profile of irradiance for one day is similar to the day before. Each day, the data is updated to accommodate the latest historical day. This model assumes that the irradiance fluctuation that occurs in tropical countries throughout the year is somewhat consistent with no abrupt and/or extreme changes. This assumption is considered valid for long-term forecasts and is used as a baseline for this study.

SVM and LS-SVM Model

The type of SVM chosen from the LIBSVM software is nu-SVM Regression or ν-SVR while the type of LS-SVM model chosen from the LS-SVM Toolbox is function estimation. The flow of steps for both models is depicted in Figure 2. The dataset is divided into two parts; the bulk of data goes into training while a small portion is used for testing. Each training datum is linearly scaled to the range of zero to one. The Radial Basis Function (RBF) kernel is selected to be used in this modeling because it yields the best result compared to the other kernels.

In order to ensure that the classifier correctly predict unknown data, the regularization parameter of the RBF kernel needs to be properly tuned. Therefore, a grid search is conducted to find the optimum values. To avoid overfitting, the standard 10-fold cross validation is applied to the training dataset. After the optimized parameter is obtained, the dataset is trained and optimized before evaluated with the testing dataset.

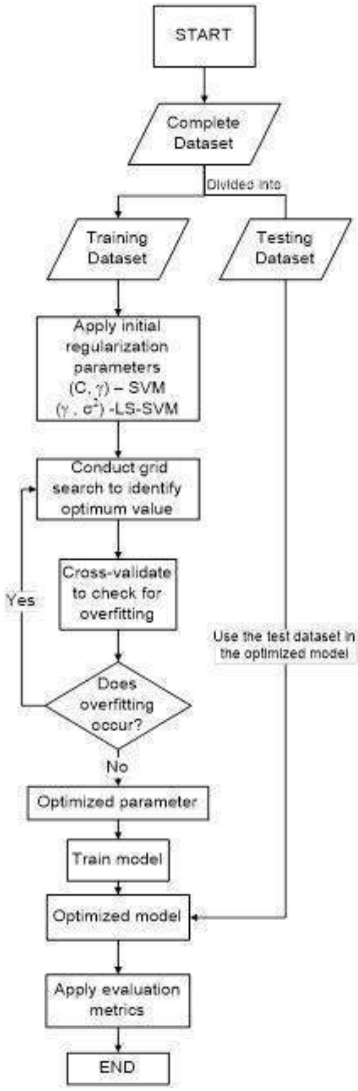

Figure 2: SVM and LS-SVM modeling methodology

MLP Model

The ANN architecture used in this paper is shown in Figure 3. It consists of a standard flow with one hidden layer with a sigmoid transfer function and one output layer with a linear transfer function. The number of hidden neurons is set to 15 while the delay factor is set at 20. The values for the hidden neurons and delay factor are obtained through trial and error.

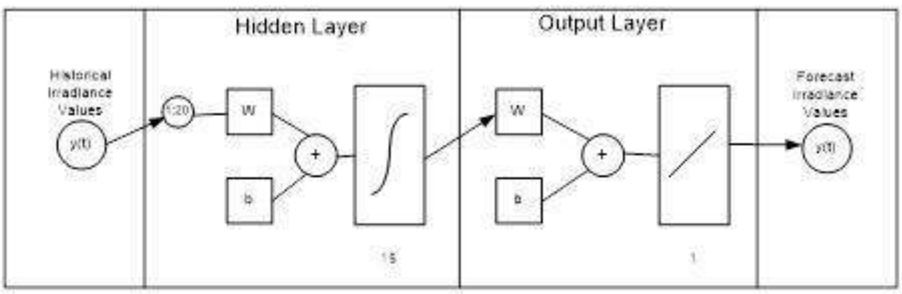

Figure 3: Architecture of the MLP Feedforward Neural Network Model

The open loop architecture shown above is chosen for two reasons. Firstly, the input to the network is more accurate since it consists of one feature only (i.e. historical irradiance value). Secondly, a purely feedforward architecture generates a more efficient algorithm for training. The dataset is divided into the ratio of 80:10:10 for training, validation and testing respectively.

ARMA Model

Figure 4 depicts the process of determining the appropriate ARMA model, adapted from (Makridakis et al., 2008).

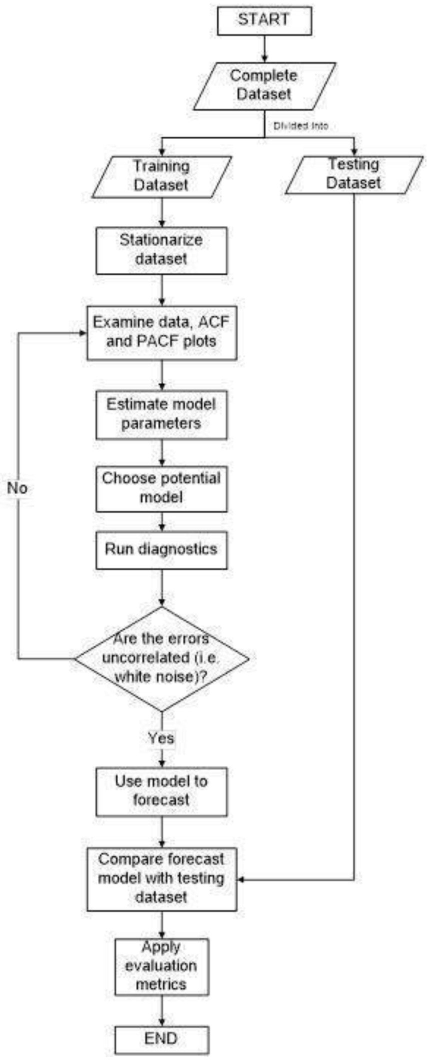

Figure 4: Methodology for ARMA model

Figure 5 shows the historical irradiance time series. It can be seen that the data roughly fluctuates around a constant mean and variance, therefore no differencing is required. Meanwhile, Figure 6 shows the respective ACF and PACF plots. It can be seen that both plots display some sort of cosine waveform. In the ACF plot, high spikes occur at the 1st (next hour) and 10th (same hour next day) lag, indicating strong seasonality factor during these two time lags. Based on these conditions, the selected model is ARMA (1, 10). Checking the ACF and PACF for the residual plot and conducting portmanteau test, we confirm that this model is suitable to be used as a forecast model.

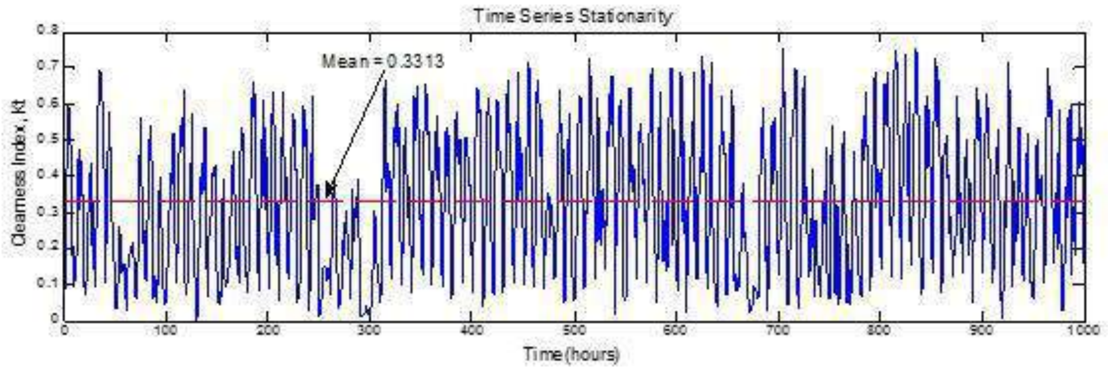

Figure 5: Irradiance time series stationarity

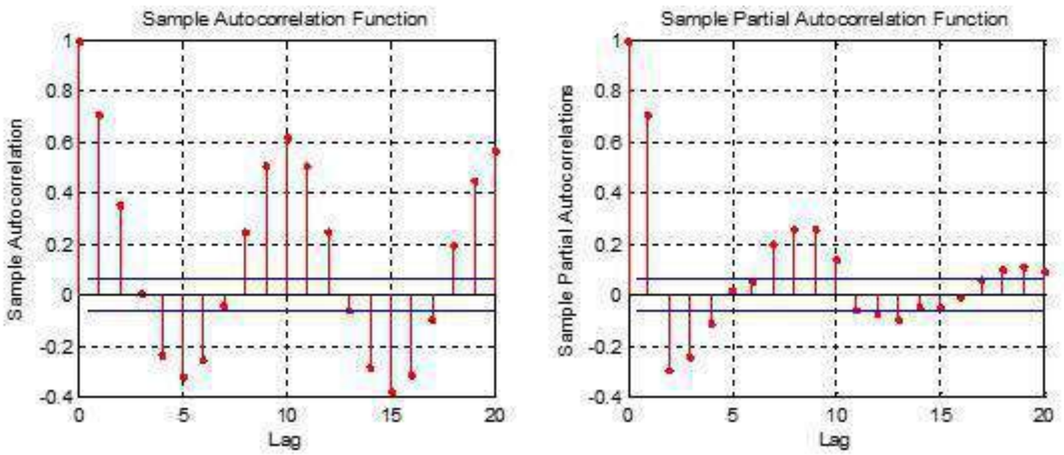

Figure 6: ACF and PACF plots for irradiance data

Evaluation Metrics

The evaluation metrics used to validate the models' performance are obtained from (Inman et al., 2013) and (Hoff, Perez, Kleissl, Renne, & Stein, 2013) and is summarized as follows:

Mean bias error (MBE) indicates the average bias of the model

$$MBE = \frac{1}{N}\sum_{t=1}^{N}(Y_t - F_t) \qquad (5)$$

Y_t is the observation data and F_t is the forecast data.

Root mean squared error (RMSE) identifies the average spread of errors

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(Y_t - F_t)^2} \qquad (6)$$

Mean absolute error (MAE) divided by the average value of irradiance provide the best practical measure of relative dispersion error and is independent from the number of observations.

$$MAE / Avg = \left(\frac{1}{\sum_{t=1}^{N} Y_t} \sum_{t=1}^{N} \lfloor Y_t - F_t \rfloor \right) \quad (7)$$

Kolmogorov-Smirnov Integral (KSI) test is used to determine whether the predicted dataset has a goodness of fit compared to actual data.

$$KSI = \int_{x_{\min}}^{x_{\max}} D_n dx \quad (8)$$

D_n is the difference between the modeled and measured normalize cumulative distribution functions.

Results and Discussion

Table I shows the performance result of the forecasting models. All stochastic and AI techniques perform substantially better than the persistence forecast, confirming their superiority in anticipating fluctuation trends of the hourly irradiance values. The MBE provides the average bias for each model and the overall performance ranges between -0.1251 to 0.00036. The RMSE measures the average spread of errors. Here, the spread for LS-SVM, SVM and MLP are within close range to the actual value while the RMSE for ARMA and persistence are considerably larger. Meanwhile, MAE/Avg is also a very good indicator for relative dispersion.

The main advantages of MAE and RMSE is that the former is independent from the number of observations while the latter is more sensitive in detecting outliers because it gives proper weightage depending on the error size. By having both metrics, a more complete description of the dispersion error is obtained. Low KSI values imply that the model is able to reproduce observed statistical distributions. Here again, the performance of LS-SVM is notably better than the rest.

Figure 7a and b shows the forecast performance for all five models during two separate duration. The strength of the LS-SVM and SVM techniques rely on their ability to anticipate sudden change of trends because of the input provided. At hour 30 and 40 of Figure 7a, the clearness index drops are accurately captured by LS-SVM and SVM and adequately followed by MLP. At hour 36, the clearness index value had a sudden drop before rising up steeply at hour 38. Again, the LS-SVM and SVM algorithm managed to adapt to the changes accordingly. The MLP were unable to respond to sudden quick changes. Due to its cyclic forecast nature, the ARMA model consistently forecasts lower than the expected values while persistence produces the opposite. Both are inherently unable to anticipate sudden fluctuations.

Table I: Evaluation Metrics Results for Forecasting Model

Technique	MBE	RMSE(%)	MAE/Avg (%)	KSI k Test Statistic
Persistence	-0.1251	19.24	44.71	0.3567
SVM	0.0480	1.15	2.94	0.0400
LS-SVM	3.6×10^{-4}	0.87	2.13	0.0200
MLP	-0.0074	1.39	1.80	0.1033
ARMA	-0.0182	2.81	31.17	0.1900

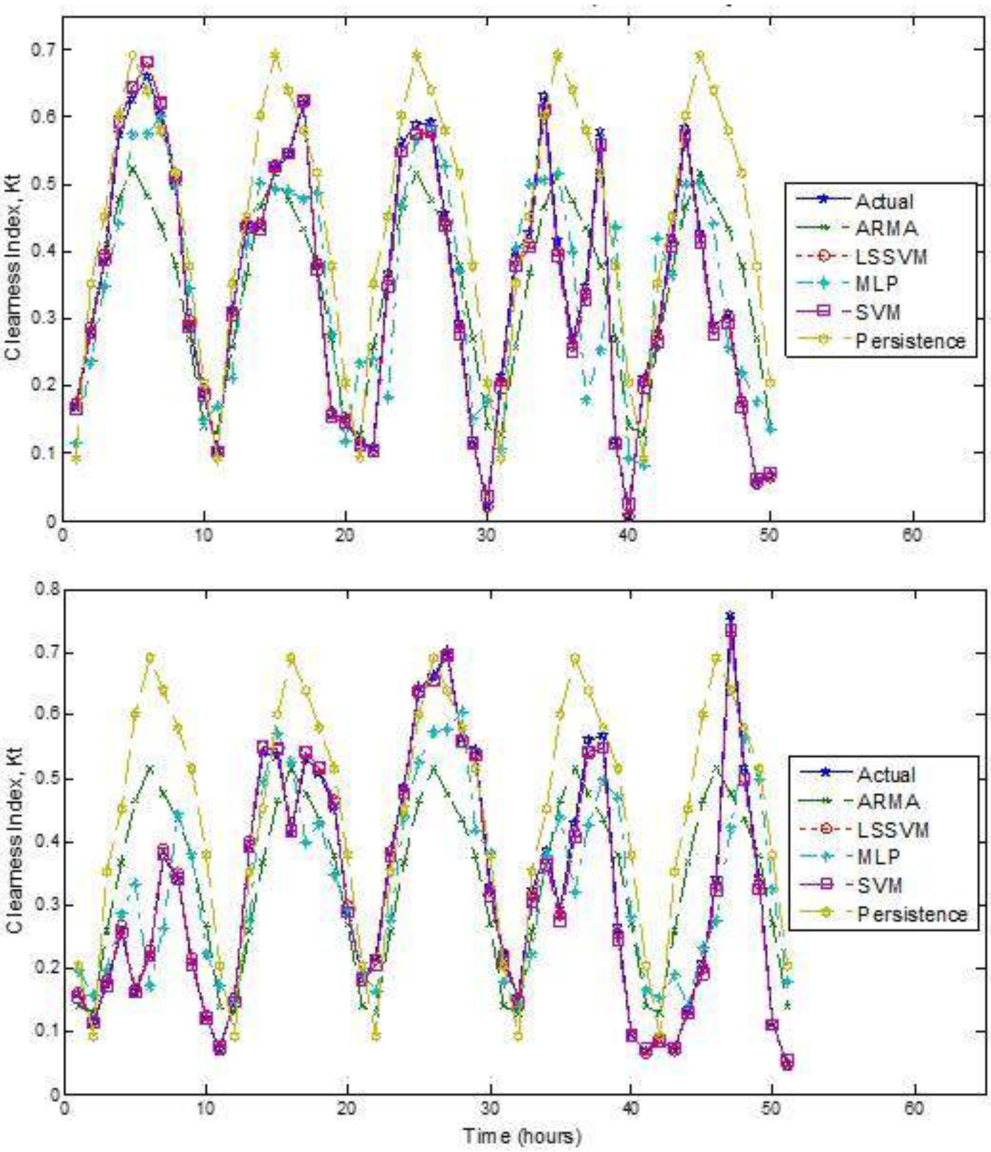

Figure 7a (top) & b (bottom): Forecast Performance of All Models for Two Separate 5-Day Duration

Figure 7b displays a duration where the irradiance fluctuation is rather erratic. Within hour 1 to 10, the clearness index is very low with some minor fluctuations. Similar conditions such as this causes large errors in ARMA and persistence model because it is not captured. The same situation occurs with the drop and sudden rise at hours 16 and 36. During hour 43 to 46, the clearness index had an exponentially increase, inducing another large error factor for ARMA and persistence model. Most of these irregularities are able to be accommodated by LS-SVM and SVM. MLP performance was also satisfactory but could not capture extreme, abrupt changes.

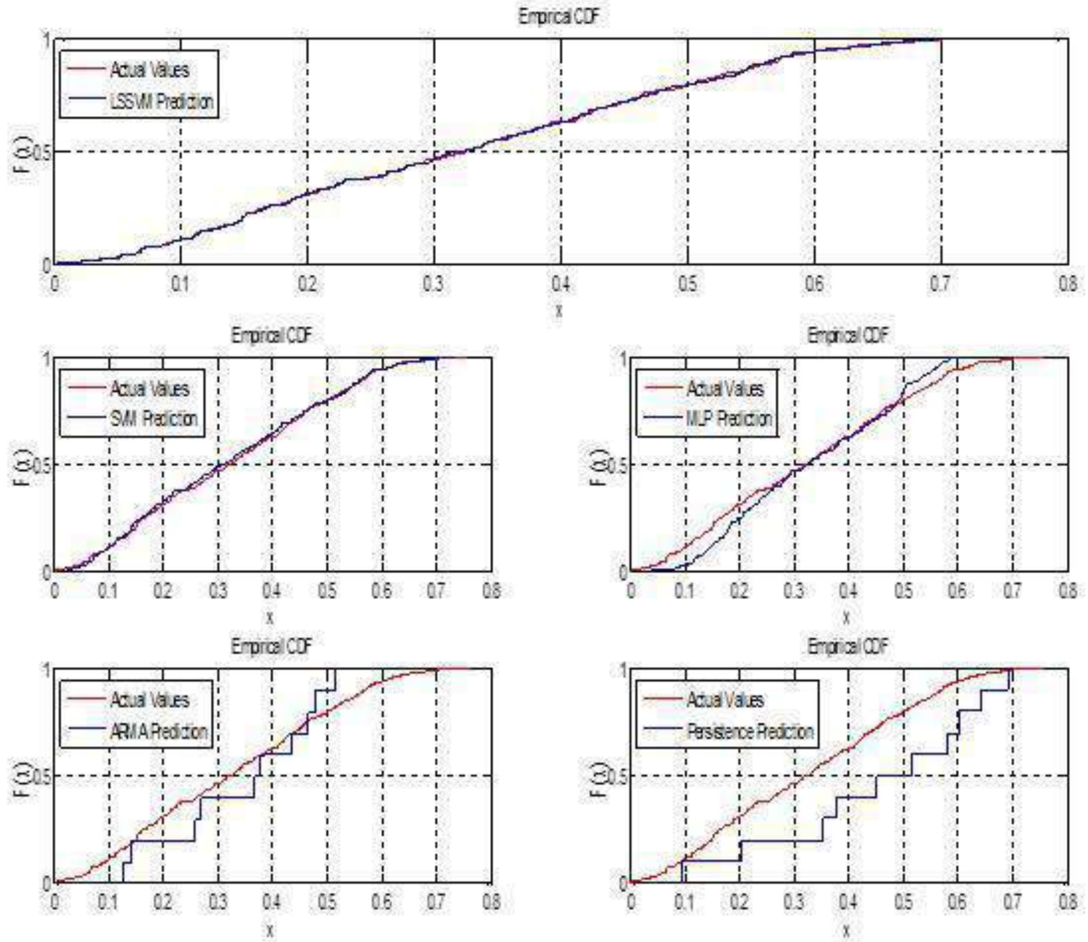

Figure 8: Cumulative Distribution Function Plots for All Forecasting Models

Figure 8 displays the result of the Kolmogorov-Smirnov Integral test in the form of cumulative distribution function plots. As can be observed, LS-SVM, SVM and MLP all have the same continuous distribution as the actual values, demonstrating its reproducibility. ARMA model performs moderately while persistence reproducibility is poor.

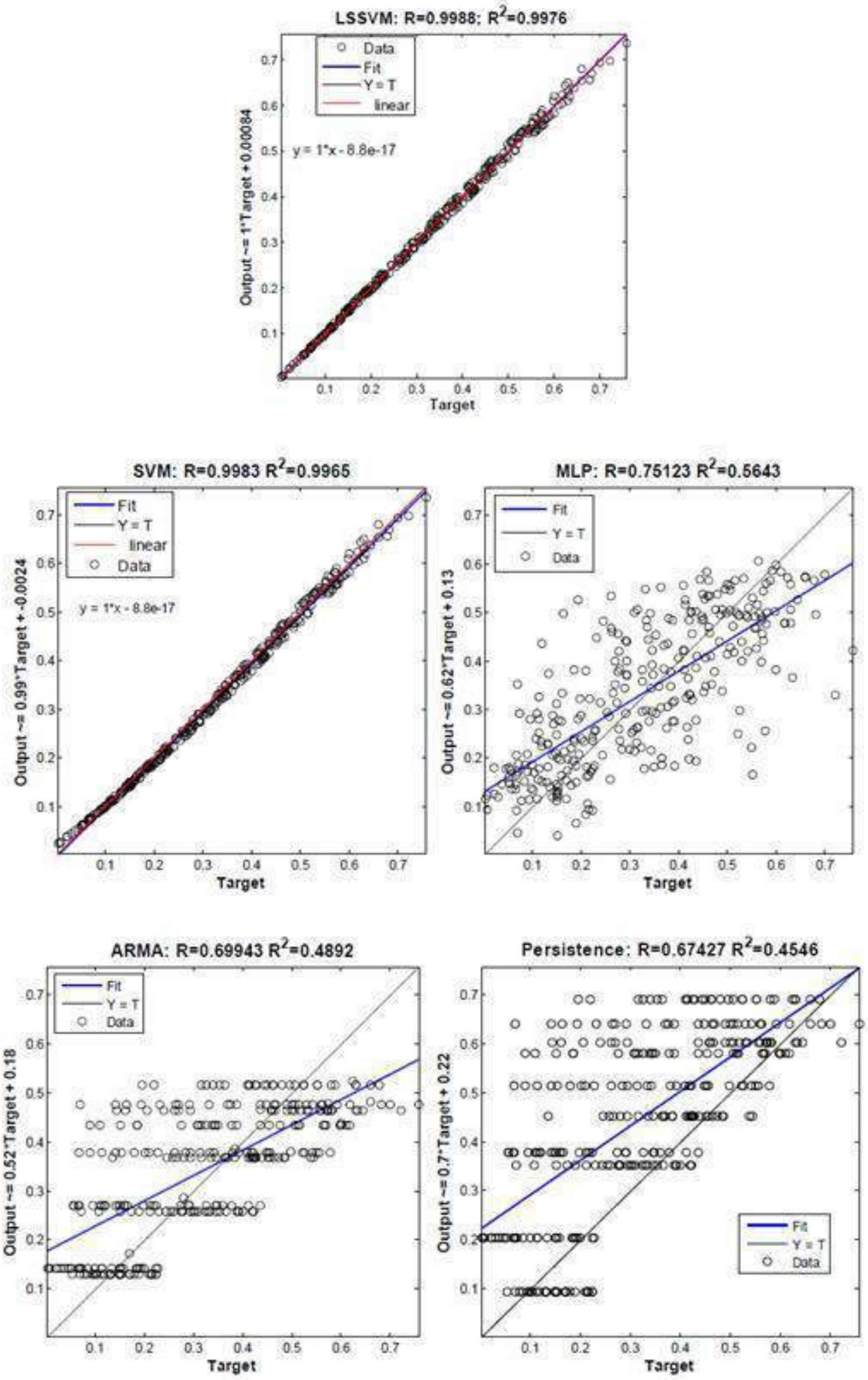

Figure 9: Forecast model regression plots

The correlation coefficient R shown in Figure 9 is a standardized measure of the mutual dependence between the actual and predicted variables, while the coefficient of determination, R2 is defined as the ratio of the explained variation to the total variation. For example, in the case of LSSVM, 99.76% of the total variation in the forecast values can be explained by the linear relationship that exists between actual and forecast values. Here it can be seen that both LS-SVM and SVM exhibit a strong positive correlation between the two variables. MLP has above average correlation, with approximately 56% of variance is predictable from one variance to another. Weak correlation are observed for the ARMA and persistence models.

Conclusion

This research compares five different techniques to forecast hourly irradiance values for a tropical country using data from Sepang, Malaysia. The study is significant because the climate conditions does not have seasonal variation throughout the year. It is characterized by abundant amount of sunshine throughout the year but with high amount of cloud cover and precipitation especially during the monsoon season.

From the analysis of the evaluation metrics, LS-SVM outperform all the other techniques in all of the metric conditions, followed by SVM (ν-SVR), MLP, ARMA and persistence respectively. This indicate that LS-SVM method is suitable for application in predicting the irradiance condition for a tropical country.

Future works include the study of intra-hour irradiance forecasting where fluctuations are mainly caused by cloud movement and the nonlinearity of the time series. This information is valuable for grid operators in managing high PV grid penetration. Combining multiple techniques to obtain the strength of each one is also a potential research area for the tropics.

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Classical Charcoal Making And Properties Of The Charcoal From Palmyra Palm Shell As The Traditional Community Practice

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Abstract
Survey on classical charcoal making from Palmyra palm shell as the traditional community practice at Ramdang, Songkhla was carried out. Results revealed that as for the community way of life. The first experiment involved with quality assessment of charcoal obtained from 4 traditional charcoal making methods. Treatments were compared using Randomized Complete Block Design (RCBD) with 4 replications. Three factors being assessed were chemical, physical and fuel properties. Results showed that burning charcoal in a circular pit using 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk (M4) gave maximum charcoal yield, charcoal weight/pit and weight /shell (51.25 g/shell) with the least weight of cracked charcoal/pit (800 g) and statistical significant different from other methods ($p<0.05$). Burning charcoal in a square pit using 1:1:1 ratio of staminate inflorescence, rice straw and husk (M2) provided high levels of volatile substances and stable carbon which were significantly different from other methods ($p<0.05$). These meant that the method had carbon as the major stable molecular components resulting in a better combustion process but the amount of ash was high. The second experiment was on the effect of fuel materials on quality of the charcoal. Results revealed that the treatment having 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk (S4) gave maximum charcoal yield and charcoal weight/shell. The other treatment having 2:1:2 ratio of staminate inflorescence, dry leaves and rice husk (S3) provided high and significant level of stable carbon resulting in a better combustion process, high ignition temperature and rapid burning due to low humidity.

Keywords: Charcoal from Palmyra Palm Shell, Biomass Energy

Introduction

Palmyra palm (Borassus flabellifer) is locally known as the sugar palm or “Tan” or “Tan Ta Not” in Thai. The by-products of palm sugar production, including the exocarp– stems, fruit calyx and husks – and endocarp,are discarded as waste and adversely affect human health and the environment both in the community and along the main roads. A survey revealed that every bunch with 1-20 young fruits produces waste amounting to 90% of the original weight after the fruits is removed; 60% endocarp per seed is left over.

Traditional charcoal making process in Ramdang Community is a part of the local way of life, which relates to Palmyra palm tree, rice field, bamboo and human. According to the process, local people normally pick ripe palm shell then dry up and burn until it becomes Palmyra palm shell charcoal. People in the community use palm shell charcoal in cooking and some for trading. The charcoal production process normally used rice straw, husk and staminate inflorescence as main fuel. The charcoal from the process as a result has high carbon level and no humidity. This qualified gave high energy to the charcoal when comparing to the dried wood. The process in turning organic substance into charcoal was called “Carbonization”. (Tharinee, 2005)

The study used the comparison method in producing process and the charcoal quality from traditional charcoal making in Laadkrating, Sanamchai, Chachoengsao and Department of Forestry from three 8 cubic meters charcoal kilns. The acacia wood was put in the first and the third kiln while eucalyptus wood was put in the second kiln. According to the experiment, it was found out that the producing method from the Department of Forestry gave 920.77 kg. (32.20%) while the traditional process gave only 894.66 kg. (28.96%). The traditional charcoal process tended to give fewer charcoal. It was also assumed that it was the result from the firewood. According to the usage of firewood, the traditional process used approximately 185.4 kg when comparing to the Department of Forestry used only 112.7 kg. In another case, the experiment from rubber charcoal gave the product only 26.18% while the coconut shell gave the product 37.33%.

When the study of heating value from rubber compared with coconut shell and charcoal, the given heat were 2333.33, 2516.67 and 1600 calories in order. The rubber charcoal used only 32.33 minutes and ashes only 5.35% but the quality was lower than coconut shell charcoal. The burn off rate was higher than normal charcoal (11.85%). The heat experiment showed that durian shell gave higher heating value than Eucalyptus. (Tipawan and Ancharika, 2546). Referring from Kedkanok and Wittawat’s study (2546), it was found out that charcoal, which gave the highest heating value, was bagasse and cassava with 4:1:1 ratio of staminate inflorescence while bagasse and cassava with 3:1:1 ratio of staminate inflorescence gave the least heating value. However, the most appropriate ratio of staminate inflorescence is 2:1:1. Therefore, Palmyra palm shell was local material fuel in Rumdang community, Songkhla Province.

The study therefore examined the feasibility of producing palmyra palm shell and local agriculture leftover as main fuel in charcoal making process.

Research Methodology

The research methodology can be divided into 2 experiments as followed;
The first experiment involved with quality assessment of charcoal obtained traditional charcoal Palmyra Palm Shell making methods in Ramdang Community.

The study began with discussions between researchers and the local community to work together to utilize Palmyra palm crop residues as a valuable commodity and at the same time benefit the local environment. Based on the King's initiatives, the study combines scientific knowledge with public participation at community level, including local farmers, monasteries, educational institutions, and local administrative organizations. The study highlights the need to implement such initiatives to ensure a balance among economic, social and environmental parameters in contributing towards realizing the goal of community energy independence.

The randomized trial consists of 4 different burning process together with local fuel, which were; circular pit using 1:1:1 ratio of staminate inflorescence, rice straw and husk (M1), square pit using 1:1:1 ratio of staminate inflorescence, rice straw and husk (M2), square pit using 2:1:2 ratio of staminate inflorescence, ash and rice husk (M3) and circular pit using 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk(M4). Density, weight, product, ash content, volatile matter and heating value would be analyzed from the chemical properties, physics and proper fuel for Palmyra palm charcoal.
The second experiment was studied the effect of fuel materials on quality of the Palmyra palm shell charcoal. The burning method was appropriate for the second experiment and was approved by Ramdang community. The randomized trial consisted of choosing local fuel with 4 ratio of fuel materials in circular pit, which were; having 1:1:1 ratio of staminate inflorescence, rice straw and rice husk (S1), 1:1:2 ratio of staminate inflorescence, rice straw and husk (S2), 2:1:2 ratio of staminate inflorescence, dry leaves and rice husk (S3) and 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk (S4).

Result

The study aimed to conduct a study to examine the benefits of using the raw materials which provide a naturally balanced and environmentally friendly alternative use of the by-products.

According to the first experiment, the result from comparing the quality of Palmyra palm shell charcoal from traditional charcoal making methods in Ramdang Community is as below;

The color, humidity and pH of the charcoal in Ramdang Community had no different from each other. In other word, Palmyra palm shell charcoal from all of pits are black, the value keys level equal 1, pH of Palmyra palm shell charcoal ashes was 9.5 and the average humidity was 30%. It was also found out that a circular pit using 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk(M4) gave maximum charcoal yield, charcoal weight/pit and weight /shell (51.25 g/shell) with the least weight of cracked charcoal/pit (800 g) and statistical significant different from other methods ($p<0.05$)(table 1).

Table 1 Shows the quantity, length and width of the Palmyra palm shell charcoal from different production method

Production method	No./pit	Weight/pit (g.)	Cracked charcoal/pit (g.)	Weight/shell (g.)	Length (cm.)	Width (cm.)
M1	45.00 ab	1850 ab	1225 a	48.50 b	65.28	67.21
M2	33.00 b	1350 b	1350 a	50.00 ab	67.49	72.71
M3	48.25 ab	1925 ab	1225 a	49.50 ab	60.75	74.18
M4	61,00 a	2325 a	800 b	51.25 a	68.72	73.93
CV %	22.10	23.68	22.52	1.71	7.88	5.31

Means in each column that followed the same letters are not significantly different at $p< 0.05$ by DMRT

While using square pit with same elements with the portion 1:1:1 as a fuel. M2 will gave higher volatile matter and fixed carbon, which statistical significant different from other methods ($p<0.05$). It could be seen that the molecule of the volatile matter affects the combustion. Since most of the molecule combines of carbon, it helped the combustion process too. However, each type of the production method did not affect the heating value and density. According to table 2, 4 methods of the traditional Palmyra palm shell charcoal gave different result. The circular pit was selected and inflorescence, rice straw husk and dry leaves as the main fuel which would lead to the research of finding proper fuel.

Table 2 Shows the density, volatile matter, fixed carbon, heating value (cal/g) and ash percentage from different production method of the Palmyra palm shell charcoal

Production method	Density (g/cm)	Volatile Matter (%)	Fixed carbon (%)	Heating value (cal/g)	Ash (%)
M1	0.44	70.325 a	24.25 ab	4327.50	4.42 b
M2	0.49	69.465 a	26.57 a	4430.25	7.65 a
M3	0.60	65.825 b	24.07 b	4691.25	4.52 b
M4	0.61	65.475 b	21.07 c	4458.75	3.52 b
CV %	26.23	3.35	4.62	4.14	10.99

Means in each column that followed the same letters are not significantly different at $p< 0.05$ by DMRT

The second experiment was studied the influence of various types of fuel in Palmyra palm shell charcoal production process. The results were as followed;

The color, humidity and basicity of the charcoal in Ramdang Community had no different from each other. Every method gave black Palm shell charcoal, which the value key equal 1, the pH level was 9 and the average humidity was 28.5%. It was also found out 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk (S4) gave maximum charcoal yield and charcoal weight/shell (59 no. charcoals/pit, 2,265 grams. of weight/pit). The statistic of this method was quite similar to the first method as showed in Table 3.

Table 3 Shows the amount, weight, length and width of the Palmyra palm shell charcoal using different ratio of fuel

Type of fuel	No./pit	Weight/pit (g.)	Cracked charcoal/pit (g.)	Weight/shell (g.)	Length (cm.)	Width (cm.)
S1	46.00 ab	1780 ab	1495 a	49.00	68.78	65.81
S2	35.00 b	1350 b	1850 a	49.50	63.88	74.64
S3	47.25 ab	1825 ab	1725 a	49.25	63.93	71.49
S4	59.00 a	2265 a	1005 b	49.00	62.19	70.43
CV %	4.56	6.89	8.34	3.60	8.43	8.98

Means in each column that followed the same letters are not significantly different at $p< 0.05$ by DMRT

While 2:1:2 ratio of staminate inflorescence, dry leaves and rice husk (S3) provided highest fixed carbon and significant level of resulting in a better combustion process, high ignition temperature and rapid burning due to low humidity. It showed that molecule structure combines of carbon, which also helped the combustion process. The process also gave less ash when comparing to other production method. Somehow, fuel resource did not cause any effects to density, volatile matter , heating value, weight, width and length of the Palmyra palm shell charcoal, as showed in table 3 and 4.

Table 4 Shows the density, volatile matter, fixed carbon, heating value (cal/g) and ash percentage from different ratio of fuel

Type of fuel	Density (g/cm)	Volatile Matter (%)	Fixed carbon (%)	Heating value (cal/g)	Ash (%)
S1	0.55	73.30	23.77 bc	4458.75	3.70 c
S2	0.55	72.79	24.50 b	4886.25	7.07 b
S3	0.56	70.92	25.80 a	4647.75	2.45 d
S4	0.50	72.10	22.70 c	4404.50	8.37 a
CV %	6.69	2.42	2.24	4.63	6.15

Means in each column that followed the same letters are not significantly different at $p< 0.05$ by DMRT

Conclusion

The study indicates that the charcoal making process a circular pit using 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk (M4) gave highest product and had the least breaking charcoal. Furthermore, gave lower rate cracking charcoal than square pit. However, the most appropriate portion charcoal making process using 3:1:3 ratio of staminate inflorescence, dry leaves and rice husk (S4) gave the high quality product. While using 2:1:2 ratio of staminate inflorescence, dry leaves and rice husk (S3) gave high percentage of fixed carbon.

It can be concluded that molecule structure combines of carbon affects combustion process and gave lower percentage of ashes. In other word, organic component of palm shell was result to charcoal making quantity. With little crackle, long combustion time and low levels of odour and smoke, the could be suitable for use in households and restaurants. In addition to contributing a supplementary source of revenue for framers, palmyra palm shell charcoal making helps maximize resource utilization, reduce the volume of waste and minimize their environmental impacts. Further work may explore refinements of the mixing rations to suit specific needs. These research findings may be readily implemented in communities with large quantities of palm waste, particularly in the other provinces of Thailand.

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Application of TRIZ in Resolving Water Crisis

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Abstract
This paper applies the TRIZ systematic approach in resolving the water crisis in Malaysia. The TRIZ tools used in this study are engineering system analysis, function analysis, cause and effect chain analysis, engineering contradiction and physical contradiction. The purpose of this study is to discover and develop some feasible and elegant solutions in order to mitigate the problem. Findings revealed that people's attitude is the most critical disadvantage among the man-made phenomena. The root cause and contradictions are then resolved by applying Contraction Matrix and Separation Principles. The recommended inventive principles are #1 Segmentation, #3 Local quality, #10 Preliminary action, #24 Intermediary, #32 Color change and #34 Discarding and recovering. Therefore, it can be concluded that TRIZ is a powerful tool in solving inventive problem.

Keywords: Engineering Contradiction, Physical Contradiction, Inventive Principles, Water Crisis, Water Sustainability Index.

1. Introduction

Originally, water is a transparent substance that forms the streams, lakes, and oceans in the world. However, 2 million tons of sewage, industrial and agricultural waste are discharged into the world's water daily (UNESCO, 2003). This has contaminated the water that exists in most of the rivers of the world. Nevertheless, water continues to play an important role in the global economy. It is one of the essential resources that is widely used in human activities. For domestic purposes, water is used for drinking, food preparation, bathing, washing, flushing toilets as well as watering lawns and gardens. In industries, water facilitates processing, cleaning, transportation, dilution and cooling manufacturing facilities. For commercial purposes, motels, hotels, restaurants, office buildings and other commercial facilities require water to run their business operations. In the agricultural sector, water is applied to farm, orchard, pasture and horticultural crops. Besides, water is also used in the production of electric power generated with heat. Without sufficient supply of water, human activities will be disrupted and eventually, economic growth will deteriorate.

Malaysia has been blessed with abundant rainfall, averaging 3,000mm annually, which amounts to 990 billion cubic meters of water over the country due to its strategic location in the equatorial region (Department of Water Supply, 2006). Therefore, Malaysia has a tropical rainforest climate. Besides its strategic location, it has an extensive river system consisting of more than 150 rivers that provide the country with more than 25,000 cubic meters of renewable water per capita per year according to an Edge report in June 2002. The amount of renewable water that Malaysia receives far exceeds that of many other parts of the world. Despite all these privileges, the usually drenched country is now facing water crisis. However, water crisis we are facing now is not just a national problem. Take a look at the world around us; we will notice a similar echo of water woes spanning the globe. Water crisis is not just happening in the third world countries but also in some developed countries like Japan, Australia and the United States. Thus, we need to take concrete measures to secure the future of our water resources. TRIZ; a systematic way of solving problem may be of help in battling the looming water shortages in Malaysia.

TRIZ is a Russian acronym for "Teoriya Resheniya Izobreatatelskikh Zadatch". In English, it means "Theory of Inventive Problem Solving". In the 1940's, Genrich Altshuller and his teammates had developed the TRIZ methodology. He was a Soviet engineer, an inventor, a scientist, a journalist and also, a writer. He analyzed over 200,000 patents and managed to identify 40 common inventive principles with his vast knowledge [(Guin et al, 2009), (Mann; 2003, 2007), (Shulyak and Rodman; 2000, 2002), (Smith, 2000) (Terninko et al, 2010), and (Yeoh et al, 2009)]. From his extensive study, there were three main discoveries. First, problems and solutions were repeated across industries and sciences. Next, patterns of technical evolution recurred across industries and sciences too. Lastly, scientific effects outside their original field were used to innovate products, services and processes of different disciplines (Barry et al). In the application of TRIZ, the process will be initiated by performing Function Analysis and Cause & Effect Chain Analysis. If possible, Trimming will be carried out to decrease and eliminate the disadvantages or harmful functions of the trimmed components. The process will then be followed with the use of various TRIZ tools. These TRIZ tools start off with the Model of Problem (such as Engineering Contraction, Physical Contraction, Function Model, Substance-Field Model), followed by the Tool (such as Contraction Matrix, Separation/Satisfaction/Bypass, Scientific Effects, System of Standard Inventive Solutions), and lastly the Model of Solution (such as 40 Inventive Principles, Specific Scientific Effect, 76 Specific Standard Inventive Solutions) (Yeoh et al, 2009).

2. Problem Statement

Starting from February 2014, Selangor has been experiencing water crisis; caused by the extended hot and dry season due to the El Nino phenomenon. This is the worst water crisis since the 1998 Klang Valley water crisis. At the initial stage, various districts in Selangor including Gombak, Petaling Jaya, Klang, Shah Alam, Kuala Selangor, Hulu Selangor and Kuala Lumpur started to impose water rationing to avoid rapid depletion of water supplies. This water rationing affects the daily lives of 722,032 households, which roughly equals to about 3.6 million people (Cruez, 2014). It has then spilled over to two other states namely Negeri Sembilan and Johore. Undeniably, water rationing is cumbersome; and indefinite water cuts defeats its purpose because consumers resolve into filling up buckets and buckets of water; so that they can carry out daily activities without much disruption when there is no water supply. At the end of the day, the net water saved is too little to help solve this scarcity. Based on news that was reported by Charles Santiago on the 10th April 2014, only seven percent of total water consumption is saved after implementing water rationing for a month (Santiago, 2014). In conclusion, this government strategy is dysfunctional. Therefore, a more radical solution is needed to resolve the water deficits; and ensure continuous clean water supply for the current and future generations of this world.

3. TRIZ Models and Tools

In this study, we apply the TRIZ process flow that is shown in Figure 1.1. First and foremost, the original problem is identified. It is then followed by function analysis, cause and effect chain analysis, engineering contradiction and physical contraction. Finally, contradiction matrix and separation/satisfaction/bypass are used to locate the specific inventive principles, which will subsequently lead to specific solution(s) [(Guin et al, 2009) and (Yeoh et al, 2009)].

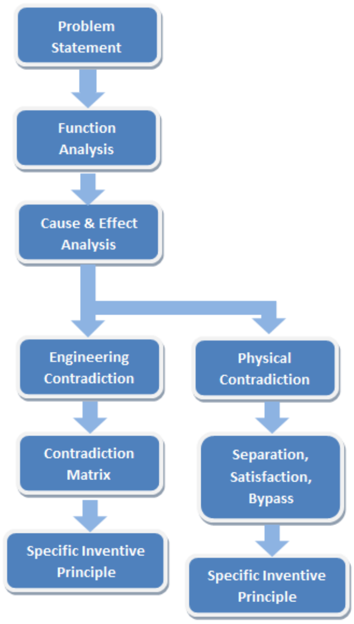

Figure 1.1 TRIZ Process Flow

3.1. Engineering System

An Engineering System consists of several components that are interacting among each other. These components are commonly known as subsystems, which are listed in Table 1.1. Besides, the subsystems are also affected by external factors, which are called supersystems. Supersystems are not designed as part of the Engineering System; however, they have an impact on the Engineering System too [(Guin et al, 2009) and (Yeoh et al, 2009)].

Table 1.1 Engineering System Analysis

Subsystems	Raw Water, Dam, Treatment Plant, Service Reservoir, Water Reticulation Main, Pipe, Particles.
Supersystems	Rain, Dry Weather, River, Industrial / Commercial Users, Households

3.2. Function Analysis

Function analysis describes the interaction between two or more subsystems as shown in Figure 1.2. The interactions between subsystems are called functions. Functions are actions that one component acting upon another component to modify parameter(s) of that component. The functions can either be useful or harmful. Useful functions comprise of "normal", "insufficient", or "excessive" functions [(Guin et al, 2009) and (Yeoh et al, 2009)].

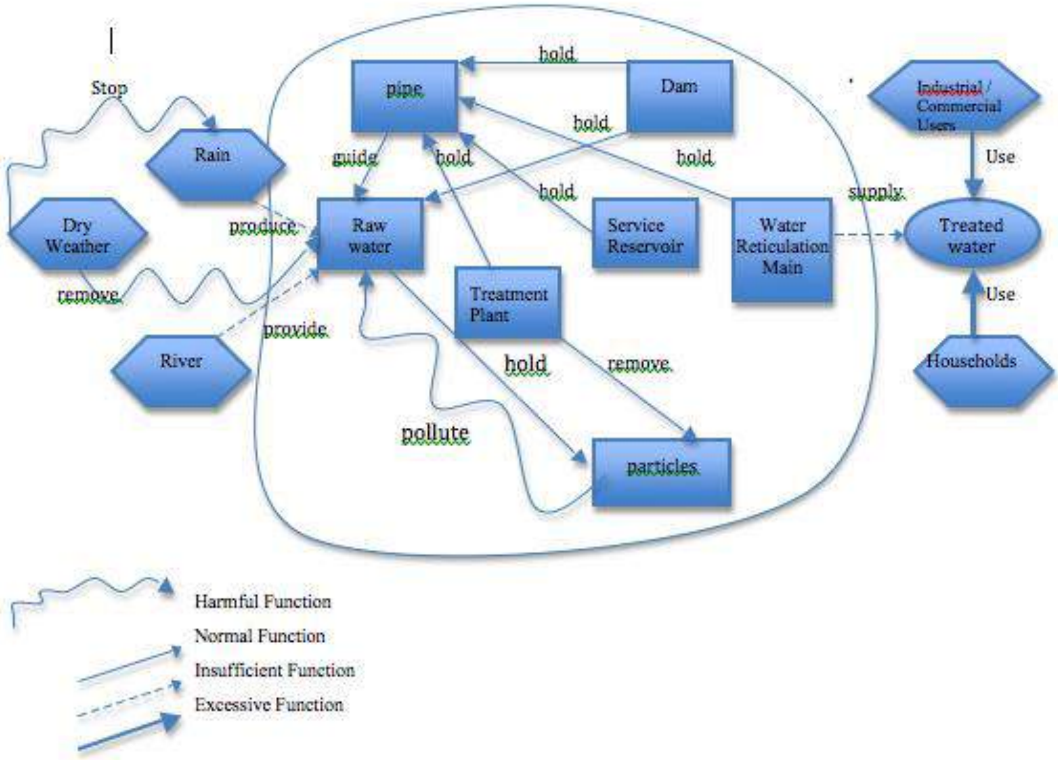

Figure 1.2 Function Analysis

3.3. Cause and Effect Chain Analysis

Cause and effect chain analysis (CECA) helps to identify the fundamental root cause(s) pertaining to the problem. The CECA is shown in Figure 1.3. This is a very crucial stage. If we diagnose the root cause wrongly, the solution derived may not be effective and the actual problem will not be resolved. At this stage, a series of "why" questions will be asked until the last "why" question cannot be answered. By doing so, high order root cause for the original problem will be distilled to next lower order root cause until the nth order root cause. The next step is to review each of the fundamental root causes. They are then discarded if not plausible, or considered as potential root cause to the original problem. Each of these potential root causes is then considered as the revised problem, which needs to be resolved (Yeoh et al, 2009).

From the CECA, there are many potential root causes. Some are natural phenomenon while others are man-made phenomenon. However, in this study, we would focus mainly on man-made phenomenon i.e. people's attitude as it is the most critical disadvantage. The result of our finding is corroborated with the statement given by the secretary-general of Water and Energy Consumer Association of Malaysia (WECAM), Mr Foon Weng Lian that wastage and shortage of water is the result of the low level of awareness and apathetic attitude among Malaysians. He reported the result of a survey conducted in 2012 that water consumption in Malaysia was 212 litres per person per day. This was one of the highest in the region, compared to 151 litres in Singapore and 150 litres as recommended by the United Nations (Voon, 2014).

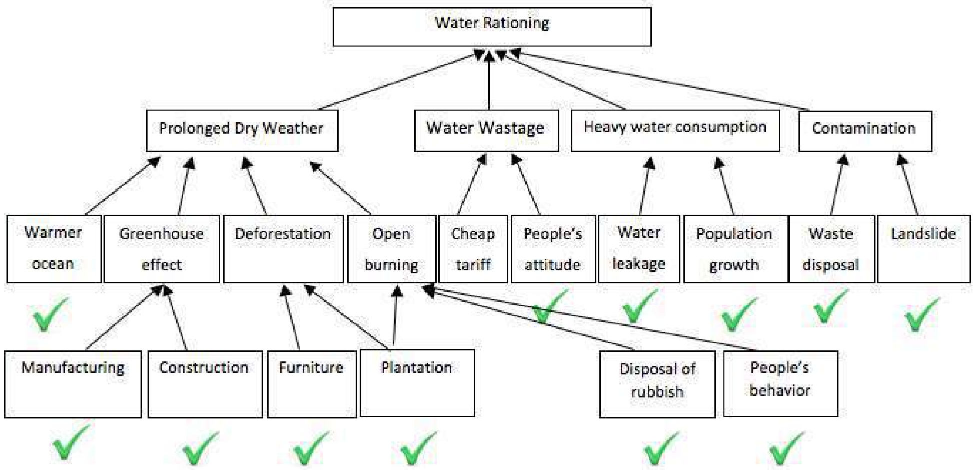

Figure 1.3 Cause and Effect Chain Analysis

Currently, effort is only focused at identifying more water sources to meet the demand and little effort is directed to look at ways on how to control the resources and its usage for long term benefits. Just like Foon's belief, it is timely for Malaysians to reflect on their bad water habits. Not only consumers are required to change their behaviour, policy makers are also required to design policies to ensure sustainability of the water resources.

3.4. Engineering Contradiction

The concept of contradiction is not the contradiction between two things external to one another, however it is in fact at the essence of one thing. Furthermore, this is inevitable in our daily life (Savransky and Stephan, 1996). Based on the work of V.I. Lenin, he has described the universality of mutually contradictory phenomena such as plus and minus, differential and integral in mathematics, combination and dissociation of atoms in chemistry, offense and defense, victory and fault in war and etc. TRIZ states that the most effective inventive solution of a problem is solution that overcomes the contradiction. Engineering Contradiction occurs when we are trying to improve one characteristic or parameter of an Engineering System (i.e. improving parameter), the other characteristic or parameter of the system is deteriorating (i.e. worsening parameter). These parameters are translated into one of the 39 engineering parameters in TRIZ. TRIZ approach is to eliminate and solve the contradiction, which is better known as engineering contradiction. Engineering contradictions can be formulated based on the cause and effect chain analysis. The contradiction is included in any process of solving the inventive problems. Therefore, contradiction matrix is used to solve the contradiction that developed by Altshuller (Shulyak and Rodman; 2000, 2002).

In this study, the Engineering Contradiction can be formulated as follows:
If water main pressure is high, then it provides convenience to people, but it will cause wastage of water. The manipulative variable is the water main pressure. While, the responding variables are shown in Table 1.2.

Table 1.2 Responding Variables

	Altshuller's 39 Parameters
Improving parameter: Provides convenience	Ease of operation (#33)
Worsening parameter: Cause wastage of water	Loss of substances (#23)

Based on the improving and worsening parameters in Engineering Contradiction, we can then refer to the contradiction matrix to search for the suggested inventive principles, which is shown in Figure 1.4. The inventive principles are:

#2 Taking out
#24 Intermediary -- *selected*
#28 Mechanic substitution -- *selected*
#32 Color change – *selected*

They are derived from the 40 inventive principles developed by Genrich Altshuller (Shulyak and Rodman, 2000).

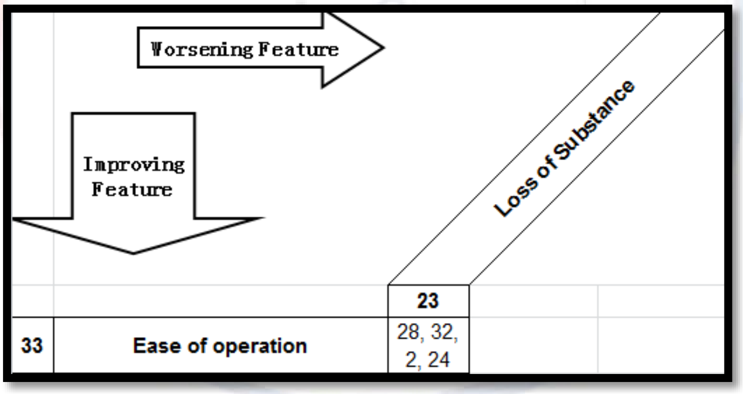

Figure 1.4 Extract of the Contradiction Matrix

3.5. Physical Contradiction

Physical contradiction can be applied as we are dealing with contradictions with a single parameter i.e. the water main pressure. This is also known as "control parameter" (Yeoh et al, 2009). Thus, we can develop the following physical contradictions:

PC1: The water main pressure needs to be high to ensure convenience to people.
PC2: The water main pressure needs to be low to ensure water is conserved.

The physical contradictions can be solved through the methods given under separation in space as well as separation in time. The suggested inventive principles under separation in space are

#1 Segmentation -- *selected*

#2 Taking out
#3 Local quality -- *selected*
#17 Another dimension
#7 Nested doll
#30 Flexible shell / thin film
#24 Intermediary -- *selected*
#4 Asymmetry

While, the suggested inventive principles under separation in time are

#15 Dynamization
#10 Preliminary action -- *selected*
#19 Periodic action
#11 Beforehand cushioning
#16 Partial or excessive action
#37 Thermal expansion
#34 Discarding and recovering -- *selected*
#9 Prior counter-action
#20 Continuity of useful action

4. Proposed Triz Solutions

Based on the suggested inventive principles given in the contradiction matrix, separation in space and time, we would like to propose the following solutions to resolve the water crisis.

4.1. Inventive principle #1 Segmentation, #3 Local quality, #28 Mechanic substitution and #24 Intermediary

By incorporating these principles, Department of Water Supply can design water plan with different packages that allow users to have access to different fixed amount of water just like the telecommunication services. Consumers are then required to subscribe to the water plans. By doing so, consumers are encouraged to manage their water usage within the stipulated plan. Water plans can be charged at different tariffs to curb excessive water usage. This was exemplified in Hungary when its government increased water prices from 0.20 euro to 0.50 euro per cu m from 1992 onwards; this has resulted in a decrease in the country's water consumption by about one-third in 1996 (Biswas and Kirchherr, 2013).

A mechanical device can be installed on all households' water reader to detect the level of water consumed. Once the reader shows that the water consumed hit certain pre-determined level based on the water plan subscribed, the intermediary will then reduce the water pressure. When the water pressure is reduced, water will continue to be supplied to households but with lesser water due to the lower water pressure.

Below are the suggested steps:

1. A water pressure reducing valve (which is shown in Figure 1.5) is installed in series directly after the PBA (Department of Water Supply) water meter at home.
2. PBA personnel will check and record the total amount of water usage and compare with the water plan subscribed by the consumer.
3. If the total amount of water consumed is more than the water plan subscribed, the PBA personnel will reduce the water pressure into the house by adjusting the

knob on the water pressure reducing valve. The valve will reduce the water pressure from the main supply to a lower pressure.

4. The amount of water pressure could be reduced by 10%, 20%, 30%, or more, depending on how much would be water consumed in excess of the water plan subscribed.
5. After adjusting the water pressure reducing valve, the PBA personnel will lock the knob of the water pressure reducing valve with special seal from PBA. This is to prevent the consumer from turning back the knob back to maximum pressure setting of the valve.
6. The level of water pressure dropped at the outlet of water pressure reducing valve will be made known to consumer through the water bill printing in different color.
7. If consumer manages to reduce the water usage within the stipulated level stated in the plan, PBA personnel will set the water pressure reducing valve back to the maximum pressure during the next visit for the bill recording.

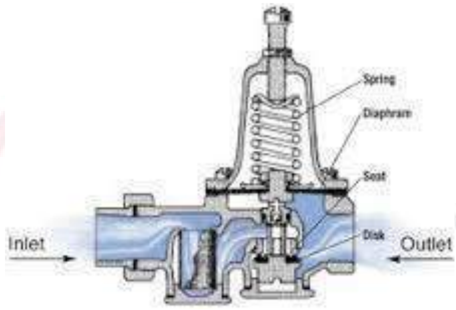

Figure 1.5. Water Pressure Reducing Valve

4.2. Inventive principle #10 Preliminary action

Water conservation awareness campaign can be organized to educate citizens on the importance of water. This campaign is important, as availability of water will directly affect the sustainability of water resources and ultimately, the country’s overall sustainable development. If water is not managed effectively, it will cause water depletion. The Water Sustainability Index showed a decrease from 64% in 1992 to 33% in 2002, reflecting that Malaysia’s water resources are depleting rapidly and have not been managed properly (WWF-Malaysia). Thus, there is an urgent need to organize more water conservation awareness campaign to disseminate information pertaining to water usage and water problems. This may help to improve water management. There are two good examples in this context. First, Arizona’s Department of Water Resources has announced that April is the state’s water awareness month. Second, Singapore’s Public Utilities Board has run conservation campaigns since early 1970s. A few events were organized by PUB for example meter reading contests and public water fora. In addition, PUB has established a Water Conservation Centre with interactive exhibitions. In 1995, PUB has also launched a remarkable awareness strategy where water supplies to 30,000 randomly selected households were withheld for as long as 14 hours per day for a week. Such campaign has fostered long-lasting behavioral changes among Singaporeans and has reduced water consumption from 172 litres per day in 1995 to 153 litres per day in 2011 (Biswas and Kirchherr, 2013).

4.3. Inventive principle #34 Discarding and recovering

Wastewater can be sent from households or businesses through a pipeline system to a treatment plant, where it is treated to a level consistent with its intended use. The water is then routed directly to a recycled water system for uses such as irrigation, industrial cooling or drinking. There are several communities in the world have been using the recycled water for many years. These include US, Singapore, Australia and Namibia.

4.4. Inventive principle #32 Color Change

The idea of color change can be applied in water bill. Water bills will be printed in different color to inform and alert consumers of their water usage. For example, red bill indicates high usage, green bill for moderate usage and white bill for low usage. This serves as a reminder to consumers so that they can manage their water usage more efficiently and effectively in order to conserve water.

5. Conclusion

Not many people would believe that Malaysia is facing water shortage because it has always been blessed with abundant rainfalls and an extensive river system. For most Malaysians, they seem to care less about how much water they have been using because they can access to water so easily and it is very cheap. On average, Malaysian family's water bill is only about 10% of its electricity bill. In this study, applying TRIZ tools particularly the inventive principles such as segmentation, local quality, preliminary action, mechanic substitution, intermediary and color change as well as discarding and recovering can help to reduce water wastage and eventually conserve water for the use of the current and future generations. Therefore, it is proven that TRIZ is a powerful innovative methodology, which can be used to resolve inventive problem.

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Finding the Leverage Point in the Sustainability Crisis: Global, National and Regional Australian Responses

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Abstract
From an economic perspective, the sustainability crisis is ultimately characterized by a worsening relationship between the resources required to support the global population and the ability of the earth to supply them. Despite the ever-increasing threat of a calamity, modern society appears unable to alter its course. The very systems which underpin global human endeavor seem to actively prevent meaningful change and the one irrepressible goal to which all societies seem to strive is the very thing that makes such endeavor ultimately life-threatening: that of global growth. Using the Australian experience as an exemplar, this paper explores how the concept of growth infiltrates societal reactions to the crisis at various scales – global, national and regional. Analysis includes historic studies, a critique of current misconceptions around population demographics, comparative evaluation of various interventions in the Australian context and considerations around potential ways to address the crisis.

Keywords: population, carrying capacity, scale, localisation, resources, growth

Introduction

The bounded nature of planet earth is enough to suggest that there is a finite dimension to its resource productivity. There are thus limits to the quantity of people, hence its carrying capacity (Lane, 2010), limits to traded goods and limits to its economic potential. However, the dominant global economic paradigm advocates infinite economic growth at all costs, a seeming impossibility on a finite planet. All facets of society reinforce this drive for growth, from government systems, to educational institutions and the business sector. Population growth and economic growth have generally gone hand-in-hand and this current period of industrialisation has seen sustained expansion of both, punctuated only rarely by brief interludes of economic recession. For instance, in the period 1850 to 2011, Australia's GDP grew 462-fold while its population grew 56-fold (GDP adjusted for inflation) (Hutchinson, 2011).

The obvious contradiction of infinite growth in a finite world can only be explained by a general unwillingness to partake in realistic long-term societal planning. Hardin (1986, p.603) explains that, "[e]conomics, the handmaiden of business, is daily concerned with 'discounting the future,' a mathematical operation that, under high rates of interest, has the effect of making the future beyond a very few years essentially disappear from rational calculation." Catton (1982, p.3) agrees that, "mankind is locked into stealing ravenously from the future," with a system out of alignment not only with principles of societal equity but one that doesn't even obey simple bio-physical imperatives.

Despite decades of warnings from carrying capacity crisis harbingers such as Ehrlich, (1971) Catton (1982) and Hardin (Hardin & Baden, 1977), the global population has continued to increase, economic growth is still the dominant paradigm, non-renewable resources have become increasingly necessary and decreasingly available long-term and the carrying capacity horizon seems to edge ever-closer. Unfortunately co-ordinated action to combat the problem has largely been unsuccessful.

Global responses

Global responses to a potential carrying capacity crisis seem to revolve largely around the hope that demographic transition will finally put an end to global population growth. The theory of demographic transition was initially developed by Notestein (1945, p.39) in 1945. Notestein argued that economic development associated with industrialisation provides incentives and technologies that tend to stabilise population numbers, eventually reaching a plateau. Firstly, the theory states that pre-industrial populations tend to exists in accordance with Malthusian principles, essentially determined by mortality rates imposed by a fluctuating food supply (Caldwell, 1976, p.325). Stage two begins with industrialisation, when modern sanitation and medicine dramatically reduce mortality, leading to a population explosion. However, once the western industrial model becomes entrenched, as Notestein (1945, p.40) points out, a large family becomes a more expensive and, "progressively difficult undertaking." Improvements to contraceptive technologies along with its promotion and ready availability have also hastened this stage of the demographic transition model.

There is little doubt that demographic transition has played a role in the slowing rate of global population growth over the last 40 years (Cohen, 1995, p.50). However, even the United Nations medium range population projection (United Nations, 2011) does not expect the global population to stabilise for at least 90 years before arriving at a population close to 11 billion people. However, Fearnside suggests such modelling is unrealistic. He states (Fearnside, 1986, p.68) that it is unlikely, "that the amount of economic progress realistically possible for many developing counties would be sufficient for the full fertility-reducing effect of the demographic transition to be realised," and that such an effect, "would be too slow-acting to prevent astronomical increases in population densities and intensification of problems following from this increases." Fearnside thus highlights the unreliability of industrialisation and economic growth to deliver timely population stabilisation. Cohen also contends that demographic transition is a poor predictor of when declines in fertility may begin and the speed of which mortality and fertility may occur (Cohen, 1995, p.50).

It is unknown whether the earth will be able to support this amount of people even if our current mode of industrial production was sustainable. Unfortunately however, given the finite nature of our industrial resources, the current societal model may not even last another 90 years so the likelihood of demographic transition, on its own, rescuing society from carrying capacity crisis seems reasonably slim.

National responses

The fact that Australia is one of the few nations bounded by sea, means that at least symbolically, it seems well suited to measurements of self-sufficiency such as carrying capacity analysis (Lane, Dawes, & Grace, 2015). Several attempts have been made to estimate Australia's carrying capacity, the most detailed of which have appeared in various government reports on the population issue.

In 1975, the federal government released a demographic analysis of Australia titled Population and Australia (Australian Government, 1975). While it states that it was not aiming to determine a national carrying capacity, (Australian Government, 1975, p.xxxvii) it nevertheless included a number of previous scholarly attempts ranging from 10 million to 480 million (Australian Government, 1975, p.180-191). In the decades leading up to the 1970s, the predominant national sentiment was one of population expansion, reflected in policy incentives such as increased immigration, limitations to abortion and restriction on the distribution and promotion of contraceptives (Cohen, 1995, p.224). Another initiative originally introduced in 1912 was a £5 baby bonus offered to all new mothers of European descent in an attempt to promote the white Australia policy (Day, 2009, p.258). By 1970, there was some debate about the merit of such population growth, but it continued nonetheless and then between 2002 and 2014, the baby bonus incentive was reintroduced for Australian parents with payments worth up to $5000 per child (Australian Government, 2011a).

In 1994, Barry Jones led a subsequent federal government report of the population issue titled Australia's Population Carrying Capacity (Jones & House of Reps Standing Committee for Long Term Strategies, 1994). While no thorough biophysical analysis was conducted, the aims of the report were ahead of their time in aspiring to explore ecological constraints to growth. McNicoll (1996, p.168) describes the outcomes of this enquiry into Australia's carrying capacity as a debate between two main groups: the ecologists advocating a maximum of 20 to 25 million people and the economists and demographers who suggested that Australia's capacity fell somewhere between 50 and 60 million. The report stressed the importance of the establishment of well-annunciated federal population policy although McNicoll (1996, p.168) correctly predicted that this was unlikely to happen.

Rather than heeding the advice of earlier reports, the most recent Australian government report on population is more of a retrograde step than advancement of the population conundrum. In 2011, the federal environment minister, Tony Burke, released the government's strategy for a sustainable population, Sustainable Australia - Sustainable Communities (Australian Government, 2011c). Prior to the report's release, minister Burke seemed to court the possibility of incorporating population limits into government policy, stating that, "we have to also take into account, do some sections of Australia have what - with my agriculture hat on - gets referred to as a carrying capacity?" (Sales, 2010). However, once the document was released any aim towards carrying capacity targets was rejected, and instead, the introduction of socio-environmental monitoring was endorsed. In so doing, the government seems to discount the possibility that as a society, we are pushing up against biophysical limits that potentially threaten modern society and that population levels are the multiplier in this challenging equation.

Rather than setting population targets, the government's population strategy purports to aim for a more sustainable Australia by managing impacts on the current population, monitoring migration and projecting population trends (Australian Government, 2011c, p.25) but these measures lack any meaningful traction without the process of identifying population limits. For instance, how is sustainability measured, if not against a certain level of certain activities performed by a certain number of people over a certain amount of time? How do we know that past population trends will continue on similar paths if barriers to future growth are not identified?

Despite the title of Burke's report, neither sustainable communities nor a sustainable nation can actually be ascertained, let alone achieved, without acknowledging firstly that limits to growth do exist and secondly that there is an inherent hierarchy contained within these limits. The hierarchy adopted by the Report (Australian Government, 2011c, p.7) gives equal weighting to economic, societal and environmental interests. This approach fundamentally illustrates the disconnect between the laws of nature and unrealistic expectations for unlimited, continued growth, be it economic or societal. An alternative model was included in the 1996 National State of the Environment Report (State of the Environment Advisory Council, 1996, p.10-12) and has been recommended to the Sunshine Coast Regional Council by its Sustainability Advisory Panel in 2009 (Sunshine Coast Regional Council, 2009). This committee provide a more realistic representation of these interests with the economy encapsulated by society, which in turn, is enclosed by the environmental sphere. This perspective recognizes that there are limits inherent in our way of life and that aspects of the economy are limited by society, be it cultural norms, ethical responsibilities or population dynamics. Additionally, society and each of its component parts including the economy are all limited by their biophysical context.

Regional Responses

The acknowledgement of societal thresholds is reflected in the Sunshine Coast Sustainability Advisory Panel's recommendation for subsequent constraints mapping, an aspect mirrored by other local councils such as Port Macquarie-Hastings (Hopkins, Leopold, & Phillips, 2009) but omitted from the federal government's approach. Instead, the government's report proposes the development of sustainability indicators in a strategy that potentially places government merely in the role of passive observer rather active planner. A more responsible planning position would attempt to build the resilience of a society within its biophysical context by utilising models that estimate biophysical constraints to growth, such as the

Carrying Capacity Dashboard, designed for the Australian context in three geographic scales: national, state and regional (Lane, Dawes, & Grace, 2014). If such a carrying capacity-orientated approach to land use planning were to be adopted, it would be possible to anticipate potential future systemic impacts such as finite fuel depletion and increasing harsh weather events in order to determine safe tolerance limits in human activity (Lane & Dawes, 2013).

In order to make accurate detailed carrying capacity estimates at a regional scale it would be important to determine the potential productivity of each piece of land by conducting land suitability assessments. While some progress has been made in this endeavour in Australia, the scale of land suitability assessments differs from state to state and between regions within each state. The appropriate scale for the usage of land suitability mapping in the process of carrying capacity assessments would be dependent on the scale at which assessment is sought. For instance, Noble (1992, p.9) states that scales of 1:5000 or 1:10,000 are most suitable for planning at the farm scale while 1:25,000 is best for catchment planning and 1:50,000 or 1:100,000 scales are most appropriate for district and regional planning. Van Gool et al. (Van Gool, Moore, & Tille, 2005, p.5) concur that assessments at scales between 1:10,000 and 1:50,000 are best for strategic planning of intensive land-use developments including urban development, farming enterprises and forestry production. However, much of Australia's landscape analysis has been conducted at scales of 1:100,000 or 1:250,000 (Australian Government, 2011b, p.74-83; Imhof, Rampant, & Bluml, 2000) so there is still much work to be done in this regard before the scale of land suitability mapping might be publicly available for small-scale carrying capacity assessments.

The responsibility for assessment and storage of land suitability mapping in Australia has largely been a state-based concern although according to van Gool et al. (van Gool, Maschmedt and McKenzie in McKenzie, Grundy, Webster, & Ringrose-Voase, 2008, p.431), in recent years the role of natural resources management has increasingly become decentralised, stimulating demand for land evaluation at the local and regional level. Imhof et al. (2000, p.6) agree that regional assessment has recently gained prominence in the minds of key stakeholders, including government agencies, industry groups, and catchment management authorities; and McKenzie et al. (2008, p.485) also argue that interest is growing, mostly as a result of farmers recognising the value of such information to their farm management practices. While such small-scale approaches to landscape suitability assessment will be essential to future carrying capacity assessments at a similar scale, it seems that the highest current priority should be towards rationalising the assessment system to facilitate cross referencing and integration of the existing state-based information. Van Gool et al. (2005, p.3) thus suggests that all available land resource surveys should be re-interpreted and correlated under a unified national system which he suggests should be administered by the Australian Soil Resource Information System (ASRIS). While ASRIS has successfully brought together a diverse array of state-managed soil information, to date it has not provided a system for re-interpreting this data as land suitability assessments (McKenzie, Jacquier, Maschmedt, Griffin, & Brough, 2012, p.7).

Conclusion

Deleterious environmental impacts from human activity are only likely to exaggerate any threats to populations' food and water supplies with land clearing and degradation, biodiversity loss and climate change all potentially effecting future agricultural yields (Pandey, 2011). While population deceleration by natural means such as demographic transition can play a role in slowing momentum towards a carrying capacity crisis, it seems unlikely it will impart enough influence in sufficient time, so more direct responses will need to occur at global, national and regional scales. Carrying capacity assessment processes are thus vital components on a path towards sustainable land usage as they indicate the size of population supportable on any particular landscape, given the population's production and consumption processes and choices. While some models such as the Carrying Capacity Dashboard (Lane, 2012) already exist, in order for more detailed and nuanced carrying capacity estimates to occur in Australia, more thorough land suitability mapping, particularly at the smaller regional scales will be necessary in the future.

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Modelling and Analyses of Underwater Acoustic Signals Emitted by Marine Energy Device

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Abstract
Assessment of the 'health' of marine based electro-mechanical devices where certain types of failure modes (e.g. damaged bearings, hydraulic faults, electrical arcs, vibrations) occur is essential for companies involved in the renewable ocean energy and marine technology sectors. This directly impacts on the operation and management costs of ocean based systems, specifically impacting on efficiency / yield, reliability, and maintenance costs. This paper presents the modelling and simulation of sound signals emitted by a point absorber WEC device. One third octave band centred frequency signals in a dominant 100 Hz - 1000 Hz range were used to estimate the propagation loss as a function of range. Estimated Sound pressure level (SPL) values from finite element (FE) models with different surface interfaces were compared to measured values from the WEC device. Rough surface interfaces of the FE models were seen to contribute significantly towards the propagation loss of the sound signals in an acoustic domain. It was also estimated that increase in the root mean square (rms) height of the rough surface led to significant increase attenuation and propagation loss. This study contributes to the knowledge of parameter effects in an acoustic environment, which is useful in the understanding and informed prediction and performance of idealized underwater acoustic models.

1. Introduction

Assessment of the 'health' of marine based electro-mechanical devices where certain types of failure modes (e.g. damaged bearings, hydraulic faults, electrical arcs, vibrations) occur is essential for companies involved in the renewable ocean energy and marine technology sectors. This directly impacts on the operation and management costs of ocean based systems, specifically impacting on efficiency / yield, reliability, and maintenance costs.

In shallow water environments, attenuation/transmission loss by bottom surface, scattering, wave interactions and boundary effects are important factors in understanding acoustic signal propagation. Attenuation of underwater acoustic signals is caused mainly by their geometric spreading. Other factors causing attenuation include surface interactions and the absorption of sound in sea water. The absorption of sound in sea water with an absorption co-efficient (α) is dependent on temperature, frequency, depth, salinity and acidity (Fisher & Simmons, 1977). Underwater acoustic models are important when it comes to the understanding and estimation of both active and passive sound navigation and ranging.

An idealized predictive medium for modelling and simulation of underwater sound propagation incorporates the spreading, absorption, and scattering loss mechanisms exhibited by underwater acoustic signals during propagation. Ray theory, normal modes, parabolic equations and couple modes are all current methods used to simulate underwater acoustic propagation and loss. The aforementioned methods, however, neglect scattered energy from the interfaces at angles which are close to normal, thus making the finite element (FE) analysis method a benchmark for approximation as discretization density increases (Isakson & Chotiros, 2011).

In this paper, Comsol FE analysis package is used, this package is capable of coupling different physical domains such as the solid and fluid domains, and approaching the exact solution of the Helmholtz equation. This paper presents a FE model that simulates the emission and analyses of acoustic signals produced by a wave energy device to aid the diagnosis of any of the aforementioned failure modes. We model the propagation of the acoustic signals produced by this device taking into account its boundary conditions such as the bathymetry of the deployment site, properties of the propagation media, type of spreading of the acoustic signal and the interaction with the surface and bottom interfaces of the acoustic environment. The results show the effect of varying surface interface roughness on the sound signal emitted by the wave energy device and it's attenuation with respect to distance.

1.1.Wave Energy Converter and Noises

The acquisition of acoustic signatures for WEC devices from their associated primary operational components such as turbines, generators, hydraulic components (pumps and valves), moving parts such as hinges and actuators, without actual field measurements is not trivial. Secondary noise sources associated with these devices include noises from cable vibration, cavitation noises and noises from water impinging on these devices.

To quantify the noise radiated by WECs, ambient noise present at the site in the absence of any WEC is usually characterised in both ebb and flood conditions

(Broudic, Croft, Willis, Masters, & Sei-Him, 2014; Miles R Willis, 2011). One of the earliest noise measurements in the direct vicinity of an operational WEC was carried out in the Bristol Channel on marine current turbines. An SPL value of 166 dB re 1 µPa at 1 m from the source (using a simple spreading law) was measured. It is important however to take caution during the interpretation of this effective source level (using the spreading law), since there might be interference effectively leading to large fluctuations in sound pressure level at short distances from the source (Richards, Harland, & Jones, 2007). A full scale point absorber, the Danish Wavestar WEC, was measured to emit 106 - 109 dB re 1 µPa in the 125 Hz to 250 Hz frequency range, which was 1 - 2 dB above ambient levels in October of 2012. Highest sounds signal emitted by this device was at 150 Hz frequency with a corresponding SPL value of between 121 - 125 dB. This was present from the hydraulic pump of the device during start-up and shut-down of the converter (Paul Lepper, 2013). Harmonic acoustic components associated with rotational speed of turbine and impulsive noise associated with increased air pressure within the air chamber, was obtained from a wave energy oscillating water column device in Portugal in 2010. SPL values measured for the harmonics at different rotational speeds of the turbine blades were highest at 126 dB re 1µPa 10m from the device (Sofia Patricio, 2012).

The characteristic noises emitted by WECs differ between different WEC concepts. In the full scale point absorber type WEC which is represented by the point source in this study, noise types include transient noises originating from the activities of the translator and stator components as demonstrated by Haikonen *et al* (Haikonen, Sundberg, & Leijon, 2013). The amplitudes of the sound signals by these components are dominant in the frequencies below 1000 Hz ranging between 118 and 155 dB re 1µPa, with peak amplitudes at 100 Hz and 300 Hz.

2. Fe Modeling And Simulation

The FE analysis involves finding the solution to the Helmholtz eqn. (2) which stems from the reduction of the wave eqn. (1). In this document only a summary of the derivation of the equation is provided, however, an exhaustive method for the derivations can be gotten from reference (Ihlenburg, 1998).

$$\frac{1}{\rho_0 c^2}\frac{\partial^2 p}{\partial t^2} + \nabla \cdot \left(-\frac{1}{\rho_0}\nabla p + q\right) = 0 \qquad (1)$$

From eqn. 1 p is the acoustic pressure, ρ_0 the fluid density and q an optional dipole source. A time-harmonic wave $p = p_0 e^{iwt}$ is substituted into eqn. (1) to obtain the Helmholtz eqn. (2).

$$\Delta p + k^2 p = 0 \qquad (2)$$

Eqn. (2) describes a harmonic wave equation propagating in a medium with an assumption of no dissipation of energy. P is the sound pressure amplitude and k is the wave number which is related to angular frequency

$\omega = 2\pi f$ and speed of sound c_s as shown in eqn. (3)

$$k = \frac{\omega}{c_s} \quad (3)$$

The homogeneous Helmholtz equation is thus derived by substituting (3) into (2) to give eqn. (4).

$$\nabla \cdot \left(-\frac{1}{\rho_0} (\nabla p) \right) - \frac{\omega^2 p}{\rho_0 c_s^2} = 0 \quad (4)$$

Sound signals radiate from a point source with the energy emitted at a given time diffusing in all directions as described by eqn. (5)

$$\nabla \cdot \frac{1}{\rho_c} \left(\nabla p_t - q \right) - \frac{k^2 p_t}{\rho_c} = 2\sqrt{\frac{2\pi P_{ref}\, c_c}{\rho_c}} \quad (5)$$

From eqn. 5, P_{ref} the reference pressure and c is the speed of sound in the medium.

2.1.1 Mesh/Length scale/Timescale

To allow for adequate convergence of the solution, triangular mesh elements were used to resolve the wavelength of the smallest sound signal into fractions as shown in Fig 1. The maximum mesh size was given as thus: mesh $(h)_{max}[m] = {}^{\lambda}/_{8}$ where $(\lambda)[m] = {}^{c}/_{f}$, with time scale$[s] = {}^{1}/_{s}$. Where, $c\ [ms^{-1}]$ is speed of sound and $f[Hz]$ is frequency.

2.2 Pressure Release Surface & a Perfectly Matched Layer

The upper boundary for the acoustic domain was modelled as a pressure-release surface (Katsnelson, Petnikov, & Lynch, 2012). This pressure release surface is depicted in Fig. 1. This boundary surface assumes a Dirichlet boundary condition (Pierson/Moskowitz spectrum at 10.3 m/s). To reduce reflections at the boundaries, perfectly matched layers were used to truncate the infinite domain. These layers were at least twice the size of the biggest wave length.

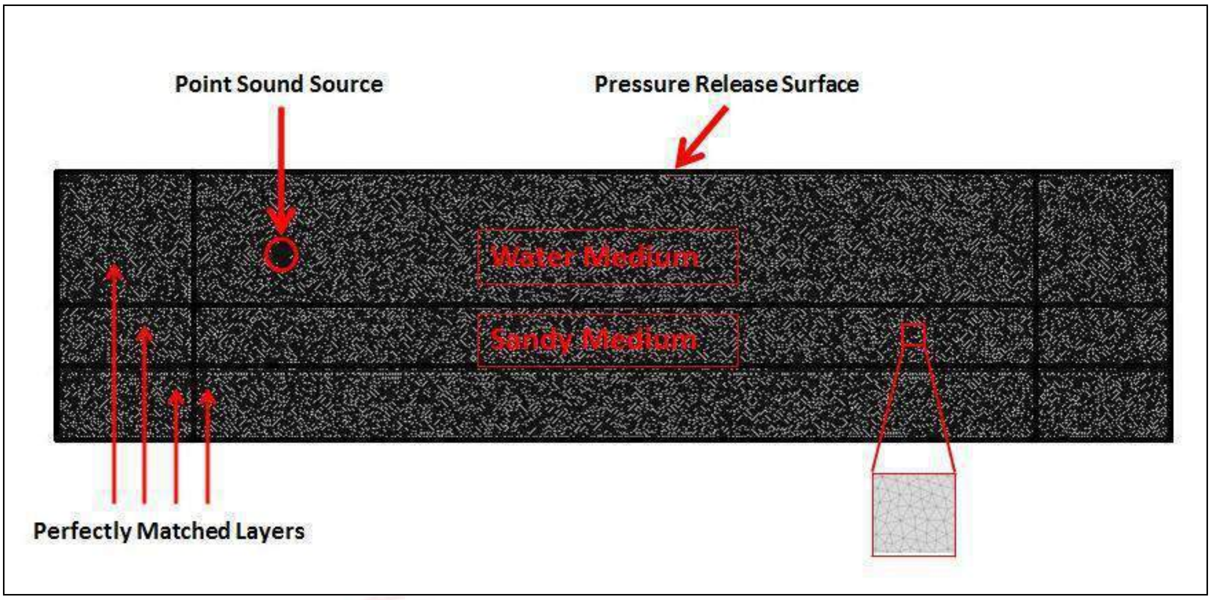

Fig. 1: Model geometry showing the different media, perfectly matched layers and pressure release surface. Zoomed in mesh shown (inset)

3. Problem Description

Sound is assumed to propagate spherically in a homogeneous acoustic medium from a point source. The mix winter Pekeris water sound speed profile is used together with other parameter values shown in Table 1.

Table 1: Acoustic parameters and properties used in the models

Parameter/Material	**Value**
Water	Density (ρ), 1029 [kg/m^3] Sound speed (c), 1500 [m/s]
Soil	Density (ρ), 2500 [kg/m^3] Sound speed (c), 1000 [m/s]
Source depth	24 [m]

Theoretical plots of frequencies against range are shown in Fig. 2 for the Spherical spreading and attenuation loss of sound signals in an acoustic medium using the simple propagation loss (PL) eqn. (6). This formula is widely used to evaluate the performance of underwater acoustic systems (Katsnelson, et al., 2012).

$$- PL = - 20 \log R - \alpha R \qquad (6)$$

From eqn. 6, R is the range from the sound source and α is the attenuation coefficient which is calculated using the temperature, depth, and salinity and acidity parameters.

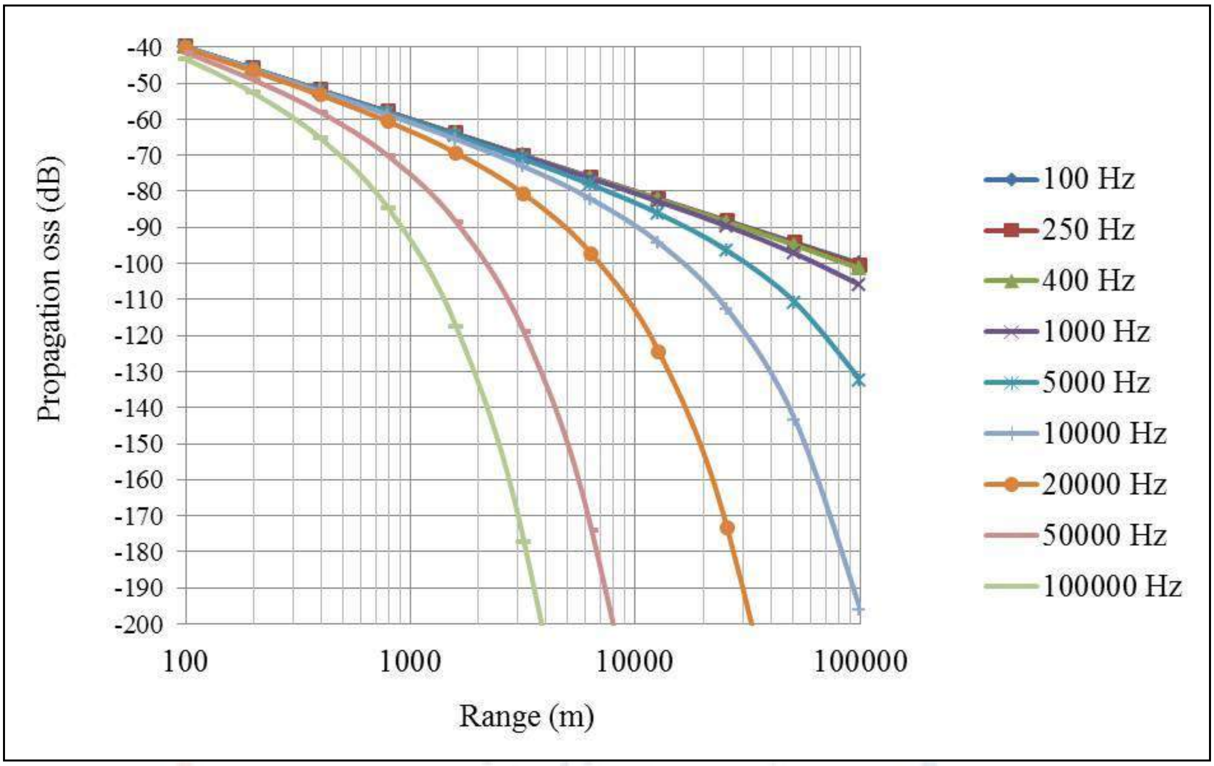

Fig. 2: Theoretical propagation loss - PL = - 20 log R – αR of frequencies as a function of range. Using Francois and Garrison absorption coefficient (α) with conditions: Temperature = 10^{o} C, Salinity = 35 p.s.u. and depth = 24 m.

Fig. 2 depicts the theoretical propagation loss of the amplitude of signals with respect to range and frequency components. Higher frequencies attenuate faster in an exponential manner, with very low frequencies having the capacity to travel further. However, more idealised propagation models require the incorporation of other propagation parameters including interfaces generating multiple concurrent paths and scattering. The models in this study therefore incorporate this other parameters and their estimates towards the propagation of sound. Table 2 details the different parameters of the models considered for analyses.

Table 2: Models used for simulation

Type	Water/Air Interface	Sand/Water Interface
Model 1 (Control)	Flat	Flat
Model 2	Rough	Rough
Model 3	Rough(Smaller)	Rough

4. Results

Analyses were carried out amongst the 3 different models. Model 1 is assumed to be the control model with no surface interface roughness, model 2 has a bigger surface interface roughness corresponding to approximately the root mean squared (rms) height of the acoustic wavelength (λ_{rms}), and model 3 a smaller surface interface roughness (0.13m λ_{rms}). One third Octave band centred frequencies 125 Hz and 1000 Hz were used. These give the limits for the frequencies range for which the amplitudes of the sound signals normally emitted by the WEC device under study are most dominant.

4.1 Analysis of Fe Models

Analyses on the FE models show a general decrease in sound pressure levels (SPL) as the sound signals propagate away from the source. Fig. 3 shows the SPL values for the three different models for an approximate range of 3000 m at 125 Hz and 1000 Hz frequency values. It is observed that as frequency values increases, the rate of attenuation of SPL increases. And this is consistent with the theoretical analysis (See Fig. 2).

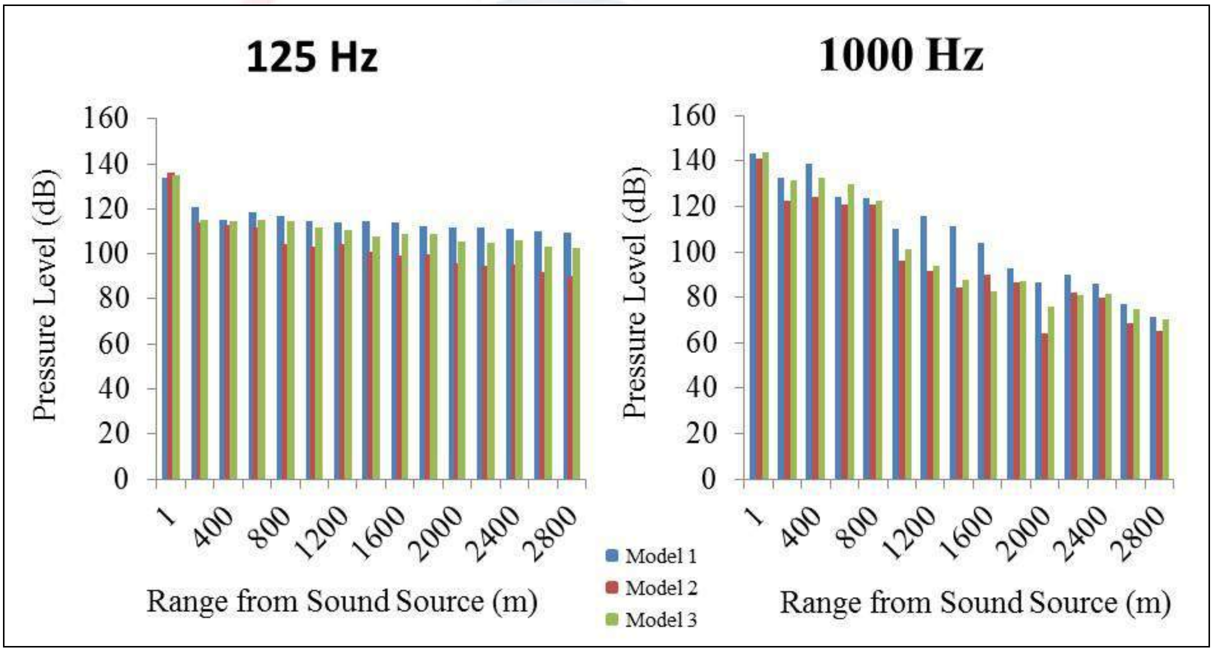

Fig. 3: Attenuation of sound as a function of frequency and range for the different models. Models exhibit the same characteristics as theoretical models with respect to frequency against range.

It is also observed that the models (2 & 3) with the rough surface interfaces attenuate more sound signals than the model (1) with the flat surface interfaces. Model 2 with bigger surface roughness attenuates more sound signals than model 3 with smaller surface roughness.

4.2. Analyses of Experimental Values

Evaluation of sound propagation loss of 1/3 octave centred frequency sound signals emitted from a point absorber device was estimation at 100 m and 1000 m from the sound source, in the 100 Hz to 1000 Hz range. The acquisition of this acoustic data from the WEC device was part of a study by Haikonen *et al* (Haikonen, et al., 2013). The parameters such as depth of the device for the acquisition of the data from the WEC are similar to those incorporated into the models in this study. Fig. 4 shows attenuation of sound signals emitted by the WEC in the 100 Hz to 1000 Hz frequency range. The signals in this range have the greatest amplitude.

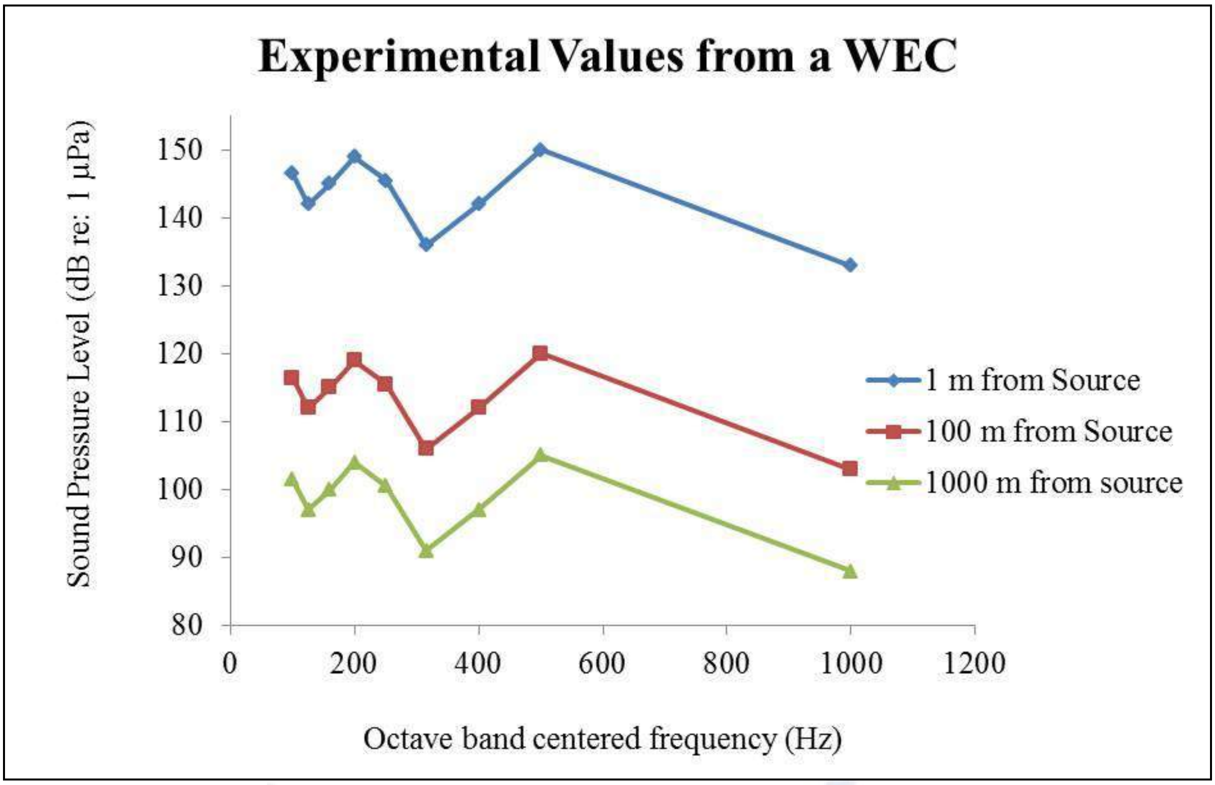

Fig. 4: Propagation loss of 1/3 Octave band centred frequency from a point absorber WEC. Sound source is at a depth of 24 m and the dominant frequency amplitudes are in the 100 Hz to 1000 Hz frequency range.

It can be seen from Fig. 4 that the overall SPL values decrease as the sound signals propagate away from the source. The propagation loss eqn. (6) was used in the estimation of the values at the different point. However, it is important to note that the attenuation loss coefficient was not accounted for during extrapolation due to lack of availability of the attenuation loss factors from the site during measurement.

Comparative analysis of values obtained from models 1 & 2 was carried out against estimated experimental values from the device. Fig. 5 depicts the values estimated at 100 m and 1000 m distances from the sound source. Model 2 provides a closer fit to the estimated measured values from the WEC device in terms of attenuation. This indicates that the increased roughness of the interface of model 2 contributes significantly to the propagation loss of the sound signals.

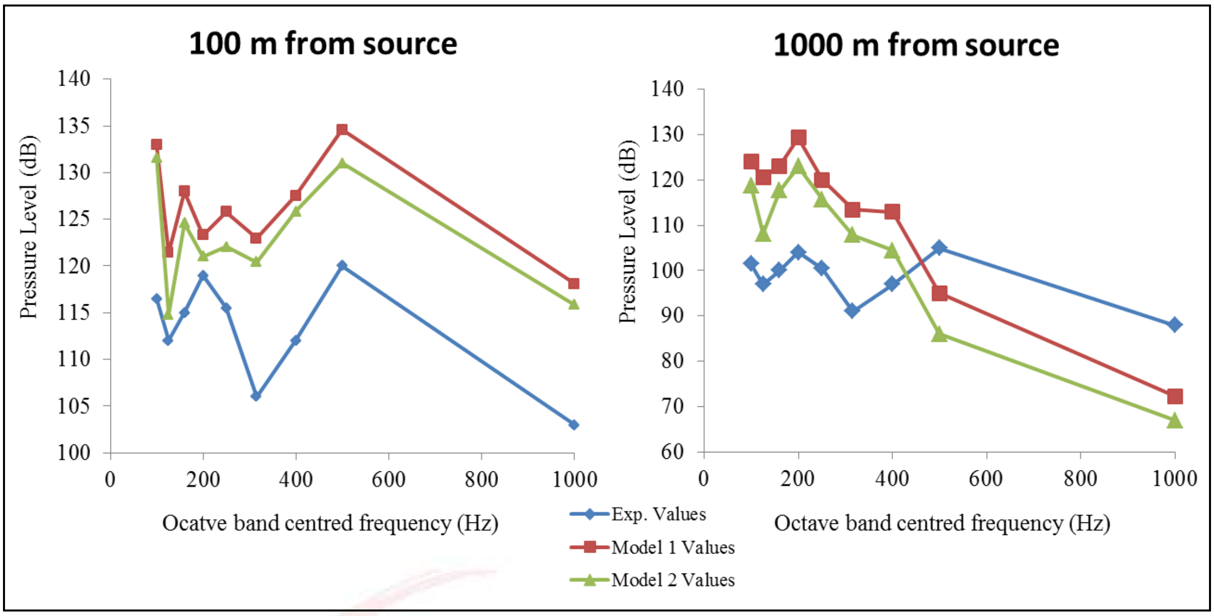

Fig. 5: Propagation loss of models 1 & 2 against estimated experimental values. Model 2 with rough surface interface exhibits more attenuation of sound signals and gives closer results to experimental values.

5. Summary

The modelling and simulation of acoustic wave propagation in an acoustic environment with different surface interfaces was carried out in this study. Spreading loss, attenuation loss due to domain properties such as temperature and density, together with losses due to scattering and interaction of waves were incorporated into the 2-D models. Results showed an increase in attenuation of sound signals as frequencies increased in all models, which is consistent with theoretical calculation of attenuation as a function of distance and frequency components. Models with roughness on the surfaces exhibited more.

5.1 Limitations

Most modelling and simulations are carried out in a 2-D domain due to computational power constraints. Implementation of a 3-D domain for simulation suggests a more idealistic representation. Sound directionality is an important factor for the modelling of sound. Sound sources are generally represented by sources which radiate signals in an omnidirectional pattern. However, this is not the case with most sound emitting sources. Incorporation of different sound speed profiles in underwater acoustics models also has an effect towards the analyses of sound propagation and loss. Lastly, single WECs do not emit a high level of noise. The deployment of an array may generate a concerning level and this should be considered in future modelling (Patrício, Moura, & Simas, 2009).

Acknowledgement

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Effects of Turbulence Models on Micro-bubble Distribution in Dissolved Air Flotation Process for Water Treatment

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Abstract
The dissolved air flotation (DAF) system is one of the water treatment processes that clarifies wastewaters by floating internal contaminants to the water surface by attaching micro-bubbles to them. Since the first use of DAF for drinking water treatment in Scandinavia during the 1920s, DAF has been very widely used in treating industrial wastewater effluents such as water treatment.
In the present study, the two-phase flow of micro air bubbles and water mixture is simulated by computational fluid dynamics to investigate changes of internal flow behaviors in a DAF system depending on the turbulence models. For a given geometry of a DAF system and boundary conditions, micro-bubble distribution is analyzed with several turbulence models, which are standard k-ε, realizable k-ε, RNG k-ε, standard k-ω, and SST k-ω, respectively. Through analysis, it is observed that the standard k-ε model, which has been frequently used in the previous studies, predicts somewhat different behaviors from other turbulence models. Also, the RNG k-ε and standard k-ω model yield relatively excessive rotational flow inside water. When computation times are compared, the all models are faster to complete computations except for the k-ε model.
From the present results, it is revealed that the selection of a turbulence model should be considered more carefully when an internal flow analysis is conducted on the DAF process.

Keywords: Dissolved Air Flotation, Computational Fluid Dynamics, 2-Phase Flow, Turbulence Model

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Introduction

The dissolved air flotation (DAF) system is a water treatment system that clarifies floating contaminants by attaching micro-bubbles on the free surface, as shown in Fig. 1. The micro-bubbles are injected into an internal flow by decreasing pressure rapidly and are attached to solid contaminants like algae and green tide. After that, the suspended solids float to surface, and then it is scraped by the skimmer. The internal flow of a DAF system is separated into two sections, which are the contact zone and separation zone. In the contact zone, contained contaminants in wastewater and scattering micro-bubbles from a nozzle are mixed together. In the separation zone, if a large number of micro-bubbles is combined with contaminants, they will float and be removed easily. Clarified water circulates inside of the tank and sinks down to near the perforated plate, which causes bubbles to rise rapidly to distribute uniformly. This also decreases the possibility that micro-bubbles are going to outlet directly.

The maintenance cost of DAF is much cheaper than that of other water treatment systems using sedimentation method because DAF does not need any additional flocculants and facilities are easy to create. For that reasons, many studies and measurements have been conducted to increase clarifying water efficiency. Experimental studies have been conducted on the internal fluid flow in order to improve the treatment efficiency of the DAF system. Lundh and Amato measured the internal bubbles' speed by using a laser doppler velocimeter (LDV) with respect to a small-scale pilot plant, which was used as a standard for determining the efficiency of contaminant removal according to the inflow conditions of the wastewater. However, a method using a experimental pilot plant in order to observe the internal flow field of the DAF tank reveals the disadvantages of excessive cost and time consumption. To compensate for the experimental study's disadvantages, computational techniques have made to it possible to calculate the liquid- and vapor-mixed complex multiphase flows numerically in recent years. So, analyses that simulate various flow phenomena occurring in the DAF system are being actively investigated using CFD (Computational Fluid Analysis) program.

DAF system analysis using CFD in this manner can predict a wide range of fluid flow at a low cost in a relatively short time. However, in order to derive physically appropriate results, it is important to apply a proper analysis model for a mixed flow field inside the tank. When we reviewed the studies, most studies used the standard k-ε model to analyze the DAF system. Therefore, we examined the effect of various turbulence models in that field by using the CFD method.

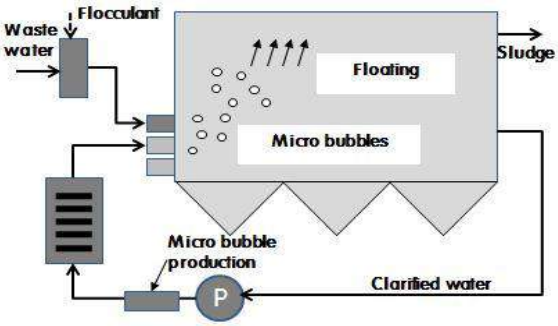


Figure 1: Schematic of a DAF process

Modeling Method

To compare the changes in the flow depending on turbulence model, analysis of the DAF system was performed by adopting the shape and the boundary condition, which were considered in Ryu's study, as shown in Fig. 2. The DAF system size is a length of 9m, and a height of 4m, and the width of the contact zone is modeled as a two-dimensional shape of 0.7 m. We then generated 20,071 structured grids because when we simulate the multiphase flow it changes the distribution of the flow field in accordance with the grid shape, unlike the single-phase flow, which does not depend on grid shape. Also, the waste water from the inlet at the top-right side of the DAF system was introduced. The nozzles were installed on the baffle to inject the micro-bubbles and mix it with the waste water to form a contact zone, and we installed the perforated plate at the bottom.

The boundary conditions applied to the DAF system analysis in this study are summarized in Table 1. First, a velocity inlet condition was used as waste water with micro-bubbles entering from the inlet, and we applied pressure outlet condition to the DAF outlet which set the same pressure as the atmospheric pressure. Then, the degassing condition provided by FLUENT v. 14.5 was used at the water surface to simulate removing the micro-bubbles. In order to better simulate the rotation and laminar flow, the calculation method in the multiphase flow was set to unsteady condition. The diameter of the micro-bubble flowing inside of the DAF system was applied as 120μm, as in Ryu's study and was mixed in the distribution of 0.73% in the circulating water. The percentage of purified water recycling to be used through the inlet was assumed as 10%. Calculation time was set until 2000 sec in time steps of 0.02 sec to observe the distribution of the internal flow field and micro-bubbles after flow fully developed.

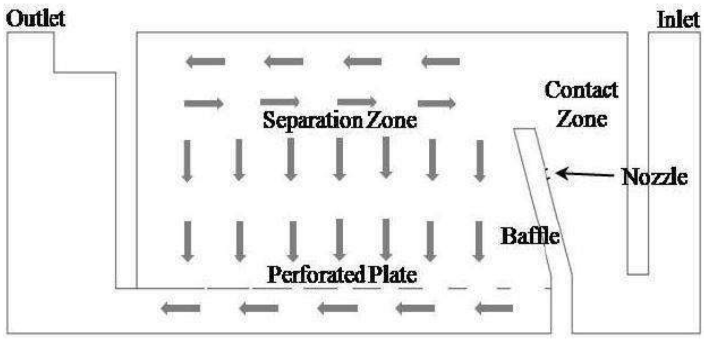


Figure 2: Flow zones of a DAF process

Table 1: Analysis conditions and boundary conditions

Analysis condition		Boundary condition	
Diameter of micro-bubble	120 μm	Waste water inlet	Velocity inlet
Calculation time	2000 sec	Micro-bubble inlet	Velocity inlet
Volume fraction	0.73%	Outlet	Pressure outlet
Flow condition	Unsteady	Water surface	Degassing

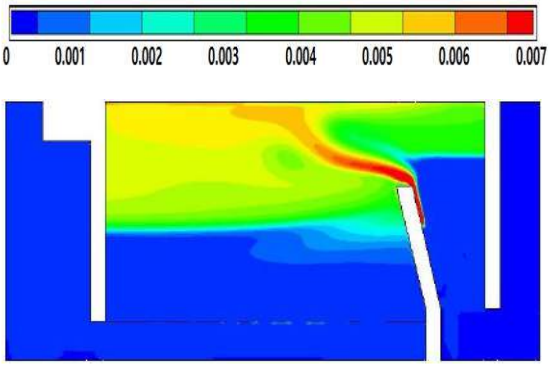
Simulation Results

First, we calculated the change of micro-bubble volume fraction distribution in a two-phase turbulent flow analysis when the five turbulence models provided by the FLUENT were applied to a DAF system. The turbulence models are standard k-ε, realizable k-ε, RNG k-ε, standard k-ω, and SST k-ω, and the micro-bubble volume fraction distributions for each result are presented in Figs. 3(a) - (e).

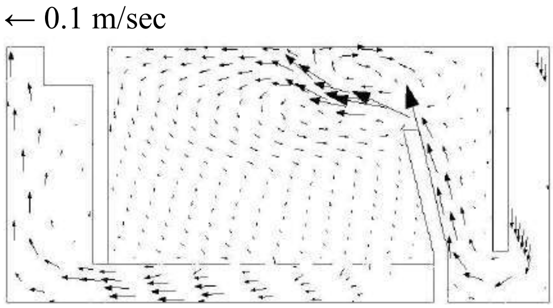
Fig. 3(a) shows the result of standard k-ε, injected micro-bubbles from a nozzle located in the baffle, going over the contact zone and moving across more than half of the separation zone, and then it can be seen that gradually rising to the water surface. On the other hand, when we applied other turbulence models to the DAF system simulation, there were somewhat different tendencies compared with the standard k-ε model. Other models showed very similar results to one another in that micro-bubbles volume fraction are more spaciously distributed in the longitudinal direction and rise to the surface directly, as shown in Figs. 3(e) - (b). The micro-bubbles' average volume fraction was calculated to be about 0.6% while the average of the other results was 0.5% at the mid-point of the surface. The micro-bubbles rise to surface relatively quickly near the baffle because the lateral velocity magnitude underneath the surface is not stronger than the standard k-ε model. It makes micro-bubbles go straight to the opposite side wall making rotating flow, and then go down to the perforated plate. Therefore, other models' micro-bubble volume fraction result at the mid-point of the surface is estimated to be about 0.1% lower than that of the standard k-ε

Meanwhile, the flow simulation results of two turbulence models, which are the RNG k-ε model and realizable k-ε model, were expected to be very similar because they consist of a similar dissipation and turbulent kinetic energy equation. However, the RNG k-ε model predicts the most active circulation flow in the upper part of the separation zone and has a uniform volume fraction distribution over a wide area, as shown in Figs. 3(b) and (c). This was determined due to the RNG k-ε model being theoretically suitable for flow variation having circulation flow with a large deformation, unlike other models. And as shown in Figs. 3(b) and (e), the result of realizable k-ε and SST k-ω models indicate the most similar volume fraction distribution of micro-bubbles.

Thus, the difference between the other turbulence models and the standard k-ε model was estimated because the standard k-ε model is suitable for the analysis of a fully developed turbulent flow at a high Reynolds number, while the flow has somewhat low accuracy when flow changes exist like in the case of a circulation flow at a low Reynolds number. To account for this result, the velocity distribution of the internal turbulent flow of each model are compared, as shown in Fig. 4. The maximum speed of the water and micro-bubbles in the separation zone was about 0.3m/sec, and the Reynolds number with respect to micro-bubble diameter was a maximum of 30, which is found to be available for the general water treatment system and represent a low Reynolds number flow. Furthermore, the momentum that rises to surface applied other turbulence model as shown in Figs. 4(b) - 4(e), is smaller than in the results of the velocity vector of Fig. 4(a) applied to the standard k-ε model. As a result, since the flow velocity at the surface is reduced, it can eventually affect rotational flow generated in the separation zone depending on size and intensity compared with other turbulence model results.



(a) Standard k-ε



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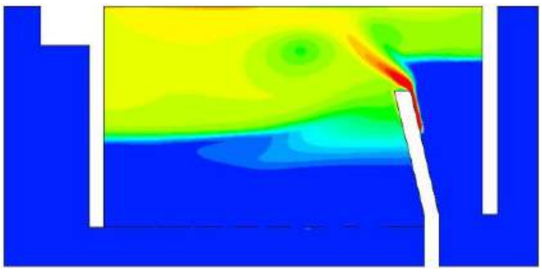
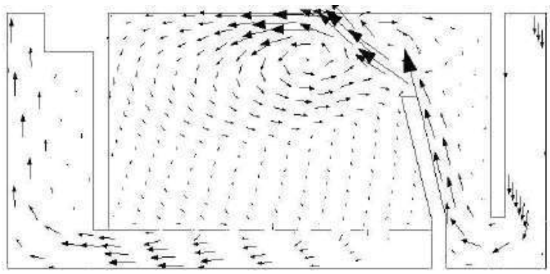
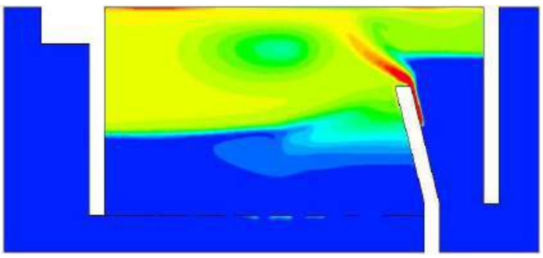


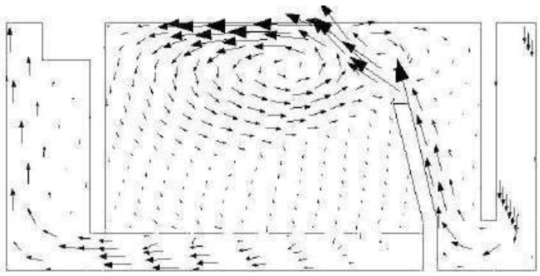
(b) Realizable k-ε



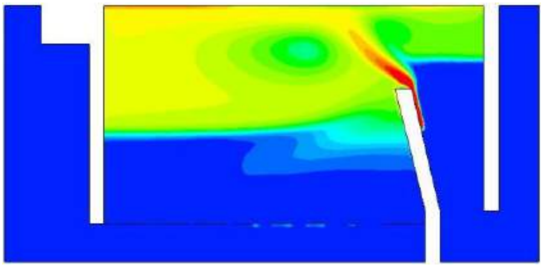
(b) Realizable k-ε



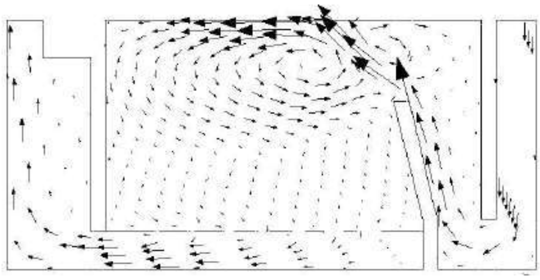
(c) RNG k-ε



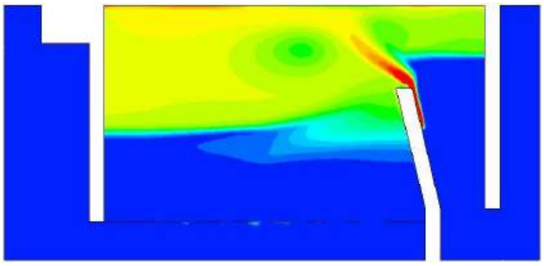
(c) RNG k-ε



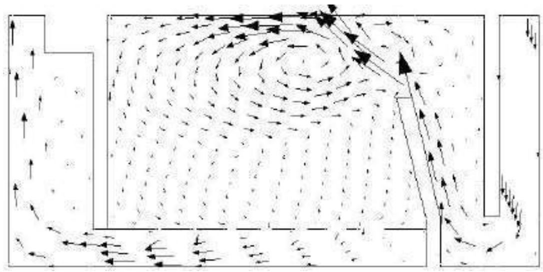
(d) Standard k-ω



(d) Standard k-ω



(e) SST k-ω



(e) SST k-ω

Figure 3: Volume fraction of various turbulence model

Figure 4: Velocity vectors of various turbulence model

Other turbulence models have improved accuracy at a low Reynolds number flow to complement the standard k-ε model, especially if you are changing the flow, such as rotational flow, the turbulent intensity is predicted to relatively low because the turbulent kinetic energy, dissipation rate, and the viscosity are reduced. So, the simulation of the turbulence flow, including the rotational flow of a low Reynolds area compared to the standard k-ε model, was found to be suitable.
When we simulated the low Reynolds number flow including rotational flow, other turbulence models than a standard k-ε model predicted a mutually similar result of micro-bubble velocity vector distribution and simulated fully developed rotational flow. Thus, simply applying the standard k-ε model for the analysis of DAF system internal flow, as in previous studies, is considered unsuitable.

Conclusion

In this study, we investigated the effect of the turbulence model in the internal flow field of the DAF system by using the CFD method. After applying the five kinds of turbulence models, namely the standard k-ε, realizable k-ε, RNG k-ε, standard k-ω, and SST k-ω, for this study, we implemented comparative analysis of the micro-bubble volume fraction and velocity distribution about each model.
Previous studies typically used the standard k-ε model. In this model analysis result, the micro-bubbles that are injected from the nozzle move through more than half of the separation zone and rise to water surface, showing horizontal behavior. On the other hand, other turbulence models predicted that the volume fraction of micro-bubbles are distributed more widely in the separation zone and immediately rise at the same time due to high longitudinal velocity. When the flow changes, such as in the case of a the low Reynolds number zone, or the circulation flow is estimated somewhat less accuracy because the standard k-ε model is suitable for fully developed turbulent flow analysis with a high Reynolds number flow, if the interpretation of a

low Reynolds number flow to rotational flow is generated as shown in this study, the standard k-ε model cannot be calculated as a relatively fully developed rotational flow. So simply applying the standard k-ε model is not suitable for internal flow analysis of DAF systems, as was done in previous studies.

Acknowledgement

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The Effect of Deforestation on Sediment in the Upper River Basin of the Lam Phra Phloeng Reservoir, Thailand

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Abstract

Land use in the upper river basin of the Lam Phra Phloeng reservoir, especially the forested area has mainly been for agricultural and residential purposes. The area suffers periodically from floods and droughts. Increased erosion since forest clearance has led to the increase of sediment load in rivers draining into the reservoir. As a result, sediment deposition in the reservoir gradually decreased the water storage capacity from 150 million m^3 in 1970 to 108 million m^3 in 2014. The objective of this study is to estimate the sediment loaded to the Lam Phra Phloeng reservoir based on the 10% and 25% deforestation using SWAT Model. SWAT is hydrological model which continuously simulate time model and operates on a daily time step at basin scale. The land use map on 2008 and the weather data during January 1981 to March 2010 were computed to simulate the monthly sediment. The results for land use for 10, 20, 50 and 100 year period are provided. If there is 10% deforestation, the accumulated annual sediment at the rainfall return period 10, 20, 50 and 100 year consist of 17.15, 18.33, 21.90 and 31.50 tons/ha, respectively. Also, for the 25% deforest, they are 36.08, 38.12, 45.53 and 65.81 tons/ha at the rainfall return period 10, 20, 50 and 100 year respectively.

Keywords: Deforestation, Erosion, Sediment, SWAT model, Reservoir

Introduction

Erosion is the most important mechanism of land degradation in the study of watershed scale because it adversely affects agricultural productivity through reducing the availability of water, nutrients, and organic matter (Cho and Zoebisch, 2003). The wearing down of a landscape is defined to be one of the erosion process and it is included the detachment, transport, and deposition of soil particles by the erosion forces of raindrops and surface flow of water. Erosion is a matter of concern to watershed and natural resource manager. The main purpose of a reservoirs are water supply and flood control. Erosion upstream of a reservoir deposits sediment in the bottom of the reservoir which lowers the reservoir's water-holding capacity and consequently its usefulness for the both of these purposes.

During 1990-1997, the Southeast Asia has experienced the highest rate of deforestation (0.91% per year) (Lambin et al., 2003). Thailand is a particular case in point (Azam et al., 2008; Singzon, 2006; Biswas, 1999). About 42% of the country was covered with forest in 1973, and the forested area was decreased to 28% by 1988 (Sumarlan, 2004). Then, the Royal Thai Government declared the forest areas closed in 1989 since the forest clearance for agriculture continued, leading to widespread land degradation. However, about one-third of the existing agricultural area was classified as vulnerable to increased soil erosion in 2002 (DEQP and UNEP.RRC.AP, 2006).

The upper area of the Lam Phra Phloeng reservoir is classified to be one of the most active agricultural areas in Thailand (Phetprayoom et al., 2009). During 1974 to 1985, forest area was reduced from 53,100 ha to 16025 ha or about 70% to be agricultural area. The forest area was continuously decreased about 80.35 sq.km from 2002 to 2005 and was converted to agricultural land. Sediment between 2002 and 2005 was found to increase approximately 185,341 tons/year. The result of deforestation has led to the increasing of sediment load in rivers draining into the reservoir. The water storage capacity gradually decreased from 150 million m^3 in 1970 to 121 and 108 million m^3 in 1983 and 2014, respectively (Heijnis et. al, 2003 and Lorsirirat, 2007). It presented that the sediment greatly increased by the land use change. Thus, the study of the upper Lam Phra Phloeng reservoir focuses on one of the most serious sedimentation problems in Thailand.

The objective of this study is to estimate the sediment loaded to the Lam Phra Phloeng reservoir based on the 10% and 25% deforestation using SWAT Model. The data required for SWAT Model can be derived from topographic, soil map, Digital Elevation Model (DEM) and land-use cover classification maps managed by the Land Development Department (LDD). The hydrological data set including evaporation, temperature, humidity, sun radiation, wind speed and rainfall was provided by the Royal Irrigation Department (RID) and Thai Meteorological Department (TMD).

A Description of Study Area

The Lam Phra Phloeng reservoir at 15°30'34" N and 101°50'28"E is located in the Lam Phra Phloeng river basin - part of the Mun river catchment - in the Thai Province of Nakhon Ratchasima shown in Figure 1. The catchment area of the Lam Phra Phloeng river basin is 231,000 ha while the upper river basin of the reservoir is

77,100 sq.km or 33.38%. The annual inflow to reservoir is about 169.75 million m^3/year over the period from 1981 to 2010. The general topography is undulating with many small hills. The elevation varies between 260-1,150 m above mean sea level. The soil texture is predominantly silly loam with gently undulating loam soil.

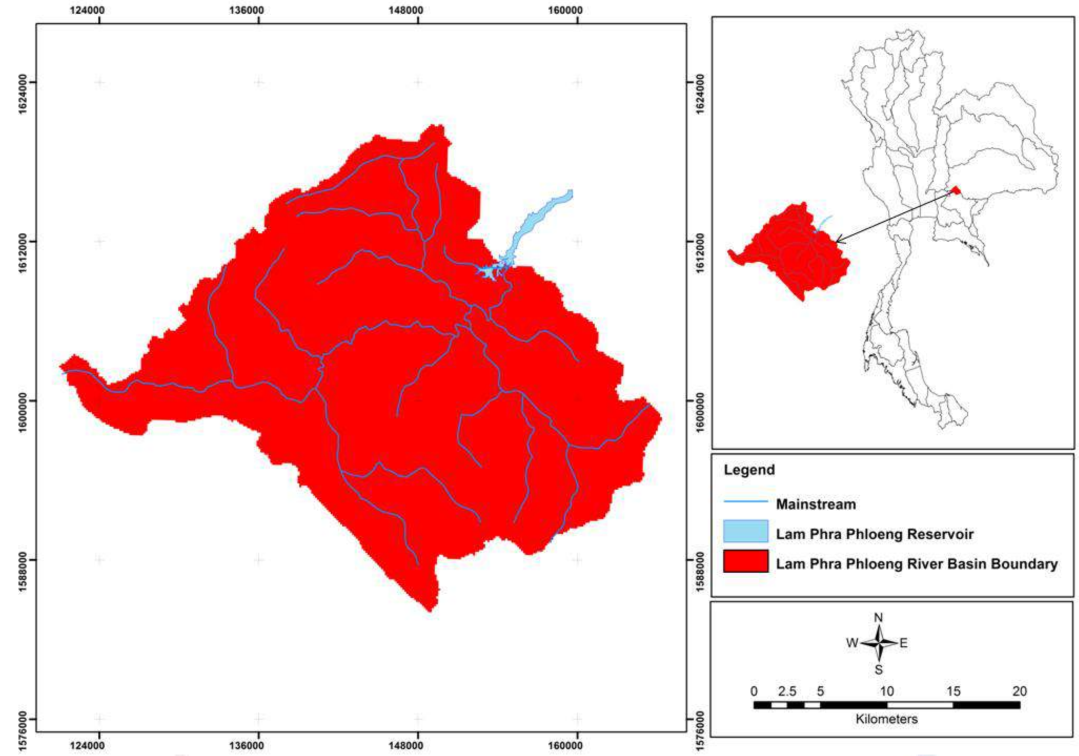

Figure 1: The upper Lam Phra Phloeng reservoir

The climate of the study area is typically tropical savannah affected by monsoon. The rainy season is from May to October while the dry season runs from November to April. The annual rainfall is about 1,135.80 mm/year and ranged from 714.10 to 1,567.60 mm/year for the period 1981 to 2010. Since the study area is in a tropical climatic zone, there are three temperature regimes: cool dry, hot dry, and the rainy season. The cool dry is from mid-October to mid-February and the lowest temperature is in December (23^{o}C). On the other hand, the hot dry runs from mid-February to mid-May and the highest normal daily temperature is 29.7^{o}C (Shahriar et al., 2008).

The initial cropping system was subsistence oriented and mainly based on indigenous knowledge that continued only for a couple of years. Currently, the cropping pattern changed from subsistence to market-oriented farming (Cho and Zoebisch, 2003). In 2008, land use in the upper Lam Phra Phloeng reservoir was dominated for agriculture land (60.78%), forest (34.44%), urban area (3.31%) and water resources (1.47%). Agricultural land is mainly consisted of rice field, maize, sugarcane, cassava and vegetables. The forest is included by tropical rain forest, deciduous forest and wood lot.

Methodology

To determine monthly sediment, daily weather data during 1981 to 2010, digital elevation model (DEM), land use 2008 and soil map were mainly input data for SWAT model. The research methodology is presented in Figure 2.

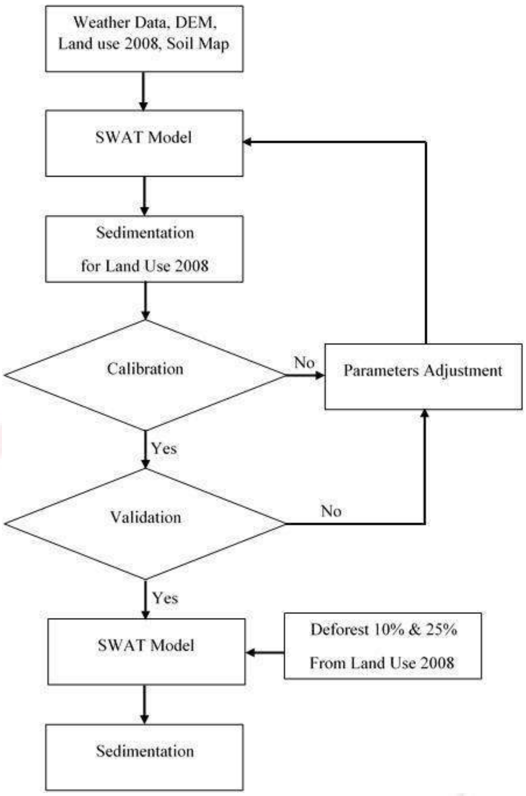

Figure 2: The research methodology for sediment estimation

Soil and Water Assessment Tool (SWAT)

To understand the hydrological cycle change and associated potential of sediment, this study applied SWAT model to evaluate the sediment in the upper Lam Phra Phloeng reservoir. SWAT is hydrological model which continuously simulate time model and operates on a daily time step at basin scale. In watershed scale, all of a range in climatic, soils, topographic, and land use condition are input data. Normally, SWAT is applied to determine hydrology element, sedimentation, nutrients, pesticides, agricultural management, and stream routing (Arnold et al., 1998). However, this study focuses only on a hydrology element that is sedimentation.

Since the study area is included the large scale spatial heterogeneity, considering information from the digital elevation model (DEM), the soil and land use map is divided into sub-basins and each sub-basin is discriminated into a series of hydrologic response units or HRUs, which are unique soil and land use. Moreover, each sub-basin is consisted of slope, reach dimensions, and climate data. For climate data, the station nearest to the centroid of each sub-basin is considered. The routing through the river system is concerned using the variable storage or Muskingum method (Abbaspour et al., 2007). Since the weather station network in the study area is not very dense and data duration is quite short, to simulate missing data, the weather generator program WXGEN is applied in SWAT model. The WXGEN program fills data gap or extends time series of daily data based on monthly statistics (Schuol et al., 2008).

To compute sediment, the surface runoff is firstly computed using the concept of water balance and the sediment is then estimated using the concept of the Modified Universal Soil Loss Equation (MUSLE) (William, 1975). The concept of water balance is concerned using the elements of hydrology cycle shown in equation (1) and (2). To accurately calculate water balance, there are two major divisions of hydrologic cycle for the watershed. Firstly, the land phase of the hydrologic cycle is analyzed to control the amount of water loading to the main channel in each sub-watershed. Secondary, the water phase of the hydrologic cycle is calculated for the movement of water through the channel network of the watershed to the outlet.

$$S_f = S_i + \sum_{i=1}^{t} (P - Q_s - ET - w - Q_g) \tag{1}$$

where S_f is the final soil water content (mm H_2O), S_i is the initial soil water content (mm H_2O), t is the time (days), P is the precipitation on day i (mm H_2O), Q_s is the surface runoff on day i (mm H_2O), ET is evapotranspiration on day i (mm H_2O), w is the water entering the vadose zone from the soil profile on day i (mm H_2O), and Q_g is the return flow on day i (mm H_2O).

$$Q_s = \frac{(P - I_a)^2}{(P - I_a + S)} \tag{2}$$

where I_a is the initial abstractions included surface storage, interception and infiltration prior to runoff (mm H_2O), and S is the retention parameter (mm H_2O) that depends on the change of soil, land use, management and slope.

The Modified Universal Soil Loss Equation (MUSLE) is applied to compute erosion caused by rainfall and runoff (William, 1975). MUSLE is a modified version of the Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith (1960, 1978). The average annual gross erosion as a function of rainfall energy is predicted USLE. In MUSLE, the rainfall energy factor is replaced with a runoff factor. This improves the sediment yield prediction, eliminated the need for delivery ratios, and allows the equation to be applied to individual storm events.

The sediment is computed by using the Modified Universal Soil Loss Equation (MUSLE) (William, 1995) shown in equation (3):

$$Sed = 11.8(Q_{surf} * q_{peak} * area_{hru})^{0.56} * K_{USLE} * C_{USLE} * P_{USLE} * LS_{USLE} * CFRG \tag{3}$$

where *sed* is the sediment yield on a given day (metric tons), Q_{surf} is the surface runoff volume (mm H_2O/ha), q_{peak} is the peak runoff rate (m /s), $area_{hru}$ is the area of the HRU (ha), K_{USLE} is the Universal Soil Loss Equation (USLE) soil erodibility factor (0.013 metric ton $m^2hr/(m^3$-metric ton cm)), C_{USLE} is the USLE cover and management factor, P_{USLE} is the USLE support practice factor, LS_{USLE} is the USLE topographic factor and CFRG is the coarse fragment factor.

The modified version of the rational equation is applied to compute the peak runoff rate shown in equation (4).

$$q_{peak} = \frac{C \cdot i \cdot A}{3.6} \tag{4}$$

where q_{peak} is the peak runoff rate ($m^3.s^{-1}$), i is the rainfall intensity ($mm.h^{-1}$), A is the subbasin area (km^2), and 3.6 is a unit conversion factor.

The soil erodibility factor is defined as the soil loss rate per erosion index unit for a specified soil as measured on a unit plot. A unit plot is 22.2-m (72.6-ft) long, with a uniform length-wise slope 9%, in continuous fallow, tilled up and down the slope. Direct measurement of the erodibility factor is time consuming and costly (Wischmeier and Smith, 1978). Moreover, a general equation to calculate the soil erodibility factor, when the silt and very fine sand content makes up less than 70% of the soil particle size distribution, is developed by Wischmeier et al. (1971) presented in equation (5):

$$K_{USLE} = [0.00021*M1.14*(12-OM) + 3.25*(c_{soilstr}-2) + 2.5*(c_{perm}-3)]/100 \tag{5}$$

where M is the particle size parameter, OM is the percent organic matter (%),$c_{soilstr}$ is the soil structure code used in soil classification, and c_{perm} is the profile permeability class.

The USLE cover and management factor or C_{USLE} is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from clean-tilled (Wischmeier and Smith, 1978). Since plant cover varies during the growth cycle of the plant, SWAT updates C_{USLE} daily using the equation (6):

$$C_{USLE} = \exp\left([\ln(0.8) - \ln(C_{USLE,\,mm})]*\exp[-0.00115*rsd_{surf}] + \ln[C_{USLE,\,mm}]\right) \tag{6}$$

The support practice factor or P_{USLE} is the ratio of soil loss with a specific support practice to the corresponding loss with up-and –down slope culture. Wischmeier and Smith (1978) define the P factor values and slope-length limits for contouring as Table 1.

Table 1 P factor values and slope-length limits for contouring

Land slope (%)	P_{USLE}	Maximum length (m)
1 to 2	0.60	122
3 to 5	0.50	91
6 to 8	0.50	61
9 to 12	0.60	37
13 to 16	0.70	24
17 to 20	0.80	18
21 to 25	0.90	15

The topography factor or LS_{USLE} is defined as the expected ratio of soil loss per unit area from a field slope to that from a 22.1 m length of uniform 9% slope under otherwise identical conditions. The topographic factor is calculated by equation (7):

$$LS_{USLE} = (L_{hill}/22.1)^{m}*(65.41*\sin^2(\alpha_{hill}) + 4.56*\sin\alpha_{hill} + 0.065) \quad (7)$$

where L_{hill} is the slope length (m), m is the exponential term, and α_{hill} is the angle of the slope.

The coarse fragment factor, CFRG, is calculated by equation (8):

$$CFRG = \exp(-0.053*rock) \quad (8)$$

where *rock* is the percent rock in the first soil layer (%).

SWAT Model Sensitivity Analysis

Sensitivity analysis was conducted to concern the influence of parameters that had on estimating sediment. Parameters were analyzed for the sensitivity analysis of calibration and validation parameters shown in Table 2.

Table 2 The calibration and validation parameters for sensitivity analysis

Parameter	Value
Spcon: Linear parameter for calculating the maximum amount of sediment that can be reentrained during channel sediment routing	0.001
Spexp: Exponent parameter for calculating sediment reentrained in channel sediment routing	1.2
Usle_P: USLE equation support practice	0.18

Calibration and Validation

The calibration and validation focused on the periods of January 2003 – December 2006 and January 2007 – March 2010, respectively. Calibration and validation were completed by comparing time series model results to gaged monthly sediment at station M171 located in the upper reservoir. Two criteria for the goodness of fit – the graphical comparison and the Nash-Sutcliffe efficiency (NSE) coefficient – were used for calibration and validation. Graphical comparison is extremely useful for judging the results of model calibration and model validation. It is overlooked by coefficient of determination (R^2). The graphical comparisons of calibration and validation are presented in Figure 3 (R^2 = 0.93) and Figure 4 (R^2 = 0.97), respectively. In addition, the Nash-Sutcliffe efficiency (NSE) coefficient is an indicator of a model ability to predict about the 1:1 line. The NSE coefficients for calibration and validation are 0.87 and 0.90, respectively. The closer the value is to 1.0, the more accurate the model.

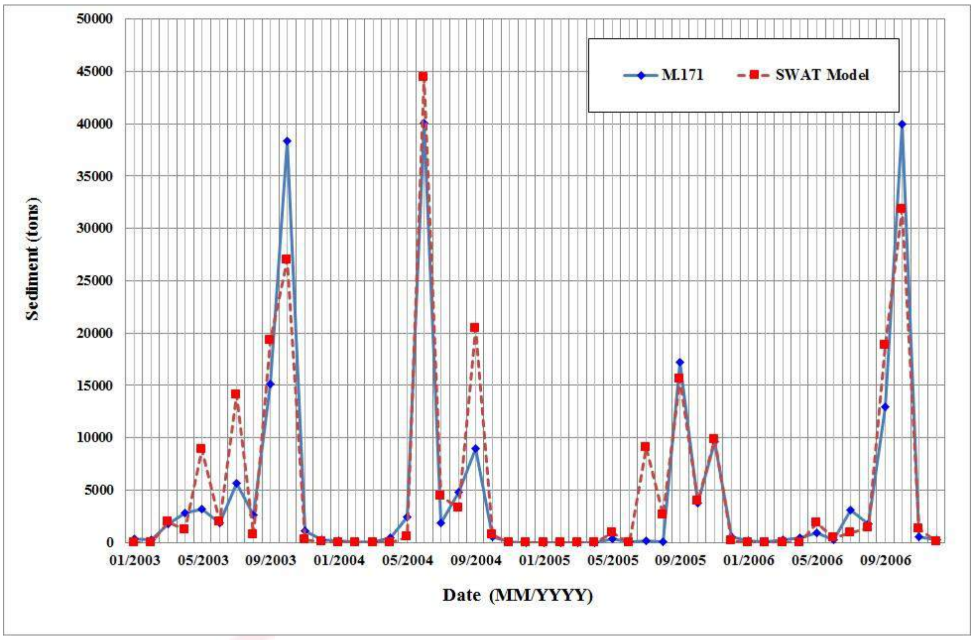

Figure 3: The comparison of mean monthly sediment between SWAT model and recorded data at M171 station during January 2003 – December 2006

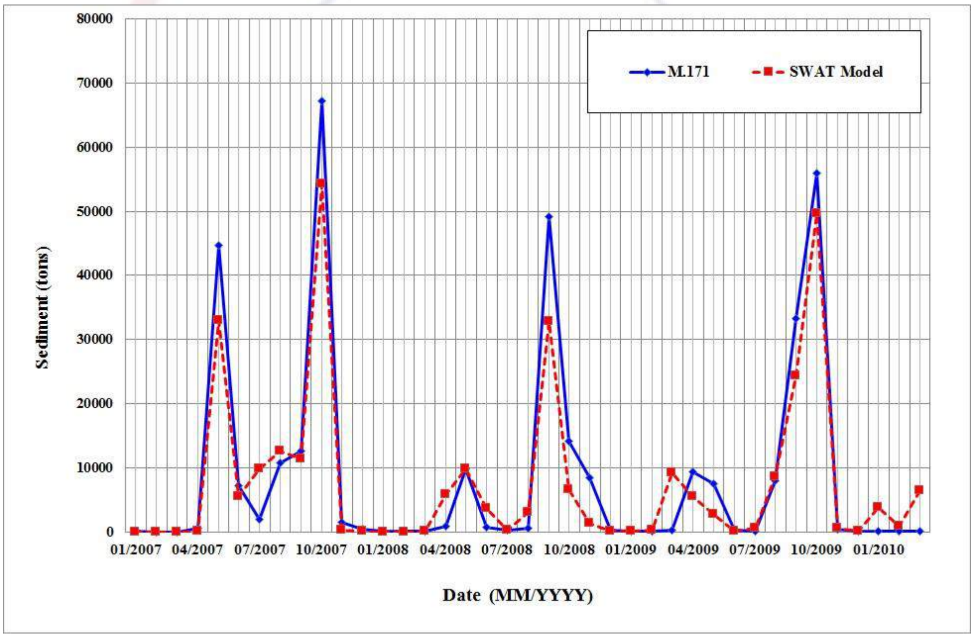

Figure 4: The comparison of mean monthly sediment between SWAT model and recorded data at M171 station during January 2007 – March 2010

After SWAT model was calibrated and validated based on land use 2008, this model was analyzed to predict monthly sedimentation for 10% and 25% deforestation. The forest area was transformed to agricultural area as the past. For 10% deforestation, forest area and agricultural area were 28.36% and 66.86%, respectively. On the other hand, for 25% deforestation, forest area and agricultural area were comprised by 19.25% and 75.96%, respectively. However, urban area and water resources were not changed for this study.

Results and Discussion

The upper Lam Phra Phloeng reservoir was classified to 17 sub-basin and 248 HRUs based on DEM, land use, soil type and slope. The sediments for rainfall return period 10, 20, 50, and 100 year are presented in Table 3. They can be explained that, in land use 2008, the accumulated annual sediment occurred in the upper reservoir for return period 10, 20, 50, and 100 year are 14.68, 15.68, 18.96, and 27.40 tons/ha, respectively. Moreover, the accumulated annual sediment drained to the reservoir for return period 10, 20, 50, and 100 year are 784900, 858500, 1080000, and 1607000 tons, respectively.

In the case of 10% deforestation, the accumulated annual sediment in the upper reservoir for return period 10, 20, 50, and 100 year are included 17.15, 18.33, 21.90, and 31.50 tons/ha, respectively. They increases about 14%-17% from the accumulated annual sediment in land use 2008. The accumulated annual sediment flow to the reservoir for return period 10, 20, 50, and 100 year are contained 916000, 1001000, 1246000, and 1846000 tons, respectively and they also accrue about 14%-17% from that in 2008.

For 25% deforestation, the accumulated annual sediment in the upper basin for return period 10, 20, 50, and 100 year are 36.08, 38.12, 45.53, and 65.81 tons/ha, respectively and they are more than that in land use 2008 about 140% - 146%. The accumulated annual sediment loaded to the reservoir for return period 10, 20, 50, and 100 year are 1767000, 1941000, 242000, and 3648000 tons, respectively. They increases about 125% - 127% from that in 2008.

Furthermore, the results present that if monthly rainfall is less than 100 mm, sediment is insignificantly affected by rainfall. On the other hand, the high sedimentation loaded to reservoir occurs during rainy season and it is due to the inflow from the tributary as well as eroded materials that come from the upland area to the reservoir.

Conclusion

The forest conservation in the upper basin of reservoir should be importantly concerned since raindrop impact can detach soil particles on unprotected land surfaces between rills and initiate transport of these particles to the rills. From the small rills, the particles move to larger rills, into ephemeral channels and then into continuously flowing rivers and reservoir. Entrainment and deposition of particles can occur at any point along the path. Thereafter, the settlement of sediment in the reservoir will bring about a rapid reduction of the ability to storage the maximum quantity of water. The results of this study are a help to policy makers, managers and planners for the appropriate land use planning, management and conservation practices in the study area for reducing the soil erosion.

Additionally, the concerns about water resources management, specifically catchment scale decision making, can be addressed with information on the hydrological processes of sediment generation. Such a case study of sedimentation, represented by simulation data, can be applied to the water resources planning and development.

Return Period	Month	Rainfall (mm)	Mean Sediment (t/ha)			Sediment loaded to reservoir (ton)		
			Land use 2008	Deforest 10%	Deforest 25%	Land use 2008	Deforest 10%	Deforest 25%
10	1	1.41	0.00	0.00	0.00	0.33	0.35	0.43
	2	9.93	0.00	0.00	0.00	0.01	0.02	0.03
	3	52.51	0.02	0.03	0.06	957.70	1,133.00	2,588.00
	4	140.28	0.77	0.94	1.97	31,450.00	38,440.00	66,510.00
	5	213.07	2.46	2.90	5.88	121,100.00	143,200.00	259,700.00
	6	134.89	1.25	1.42	3.03	66,840.00	76,140.00	149,200.00
	7	104.93	1.64	1.83	4.01	98,160.00	109,600.00	227,600.00
	8	178.60	4.54	5.37	11.46	246,400.00	290,900.00	572,500.00
	9	100.59	0.87	1.06	2.16	41,470.00	50,280.00	88,970.00
	10	196.88	3.12	3.61	7.51	178,000.00	205,900.00	399,700.00
	11	14.35	0.00	0.00	0.00	414.00	422.00	424.50
	12	0.00	0.00	0.00	0.00	46.27	45.95	43.56
	Total	1147.45	14.68	17.15	36.08	784,900.00	916,000.00	1,767,000.00
20	1	5.08	0.00	0.00	0.00	0.33	0.34	0.34
	2	8.05	0.00	0.00	0.00	0.15	0.15	0.14
	3	58.23	0.01	0.01	0.02	248.20	281.50	712.00
	4	183.99	2.19	2.64	5.47	110,600.00	131,700.00	252,900.00
	5	143.83	2.38	2.77	5.74	126,200.00	147,200.00	280,000.00
	6	93.38	0.94	1.09	2.40	48,120.00	55,440.00	111,300.00
	7	29.56	0.03	0.04	0.06	1,405.00	1,895.00	3,001.00
	8	128.56	0.66	0.73	1.56	36,850.00	41,470.00	85,190.00
	9	353.21	7.78	9.04	18.86	442,500.00	513,800.00	1,013,000.00
	10	168.11	1.37	1.61	3.24	75,130.00	87,920.00	160,400.00
	11	35.28	0.33	0.40	0.77	17,200.00	20,760.00	33,710.00
	12	3.06	0.00	0.00	0.00	234.10	235.40	238.40
	Total	1210.34	15.68	18.33	38.12	858,500.00	1,001,000.00	1,941,000.00
50	1	3.54	0.00	0.00	0.00	3.61	4.08	5.01
	2	5.10	0.00	0.00	0.00	0.00	0.01	0.01
	3	32.35	0.01	0.01	0.02	110.30	138.10	276.90
	4	157.61	0.40	0.47	0.96	17,070.00	20,460.00	36,060.00
	5	265.44	5.60	6.46	13.41	327,400.00	376,800.00	749,400.00
	6	140.86	1.57	1.74	3.80	92,820.00	102,500.00	211,800.00
	7	59.59	0.68	0.79	1.55	40,650.00	47,880.00	89,520.00
	8	157.36	2.32	2.66	5.63	130,600.00	149,500.00	299,100.00
	9	201.17	2.92	3.34	7.03	168,700.00	193,300.00	379,500.00
	10	286.43	5.16	6.07	12.49	286,500.00	336,500.00	647,300.00
	11	52.01	0.30	0.36	0.66	15,370.00	18,840.00	29,090.00
	12	0.73	0.00	0.00	0.00	250.30	261.10	286.10
	Total	1362.2	18.96	21.90	45.53	1,080,000.00	1,246,000.00	2,442,000.00
100	1	0.00	0.00	0.00	0.00	0.25	0.33	0.48
	2	39.81	0.05	0.06	0.14	1,837.00	2,230.00	4,301.00
	3	14.34	0.00	0.00	0.00	3.29	5.99	6.28
	4	170.68	1.58	1.75	3.72	94,010.00	104,800.00	214,800.00
	5	231.03	6.32	7.10	15.23	390,200.00	438,900.00	912,800.00

	6	160.01	2.98	3.47	7.43	159,600.00	185,900.00	363,000.00
	7	100.2	0.98	1.10	2.31	59,030.00	66,570.00	133,500.00
	8	170.63	3.18	3.66	7.88	175,500.00	201,800.00	407,600.00
	9	375.07	7.30	8.42	17.30	435,400.00	502,200.00	976,300.00
	10	178.09	3.02	3.66	7.03	174,500.00	209,800.00	377,700.00
	11	118.52	1.99	2.28	4.77	116,400.00	133,000.00	257,600.00
	12	0.00	0.00	0.00	0.00	315.60	314.80	299.00
	Total	1558.39	27.40	31.50	65.81	1,607,000.00	1,846,000.00	3,648,000.00

Table 3 Mean sediment and sediment flow to reservoir for return period 10, 20, 50, and 100 year

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Solar Photocatalytic Degradation of 4-Chlorophenol in Water with Novel Shell-Core P3HT@Tio_2 Nanoparticles

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Abstract
Shell-core poly 3-hexylthiophene (P3HT)@TiO_2 nanoparticles were synthesized by a physical deposition method using tetrahydrofuran (THF) as a solvent of P3HT in a P-25 TiO_2/THF suspension. The P3HT@TiO_2 nanoparticles were characterized by Scanning Electron Microscope (SEM), X-ray Energy Dispersive Spectrometer (EDS), X-ray diffraction (XRD), UV/VIS Diffuse Reflectance Spectroscopy (UV/VIS DRS), and Fourier Transform Infrared Spectroscopy (FTIR). The spectrum of UV/VIS DRS showed that the P3HT@TiO_2 nanoparticles are more responsive to visible light and 1% of the P3HT content of P3HT@TiO_2 nanoparticles could increase the absorption up to 75% in the band of visible light. 4-chlorophenol (4-CP) was used as the target pollutant in aqueous media to assess the solar photocatalytic activities of the P3HT@TiO_2 nanoparticles. Response surface methodology (RSM) with a 3*3 experimental design of Box-Behnken was applied to investigate the effect of critical process parameters ([catalyst], P3HT content, composites catalyst percentage) on treatment performance in terms of 4-CP degradation efficiency. It was found that the optimized reaction conditions were established as a photocatalyst dosage of 1.0 g/L, a P3HT of 0.5% in P3HT@TiO_2 and a 25% P3HT@TiO_2 of total photocatalyst dosage for a 4-CP degradation efficiency of 95%. Under the optimized reaction conditions, the TOC mineralization efficiency of 4-CP wastewater increased 16.3% as compared to that of TiO_2 process for a reaction time of 120 min. As a result, the hybrid of P3HT onto the surface of TiO_2 could extend successfully the visible light photoresponse range of TiO_2 and could effectively enhance TiO_2 solar photoactivity.

Keywords: solar photocatalytic degradation, 4-chlorophenol, P3HT@TiO_2, response surface methodology

Introduction

Energy conservation and carbon reduction are important issues in the world currently. Solar energy is an essentially unlimited alternative to fossil energy and its utilization is ecologically benign. In the wastewater treatment sector, solar technology can be used as alternative to UV lamps to reduce the operation cost in advanced oxidation processes (AOPs). AOPs are able to produce a highly reactive, nonspecific oxidant, mainly hydroxyl radicals (·OH). The hydroxyl radical possesses inherent properties that enable it to attack refractory organic pollutants in water to achieve a complete mineralization. Among the AOPs, TiO_2 photocatalysis (eq. (1-3)) using solar irradiation has been used as an economically viable process and has attracted great interest in recent years (Malato *et al.*, 2009). However, due to the intrinsic structure characteristics and broad band gap (3.2 eV for anatase) of TiO_2, TiO_2 can only be excited by ultraviolet light (<387nm) (which is less than 5% in solar light) to produce photoinduced hole–electron pairs and the inherent recombination of photo-generated electron-hole pairs, resulting in a low utilization of solar energy and photocatalytic activity.

$$\mathrm{TiO}_2 \xrightarrow{h\nu(\lambda<382nm)} h_{vb}^{+} + e_{cb}^{-} \tag{1}$$

$$h_{vb}^{+} + \mathrm{H_2O} \rightarrow \cdot\mathrm{OH} + \mathrm{H}^{+} \tag{2}$$

$$h_{vb}^{+} + \mathrm{OH}^{-} \rightarrow \cdot\mathrm{OH} \tag{3}$$

To eliminate these drawbacks of TiO_2, dye-sensitized photocatalytic materials exhibit high efficiency in degradation of organic pollutants and utilization of visible light has been hybridized with TiO_2. However, the stability of dye with low molecular weight has been suggested as one of the critical factors limiting the long-term performance of the dye-sensitized photacatalytic materials. In recent years, conjugated polymers such as polythiophenes, polypyrroles, polyanilines and their derivates are extensively be applied in photocatalytic area to sensitize TiO_2 and produce polymer/TiO_2 photocatalytic composite materials. Poly(3-hexylthiophene)(P3HT) has a higher charge carrier mobility, dissolubility and processability, long-term stability and a broad and strong absorption invisible region (with bandgap of 1.9–2.0 eV) (Motaung *et al.*, 2009). Therefore, it should be a good candidate for a sensitizer of TiO_2. Under UV light irradiation as shown in Figure 1, P3HT promote the separation efficiency of photoinduced electron–hole pairs due to high mobility of photoinduced holes in P3HT conjugated polymer bone (Zhu and Dan, 2010). Under visible light irradiation as shown in Figure 2, P3HT are excited to produce photoinduced electron–hole pairs. And then the photoinduced electrons inject into the conduction band (CB) of TiO_2. They will react with the electron acceptors such as oxygen adsorbing on the surface of TiO_2 to generate oxidative species, such as hydroxyl radicals and superoxide radicals (Xu *et al.*, 2011).

Chlorophenols (CPs) have been notified as potential toxic compounds by United States Environmental Protection Agency (USEPA) and constitute an important category of organic water pollutants that are not readily biodegradable (Abe and Tanaka, 1997). Consequently, conventional biological treatment is not very effective and activated carbon adsorption is commonly used for removing CPs from chemical effluents. However, the need of frequent carbon reactivation renders this process both inconvenient and costly. Advanced oxidation processes (AOPs) have been previously described as a promising option to remove persistent pollutants from contaminated water (Al Momani, 2006) when conventional water treatment processes are not efficient enough.

In this study, P3HT@TiO_2 composite nano-particles were prepared and assessed for their solar photocatalytic activities in degrading 4-chlorophenol in water. Response surface methodology (RSM) was employed to obtain the optimal reaction conditions of critical process parameters (including photocatalyst dosage, g/L; P3HT@TiO_2, %; P3HT@TiO_2/(P3HT@TiO_2+TiO_2), %) to reach a 4-CP degradation efficiency of 95%.

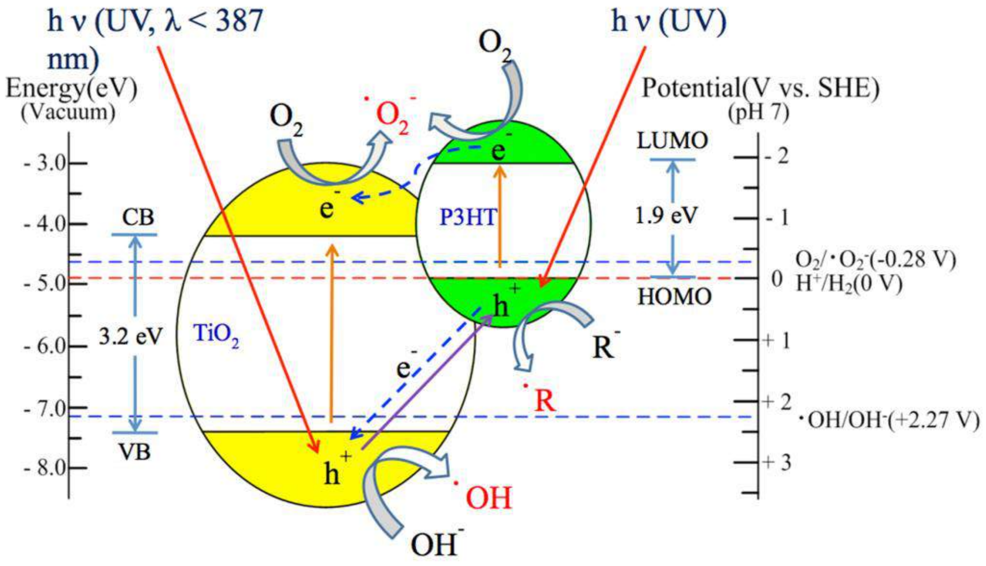

Figure 1: Electron transfer pathway on P3HT@TiO_2 composite under UV irradiation (Zhang, 2014)

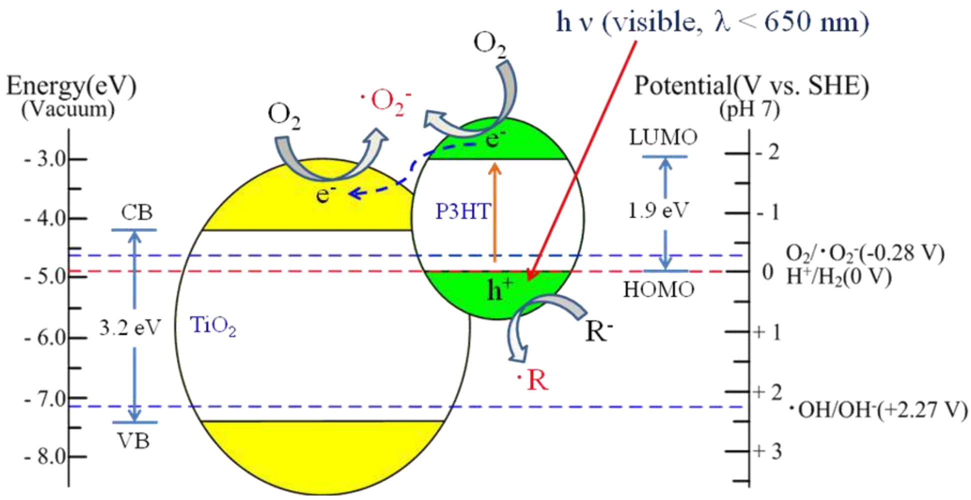

Figure 2: Electron transfer pathway on P3HT@TiO_2 composite under VIS irradiation (Zhang, 2014)

Material and Methods

Materials and Sample Preparation

4-CP with a purity of 99% were purchased from Acros Co., USA and used without further purification. An initial 4-CP concentration of 50 mg/L was prepared for all experimental runs. TiO_2 powder - P25 (mainly anatase form, with a mean particle size of 30 nm and a BET surface area of 50±15 m^2/g) from Degussa Co. (Frankfurt, Germany) were used in this study. HPLC grade methanol (J.T. Baker Co., USA) was employed as eluent. P3HT (MW: 40,000 - 80,000) with a purity of 99.9% were purchased from Uni-Ward Co., Taiwan and used without further purification. All other chemicals used in this study were analytical grade and used as received. The shell-core P3HT@TiO_2 composite particles were synthesized by a physical deposition method using tetrahydrofuran (THF) as a solvent of P3HT in a TiO_2/THF suspension. The composites are labeled as P3HT(X %)/TiO_2, where X corresponds to the P3HT content in the composites.

Characteristic Analysis of P3HT@TiO_2 Composites

The shell-core P3HT@TiO_2 composites were characterized by a JEOL JSM-6700F Scanning Electron Microscope (SEM)/ X-ray Energy Dispersive Spectrometer (EDS), a Rigaku TTRAX III X-ray diffraction (XRD), a Hitachi U-3900 UV/VIS Diffuse Reflectance Spectroscopy (UV/VIS DRS), and a Microtrac S3500 Laser diffraction particle size analyzer.

Experimental Procedures

All experiments were carried out in a batch mode and performed under artificial solar light irradiation. A 0.7-L stainless steel beaker containing 200 mL of 4-CP solution was used. In this study, a 3 factors * 3 levels experimental design with three replicates at center point according to the methodology of response surface (Box *et al.*, 1978) as shown in Table 1 was applied to investigate the influence of three factors (namely, photocatalyst dosage, g/L; P3HT@TiO_2, %; P3HT@TiO_2/(P3HT@TiO_2+TiO_2), %) for 4-CP and TOC degradation efficiency. In the RSM runs, the prepared 4-CP solution was placed into the photoreactor and irradiated by a 1500 W Xe lamp in an ATLAS Suntest CPS+ solar simulator (ATLAS Co., USA) emitting artificial solar light with a spectral distribution resembling the solar spectrum (300 – 800 nm) in which the $UV_{280\text{-}400nm}$ intensity is around 55±1.0 W/m^2 as showed in Figure 3. In addition, the 4-CP solution was maintained at 25±0.5 ^0C in a water bath. During the experiments, the pH of the solution was monitored using a pH meter (SP-701LI 120, Suntex Co., Taiwan) equipped with a glass electrode. Samples were withdrawn from the reactor at preset time intervals and then stored at 4 ^0C for the following 4-CP, TOC and IC analysis.

Table 1: Experimental range and levels of the process independent variables

	Factor	Range and level		
Independent variable		**-1**	**0**	**+1**
Photocatalyst dosage, g/L	X_1	0.5	1.0	1.5
P3HT@TiO_2, %	X_2	0.1	0.5	1.0
P3HT@TiO_2/(P3HT@TiO_2+TiO_2), %	X_3	25	50	75
Y (Response) – 4-CP degradation, %				

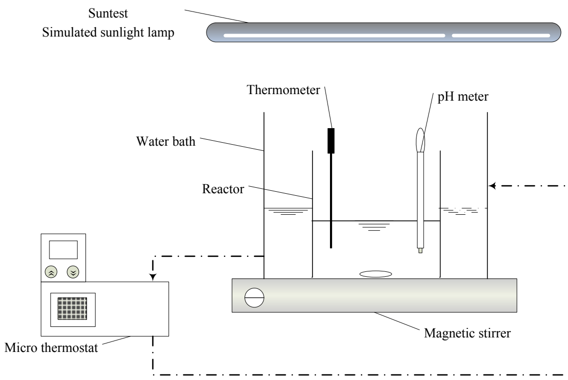

Figure 3: Schematic diagram of the solar photocatalytic reactor

Analysis

Analytical Measurement of 4-CP

Residual 4-CP in solution was analyzed by HPLC using a Jasco system (Japan). This system was equipped with two PU1580 of pumps and a MD-2010 of PDA detector setting at a wavelength of 280 nm for 4-CP analysis. A Supelco C-18 reversed phase column (L: 25 cm, ID: 4.6 mm, particle size: 5 lm) was used. The mobile phase was a mixture of methanol (50%) and deionized water (50%). The flow rate of mobile phase was set at 1 mL/min. Under the analytical conditions, the retention time of 4-CP was 19.3 ± 0.1 min.

Total Organic Carbon (TOC) Measurement

TOC of solution was measured by using a Shimadzu VCPH analyzer (Shimadzu Co., Japan) in order to know the amount of 4-CP molecules degraded to CO_2 during oxidation.

Results and discussion

Characteristics of the P3HT@TiO_2 Photocatalysts

Fig. 4 shows the appearance of TiO_2 and P3HT(X%)@TiO_2 powder. As showed in Fig. 4, the more the P3HT content on TiO_2, the more purple the color of the composite. Fig. 5 shows the UV-VIS diffuse reflectance spectra of TiO_2 and P3HT(X%)@TiO_2 and P3HT powder. It found that TiO_2 powder could only absorb UV light with wavelength lower than 390 nm while the pure P3HT powder can absorb

UV and VIS light with wavelength lower than 650 nm because of its narrow band gap (1.9 – 2.0 eV). P3HT@TiO_2 composites can absorb both UV light (200 – 400 nm) and visible light (400 – 700 nm). This may be due to the characteristic absorption of TiO_2 and the P3HT absorption band in the UV light region. Also, it is attributed to the electron transition from the valence bond to the antibonding polar on state (π-π* type) of P3HT in the VIS band (Zhu and Dan, 2010). With an increase of P3HT content, the absorbance for P3HT@TiO_2 composites increases in the visible light region. This result was similar to that showed in the study of Zhu and Dan (2010). In this study, P3HT(1%)@TiO_2 composites could increase the absorption up to 75% in the band of visible light.

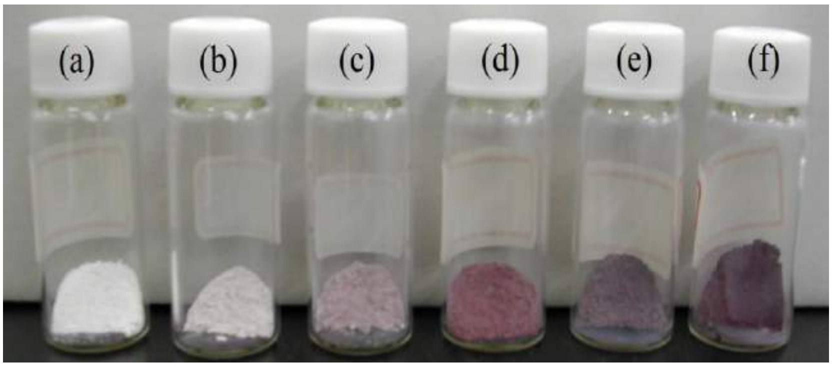

Figure 4: Photograph of the powders - (a) P-25 TiO_2; (b) P3HT(0.1%)@TiO_2;(c) P3HT(0.5%)@TiO_2; (d) P3HT(1%)@TiO_2; (e) P3HT(2%)@TiO_2; (f) P3HT(4%)@TiO_2

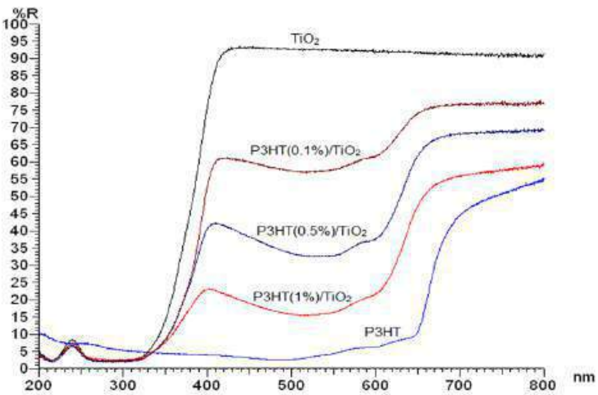

Figure 5: UV-VIS diffuse reflectance spectra of TiO_2, P3HT(X%)@TiO_2 and P3HT powders

Powder XRD analysis confirmed the presence of TiO_2 mainly with anatase phase in the composites as showed in Fig. 6 (a). Also, the representative peak (5.3^0) of P3HT appeared in Fig. 6 (c), illustrating the existence of P3HT in P3HT@TiO_2 composite. In addition, Fig. 7 showed the SEM images of TiO_2 and P3HT@TiO_2 composites. As shown in Fig. 7, P3HT polymers were homogeneously dispersed onto the surface of TiO_2. The particle size of TiO_2 and P3HT@TiO_2 were estimated to be in the same range. The results of laser particle size analysis (Fig. 8) showed that the mean size of these two photocatalysts as be dispersed in water during experiments were to be in the range of 3.0 – 3.2 μm.

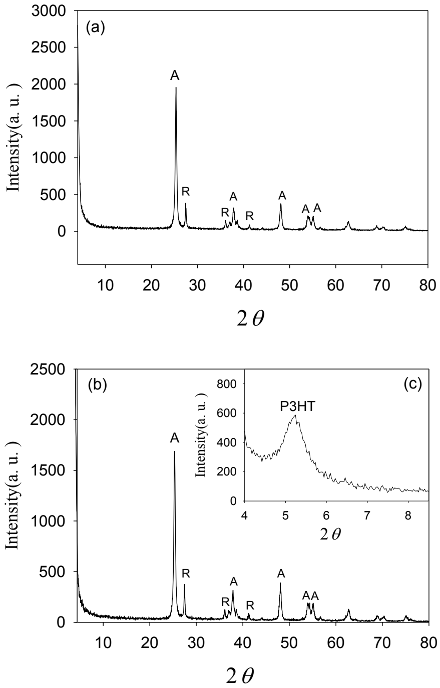

Figure 6: XRD patterns of the powder of ((a) TiO_2; (b) P3HT(1%)@TiO_2; (c) P3HT(4%)@TiO_2)

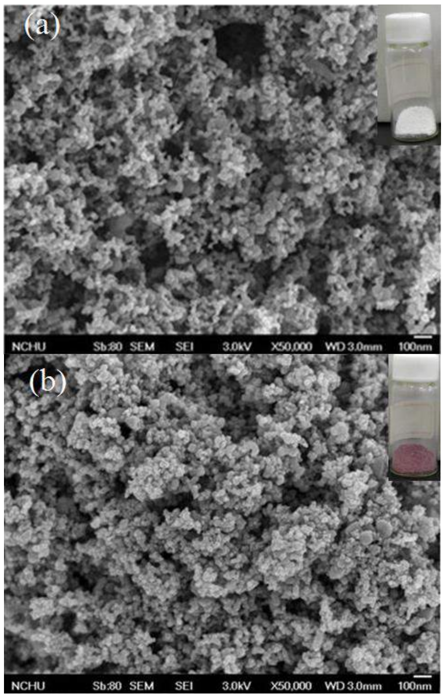

Figure 7: SEM images of (a) TiO_2 and (b) P3HT(1%)@TiO_2

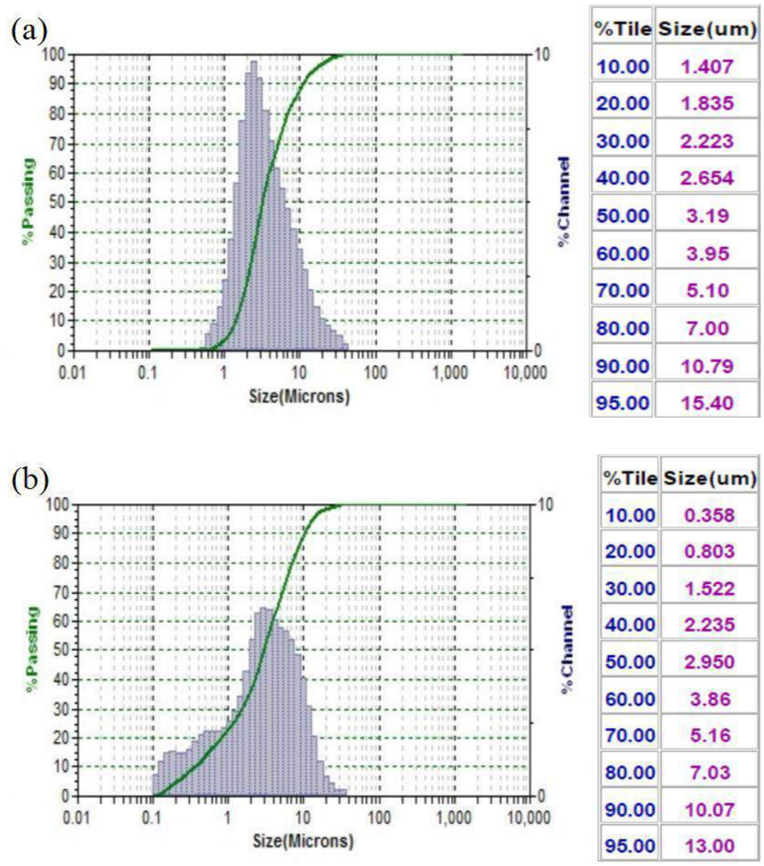

Figure 8: Laser particle size analysis of (a) TiO_2; (b) P3HT(1%)@TiO_2

Photocatalytic Degradation of 4-CP Wastewater

Table 2 lists the 4-CP degradation efficiency at a reaction time of 90 min for each run with a 3*3 Box-Behnken experimental design. Based on the results, a regression model (eq. (4)) could be established with a high coefficient of determination (r^2: 0.962). Therefore, this regression model was used to develop 3 D response surface plots for 4-CP degradation efficiency and to predict the required experimental conditions for a preset of 4-CP degradation efficiency using Minitab R16 software. Fig. 9 displays the three dimensional response surface plots for percent 4-CP degradation efficiencies as a function of P3HT@TiO_2 (%) and P3HT@TiO_2/(P3HT@TiO_2+TiO_2) (%). As shown in Fig. 9, with an increase in the P3HT content of P3HT@TiO_2 composites, the 4-CP degradation efficiency first increases and then decreases. This could be due to P3HT with π-conjugated structure which has high electron mobility, leading to facilitate the separation of the electron–hole pairs generated under UV-irradiation, a certain content of P3HT can improve the photocatalytic activities of P3HT@TiO_2 composites (Zhu and Dan, 2010). With the content of P3HT increasing, P3HT gradually exhibits its contribution on charger transfer, and the adsorption capacities of composites was enhanced, P3HT(0.5%)/TiO_2 composites exhibit the highest 4-CP degradation efficiency. With a further increase in P3HT content, the decrease in activity of P3HT/TiO_2 composites is considered to be related to the increased absorbing and scattering of photons by a large amount of P3HT adsorbed on the surface of TiO_2.

It was found that the optimized reaction conditions were established as a photocatalyst dosage of 1.0 g/L, a P3HT of 0.5% in P3HT@TiO_2 and a 25% P3HT@TiO_2 of total photocatalyst dosage for a 4-CP degradation efficiency of 95%. Under the optimized reaction conditions, the TOC mineralization efficiency of 4-CP wastewater increased 16.3% as compared to that of TiO_2 process for a reaction time of 120 min (Fig. 10). As a result, the introduction P3HT onto the surface of TiO_2 could extend successfully the visible light photoresponse range of TiO_2 and could effectively enhance TiO_2 solar photoactivity.

Table 2: Box-Behnken design matrix and the 4-CP degradation efficiency at each run

Run	X_1	X_2	X_3	4-CP degradation (%) @ 90 min
1	1	-1	0	99.00
2	0	-1	-1	92.00
3	0	0	0	95.33
4	-1	1	0	95.88
5	0	1	1	90.47
6	1	0	-1	91.78
7	0	0	0	95.09
8	-1	0	1	94.20
9	0	0	0	97.06
10	-1	0	-1	97.40
11	-1	-1	0	95.79
12	1	0	1	98.63
13	0	1	-1	88.82
14	0	-1	1	90.46
15	1	1	0	94.30

$$Y_{degradation(\%)}=95.83 + 0.06X_1 - 0.97X_2 + 0.47X_3 + 2.74X_1^2 - 2.32X_2^2 - 3.06X_3^2 - 1.20X_1X_2 + 2.51X_1X_3 + 0.80X_2X_3, \quad r^2= 0.962 \qquad (4)$$

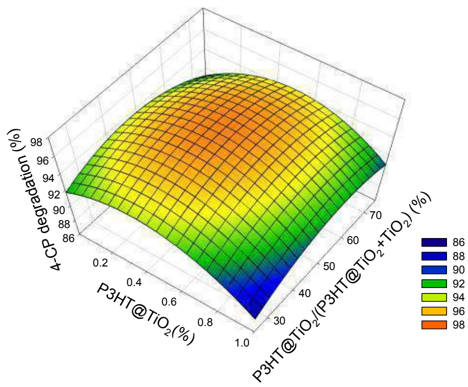

Figure 9: Response surface for the degradation efficiency of 4-CP wastewater (photocatalyst dosage: 1 g/L; photocatalytic reaction time: 90 min)

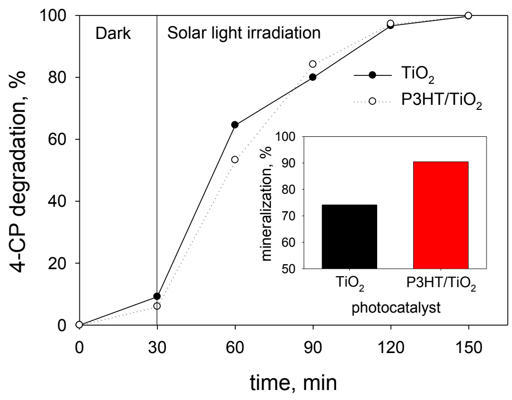

Figure 10: Comparisons of the 4-CP degradation efficiency with dosing pure TiO_2 and 25% P3HT(0.5%)@TiO_2 + 75% TiO_2 (total photocatalyst dosage: 1 g/L)

Conclusion

Based on the results of this study, the shell-core P3HT@TiO_2 composites are promising materials which can be excited by solar light and could be used effectively to enhance TiO_2 solar photoactivity. Also, it was suggested that the RSM technique was an efficient approach to predict the optimum operation conditions for solar photocatalytic process. The optimized reaction conditions based on the application of a 3*3 RSM regression model were established as a photocatalyst dosage of 1.0 g/L, a P3HT of 0.5% in P3HT@TiO_2 and a 25% P3HT@TiO_2 of total photocatalyst dosage for a 4-CP degradation efficiency of 95% for a reaction time 90 min. Under the optimized reaction conditions, the TOC mineralization efficiency of 4-CP wastewater increased 16.3% as compared to that of TiO_2 process for a reaction time of 120 min.

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Assessment of GHG Emissions from Tableware Ceramic Production in Thailand

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Abstract
Ceramic industry is one of energy intensive industry. This paper reported the energy consumption and GHG emission of tableware ceramic production in Thailand in the boundaries of "gate-to-gate". The activity data of the tableware ceramic manufacturing were collected from a small enterprise manufacturing plant and 1 kg of ceramic bowl (8 inches diameter) was chosen as the functional unit of data analysis. The amount of GHG emission in the unit kg CO_2 e /kg of product was calculated by the method from IPCC 2006 and the emission factors used in this study were from Thailand Greenhouse Gas Management Organization (TGO). The hotspots of energy consumption and GHG emissions were then identified. The results indicated that the energy consumption per functional unit was 21.80 MJ/kg of product and almost 95% of total energy consumption was from liquefied petroleum gas (LPG) consumption during firing. The direct GHG emissions were from LPG used as fuel (47.54%) and from the decomposition of carbonates during firing process (0.26%). While the indirect GHG emission was from the electricity consumption for electrical equipments (52.20%). The total GHG emission based on functional unit was 0.34 kg CO_2 e /kg of product.

Keywords: greenhouse gas emissions, energy consumption, ceramic tableware, ceramic production, Thailand

1. Introduction

The tableware ceramic manufacturing is a traditional industry sector in Thailand. There are approximately 100 tableware ceramic industries in Thailand [1]. Most of them are small and medium-sized. At present, ceramic industry has suffered from high energy cost due to continuous increasing LPG price, which is the key factor affecting a ceramic industry's competitive in the world market.

Various studied are emphasis on energy consumption and greenhouse gas emission from ceramic industry. Quinteiro, *et al*.[2] studied carbon footprint and energy consumption of a commercially produced earthenware ceramic piece. The results indicated that energy hotspots are natural gas production, biscuit firing and condensing boiler. The carbon footprint of the selected ceramic piece is 1.22 kg CO_2e per piece. The total energy consumption during the life cycle of the ceramic piece is 8.19 kWh, and the manufacture stage represents almost 90% of the total energy consumption across the life cycle of the ceramic piece. Peng, *et al*.[3] studied carbon dioxide emission in the ceramic tile manufacturing process and found that about 80% of the total CO_2 is emitted during the processes of firing and drying. Several solution are proposed to reduce CO_2 emission from these two processes and substituting coal with natural gas seems to be the most efficient way. Barros, *et al*.[4] presented the analysis of the consumption and emission levels of the main pollutants is made from ceramic manufacturing process in Spain. The results revealed that main GHG emissions are from raw materials preparation process and thermal treatment process. In addition Monfort, *et al*.[5] analyzed energy consumption and carbon dioxide emissions in the ceramic tile industries from 50 participating companies in Spain. It can be seen that the firing stage emits the highest carbon dioxide in ceramic tile manufacture (185 kg CO_2/t fired product), followed by spray drying of the suspensions (90 kg CO_2/t fired product) and tile drying (20 kg CO_2/t fired product). Ibanez-Fores, *et al*.[6] presented a methodology for identifying sustainable and most appropriate BAT for a given industrial installation and sector. The methodology involves identification of environmental hot spots from an installation by using life cycle assessment (LCA) to guide the selection of candidate BAT option for targeting the hot spots. The selected BAT options are then assessed on sustainability using relevant environmental, economic, technical and social indicators. The results indicate that firing and drying are the hot spots for most sustainability impacts considered.

In Thailand, the report from the Department of Alternative Energy Development and Efficiency (DEDE) presented the energy use data from ceramic industry in Thailand. Natural gas and electricity are the main source of energy for the ceramic manufacturing plants. Liquid petroleum gas (LPG) is used in small and medium scale industries while natural gas (NG) is used primarily as a fuel in large scale Industries [7]. Although, ceramic manufacturing process use a lot of energy and is one of the main contributors to CO_2 emissions, at present there is no data of energy consumption and GHG emission from small ceramic tableware manufacturing plant in Thailand. Therefore, the purpose of this study is to analyze GHG emissions and energy consumption in a small ceramic tableware manufacturing plant. Moreover, the hotspots of energy consumption and GHG emission were identified. The outcome of this study will be important data for ceramic industry to reduce their energy consumptions and GHG emissions.

2. Methods

2.1. Data collection

The general objective of this research is to assess GHG emissions and energy consumption and identify the GHG emissions and energy consumption hotspot from ceramic tableware production. This research was conducted in a small tableware ceramic manufacturing in Thailand. The necessary data from each unit process were collected and 1 kg of ceramic bowl (8 inches diameter) was chosen as the functional unit of data analysis as shown in Fig.1. The average weight of the bowl was 0.785 kg/piece. The assessment of partial product life cycle was carried out in a boundary of gate to gate (raw material preparation, forming, drying, biscuit firing, glazing, glost firing and QC). A scope of study was shown in Fig.2.

Figure 1. A selected ceramic bowl (8 inches diameter) of this study

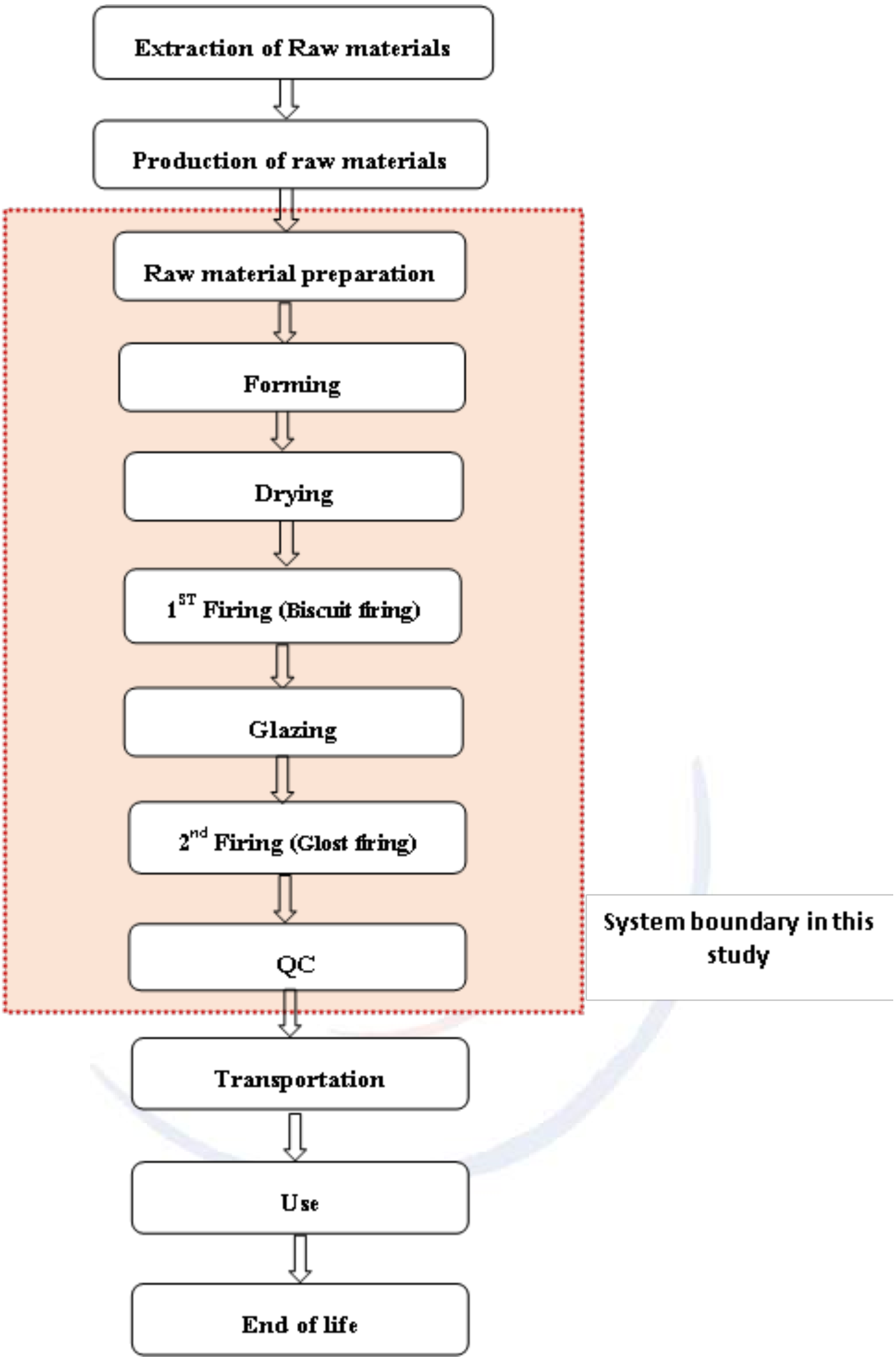


Figure 2. System boundary of this study

2.2. Calculation of GHG emissions

The sources of CO_2 emissions in ceramic production come from electricity consumption, fuel combustion and industrial process. The amount of GHG emission in the unit kg CO_2 e/kg of product was calculated by the method from IPCC 2006 [8] and the heating values of fuel come from the Department of Alternative Energy Development and Efficiency (DEDE), Thailand [7]. The calculation of GHG emissions from fuel combustion and electricity consumption are shown in Eq(1) and

Eq(2). The calculation of GHG emission from decomposition of calcium carbonate is shown in Eq(3). The emission factors used in this study were from Thailand Greenhouse Gas Management Organization (TGO) [9] and IPCC 2006 [8] as presented in Table1.

$$CO_{2\ \text{emission, LPG}} = \text{LPG Consumption (kg) x } EF_{LPG} \quad (1)$$
$$CO_{2\ \text{emission, electricity}} = \text{Electricity consumption (kWh) x } EF_{electricity} \quad (2)$$

where
EF_{LPG} = emission factor, $kgCO_2e/kg$

$EF_{electricity}$ = emission factor, $kgCO_2e/kWh$

$$CO_2 \text{ Emissions from decomposition of } CaCO_3 = M \times EF_{CaCO_3} \times F \quad (3)$$

where
EF_{CaCO3} = emissions factor for the particular carbonate, tonnes CO_2/tonne carbonate

M = weight or mass of the carbonate, tonnes

F = fraction calcination achieved for the carbonate, fraction (this study used 1 for F fraction)

Table 1. The emission factors used in this study.

Activity data	Unit	Emission factor	References
Liquefied petroleum gas (LPG)	kg	0.3874 $kgCO_2e$/unit	[9]
Electricity	kWh	0.6093 $kgCO_2e$/unit	[9]
Calcium carbonate ($CaCO_3$)	kg	0.43971 kg CO_2/ unit	[8]

3. Results and Discussion

3.1 Energy consumption and hotspot Identifications

Figure 3 shows the percentage of energy used in the production of ceramic tableware. It was contributed by electricity (5%) and LPG (95%).The electricity is used in forming machine and Liquid Petroleum Gas (LPG) is used in shuttle kiln for firing product. The energy consumption of ceramic tableware production from each process is shown in Table 2.

The total energy consumption of ceramic tableware production was 21.80 MJ/kg of product. The electricity consumption was from raw material preparation and forming process (1.06 MJ/kg of product) and LPG consumption was used for combustion in biscuit firing process (4.02 MJ/kg of product) and glost firing process (16.72 MJ/kg of product). The largest energy consumption was from glost firing (76.70%), followed by biscuit firing (18.44%), raw material preparation (4.50%) and forming (0.37%). Thus, glost firing process was determined as a hotspot of energy consumption, accounted for 76.70% of total energy consumption.

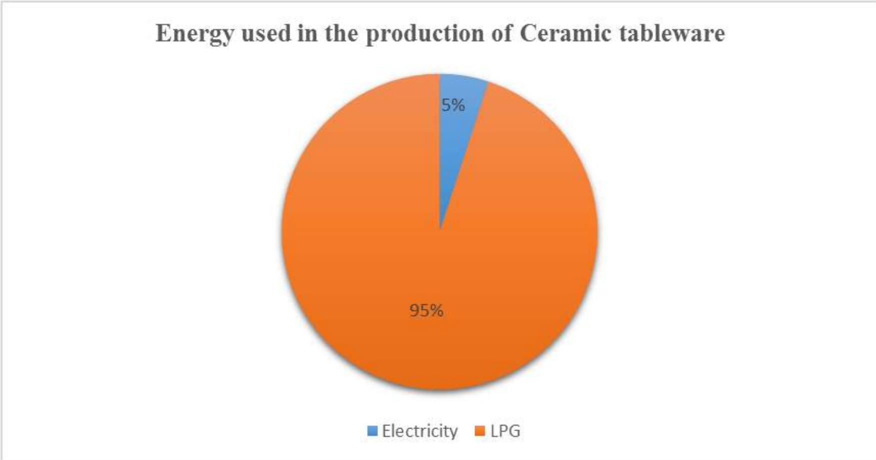


Figure 3. The percentage of energy used in the production of ceramic tableware

Table 2. The energy consumption of ceramic tableware production from each process (per 1 kg of product)

Unit Process	Energy Consumption			
	Electricity (MJ)	LPG (MJ)	Total (MJ)	%
1. Raw material preparation	0.98	-	0.98	4.50
2. Forming	0.08	-	0.08	0.37
3. Drying	-	-	-	-
4. Biscuit firing	-	4.02	4.02	18.44
5. Glazing	-	-	-	-
6. Glost firing	-	16.72	16.72	76.70
7. QC/packing	-	-	-	-
Total	1.06	20.74	21.80	100

3.2 GHG emissions and hotspot identifications

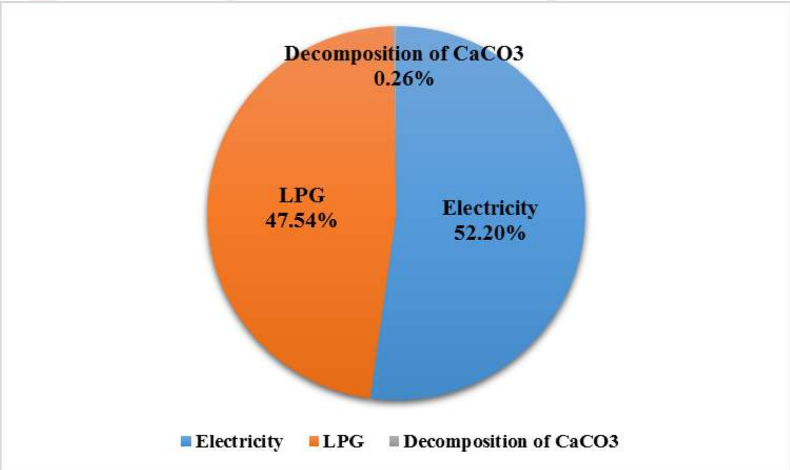
The GHG emissions from ceramic tableware production were from the consumption of energy (electricity and LPG) and the decomposition of calcium carbonate ($CaCO_3$) during glost firing. From Figure 5, the largest GHG emission was from electricity consumption (52.20%), followed by LPG during biscuit and glost firing (47.54%) and decomposition of calcium carbonate (0.26%). The results are shown in Table 3. Total GHG emission was 0.343 $kgCO_2e$/kg of product. The largest GHG emission was from raw material preparation process (0.166 $kgCO_2e$/kg of product), followed by glost firing process (0.131 $kgCO_2e$/kg of product), biscuit firing process (0.032 $kgCO_2e$/kg of product) and forming process (0.006 $kgCO_2e$/kg of product).

Thus, raw material preparation and glost firing process was also found to be the hotspot of GHG emission. Accordingly, the energy conservation and GHG mitigation options for ceramic tableware production should be focused in raw material preparation and glost firing process.

Table 3. The GHG emissions in the unit of $kgCO_2e$ per kg of product

Unit Process	GHG Emission ($kgCO_2e$)				
	Electricity	LPG	Decomposition of $CaCO_3$	total	%
1. Raw material preparation	**0.166**	**-**	**-**	**0.166**	**48.41**
2. Forming	0.013	-	-	0.013	3.79
3. Drying	-	-	-	-	-
4. Biscuit firing	-	0.032	-	0.032	9.33
5. Glazing	-	-	-	-	-
6. Glost firing	**-**	**0.131**	**0.0009**	**0.131**	**38.53**
7. QC	-	-	-	-	-
Total	**0.179**	**0.163**	**0.0009**	**0.343**	**100**

Figure 5. Percentages of GHG emissions divided by sources in ceramic tableware production



4. Conclusion

The total energy consumption from the production of 8-inch ceramic bowl was 21.81 MJ/kg of product and almost 95% of total energy consumption was from LPG consumption during firing process. The amount of GHG emission was 0.34 $kgCO_2e$/kg of product. The largest GHG emission was from electricity consumption (52.20%), followed by LPG consumption (47.54%) and decomposition of calcium carbonate (0.26%). Raw material preparation process and firing process in kiln were found to be hotspots of energy consumption and GHG emission. Thus, the energy conservation and GHG mitigation options for ceramic tableware production should be focused in raw material preparation process and glost firing process.

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Developing the Methodology to Investigate the Thermal Comfort of The Elderly for Sustainable Living in Hot-Humid Thailand

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Abstract
Gaining thermal comfort is one of the main requirements for housing and the ways in which thermal comfort can be obtained closely relate to sustainability. This paper describes how a survey instrument was designed to measure the physiological and psychological condition of the elderly in the hot-humid climate zone with a view to enhancing living conditions. Participants in the research were 60 years old or more and lived in retirement homes in Thailand. The fieldwork was conducted in three phases - an exploratory survey, instrument development, and pilot survey. The exploratory survey was conducted in Bangkok and Chiang Mai by interviewing 47 participants. The results show that both physical and mental health levels of the elderly affected their thermal perceptions as well as culture influencing adaptive behaviour. The exploratory survey was adjusted to account for apparent perception difficulties.

After developing the main instrument, a pilot survey was conducted in Bangkok to test several variables relating to personal matters, for example, health condition, thermal perception and adaptive behaviour. The research found that the education level of the elderly influenced their understanding of the questions and their capacity to answer them. However, a series of graphics were introduced to support the questions which helped responses to the survey considerably.

Keywords: methodology, thermal response, elderly, hot-humid climates

1. Introduction

What does thermal comfort for sustainable living mean for the elderly in hot-humid climates? First, a sustainable design (Brawley, 2006) means several generations should be comfortable in the same house, including the elderly. For the elderly, thermal sensitivity changes gradually, so that they become less sensitive to heat (Huang, Wang and Lin, 2010; Ohnaka et al., 1993; Smolander, 2002) and much more sensitive to draughts (Sarkissian, 1986). Secondly, since the climate appears to be changing, improved design for thermal comfort should cover both hotter and cooler changes of environment. The IPCC (2007) confirmed the average temperature in South-East Asia is expected to increase 3-5°C in a century. It means that the vulnerable people such as the elderly would suffer greatly from heat stress in hotter summers. The elderly are also usually conservative which can lead to constraints on adaptive behaviour. However, there is limited research on the thermal comfort of the elderly in these climates. Thermal comfort studies in hot-humid Asia have been conducted in Thailand, Malaysia, Indonesia and Singapore, but none focuses on the elderly. Since there has been little consideration of housing design for the aged, elderly housing may become less comfortable over the next few decades. Therefore, research on the thermal comfort of the elderly and their physiological and psychological responses to excess heat, should necessarily concentrate on this area.

The surveys of thermal comfort and the responses of the elderly are presented in this paper. Drawing on the existing literature, the research responds to the question: ‘which factors should be considered in conducting thermal comfort surveys of the elderly?

1.1 Context of the survey

Two retirement homes in Bangkok and four in Chiang Mai, Thailand were visited. These homes are in the government sector which provides social welfare to low income elderly who are without care-givers. There were 47 participants in the exploratory survey and six participants in the pilot survey.

With a difference in latitude and altitude, the temperature profile in both cities is slightly different. Bangkok is located in 13°45’N and 0 m. above sea level, whereas Chiang Mai city is at 18°47’N and 320 m. height. Given these differences, mean minimum to maximum temperatures in Bangkok ranged from 24.9-33.3°C, with the highest recorded temperature at 40.2° (Thai Meteorological Department, 2001). Although Chiang Mai is further from the equator and has a lower mean minimum-maximum temperature than Bangkok at 20.8-32.2°C, its 30-year highest recorded temperature is 42.4° (Thai Meteorological Department, 2001). Both cities have average humidity of over 70% for most of the year. This can lead to feelings of discomfort.

1.2 The literature on thermal comfort indices

Many indices have been developed to assess factors like thermal sensation, comfort, preference and acceptability. Moreover, scales can vary according to the sensitivity of the participant. Table 1 assembles all available thermal comfort indices for assessing thermal sensation, thermal preference and thermal acceptability, including their references. Although the ASHRAE seven-point scale for thermal sensation has been used widely, there are several different ways in which questions can be asked, depending on factors like age and education level of the participant and purpose of the survey. Regarding thermal comfort assessment, Bedford (1936) established a psychological instrument to assess comfort feeling with a seven-point scale. This scale was used for many years until ASHRAE enhanced it and it became the standard. ASHRAE has produced three later versions of the thermal comfort index, such as the thermal sensation vote (TSV, 7 to 9 point scale in 1992), the actual thermal sensation vote (ATSV, 7-point scale in 2010) and the thermal sensation index (TSENS, 7 to 11 point scale in 2011). Meanwhile, an overall thermal comfort assessment also has been used which was developed from the Bedford scale and been subsequently used in the International Standard Organization, ISO10551: 1995, *Ergonomics of the thermal environment – Assessment of the influence of the thermal environment using subjective judgement scales.*

Thermal preference assessment was launched by McIntyre (1978) and by ISO10551 (1995). Although the 7-point scale for thermal preference in ISO10551 gives more detail, McIntyre's instrument is far more popular because of its practicality. With a 3-point assessment, McIntyre's scale is applied by many researchers (De Dear and Brager, 2002; De Dear and Spagnolo, 2005; Hwang and Lin 2007; Lin, De Dear and Hwang, 2011; Haddad, et al., 2012; Yang, Wong, and Jusuf, 2013; Zhou, et al. 2013).

Thermal acceptability is more related to psychology than thermal sensitivity and preference and there are many indicators to define this. Direct thermal acceptability is the most practical scale. It can be analysed with thermal sensation and thermal preference to derive an overall thermal comfort perception. ASHRAE 55-2010 also provides a sensitivity scale for acceptability assessment by appraising seven degrees of satisfaction. On the other hand, ISO10551:1995 arranges the scale to identify the degree of tolerance. This scale classifies how well people tolerate a thermal environment, from perfectly tolerable to intolerable (see Table 1 Thermal acceptability). This scale was also applied to the concept of acceptability which specifies the number of degrees that represents a change from acceptable to somewhat unacceptable and so on.

There is no standard for perception of wind, solar radiation and humidity. Many researchers conduct surveys by applying five and seven point scales of the ASHRAE thermal sensation vote to identify wind and solar perceptions (Stathopoulos, Wu and Zacharias, 2004; De Dear and Spagnolo, 2005; Rangsiraksa, 2006; Hwang and Lin 2007; Lin, De Dear, and Hwang, 2011; Yang, Wong and Jusuf, 2013; Zhou, et al., 2013). Some researchers have also developed a humidity perception assessment (Toftum, Jørgensen and Fanger, 1998; Stathopoulos, Wu and Zacharias, 2004; Yamtraipat, Khedari and Hirunlabh, 2005; Yang, Wong and Jusuf, 2013). However, Stathopoulos, Wu and Zacharias (2004) present wind perception differently. By assessing five degrees of agreement, the perceptions of "Strong wind force sensation" and "Stronger wind desired" have been used for sensation and preference assessment. These were also applied for gauging solar perception. There are two approaches to answering this assessment: a degree of satisfaction with ambient conditions and a degree of agreement with the statement. The 3-point preference scale of "Want more", "No change" and "Want less" can be applied to both wind and solar preference. Also, it is easily understood by elderly people than other assessment questions.

Humidity perception is another subjective issue which needs to be discussed. It can be expressed from three different angles: relative humidity, sweating sensation and wetness of skin. Humidity sensation refers to a combination of environment and perception of humidity in general. People's reaction to humidity can be defined on a five-point sensitivity scale. Subsequently, Toftum, Jørgensen and Fanger (1998) suggested an improvement to the measurement of humidity perception by asking a question about skin wetness in the questionnaire. Additionally, the level of sweating sensation can be another way of identifying humidity response because in high temperatures, the body mechanism will promote sweating to relieve heat. However, in high humidity conditions, evaporative cooling will not reduce heat efficiently. Lastly, research suggests that discomfort in hot climates is usually influenced by wetness of the skin. It is assessed, for example, as 'Sweat runs off the skin', 'Body wet - clothing sticks to the skin', 'Body wet - chest and back', 'Chest and back slightly wet' to 'Normal dryness' (Berglund, Cunningham and Stolwijk, 1983; Nielsen and Endrusick, 1990).

Table 1 *Subjective perception: thermal environment*

Parameters	Standards/ Reference	Interview questions used	Scale	Scale details	Researchers
Thermal comfort					
Thermal comfort vote (combine Thermal sensation +comfort)	Bedford, 1936	"How do you feel at this moment?"	7-point	Much too warm (+3), Too warm (+2), Comfortably warm (+1), Comfortable (0), Comfortably cool (-1), Too cool (-2), Much too cool (-3)	Jitkhajornwanich, 2007
Thermal comfort (affective evaluation)	ISO 10551, 1995	"Do you find this environment…?"	4-point	Comfortable (0), Slightly uncomfortable (1), Uncomfortable (2), Very uncomfortable (3)	Zhou et al., 2013
			5-point	Above plus; Extremely uncomfortable (4)	
Thermal perception / Thermal sensation vote (TSV)	ASHRAE 55-1992, ISO 10551, 1995	"How are you feeling now (about the thermal conditions on this site)?" / "How do you rate your thermal sensation?"	7-point	Cold (-3), Cool (-2), Slightly cool (-1), Neutral (0), Slightly warm (+1), Warm (+2), Hot (+3)	Lin et al., 2013; Yang, Wong and Jusuf, 2013; Zhou, et al., 2013
			9-point	Above plus; Very cold (-4), Very hot (+4)	
Thermal sensation (TSENS) or Actual Thermal Sensation Vote (ATSV)	ASHRAE 55, 2004; ASHRAE 55, 2010; ASHRAE 55, 2011	"What is your general thermal sensation?"	7-point	Cold (-3), Cool (-2), Slightly cool (-1), Neutral (0), Slightly warm (+1), Warm (+2), Hot (+3)	Spagnolo and De Dear, 2003; Nakano and Tanabe, 2004; De Dear and Spagnolo, 2005; Hwang and Lin, 2007; Jitkhajornwanich, 2007; Haddad, et al., 2012; Yang, Wong and Jusuf, 2013; Zhou, et al. 2013;
			11-point	Extremely cold (-5), Very cold (-4), Cold (-3), Cool (-2), Slightly cool (-1), Neutral (0), Slightly warm (+1), Warm (+2), Hot (+3), Very hot (+4), Extremely hot (+5)	

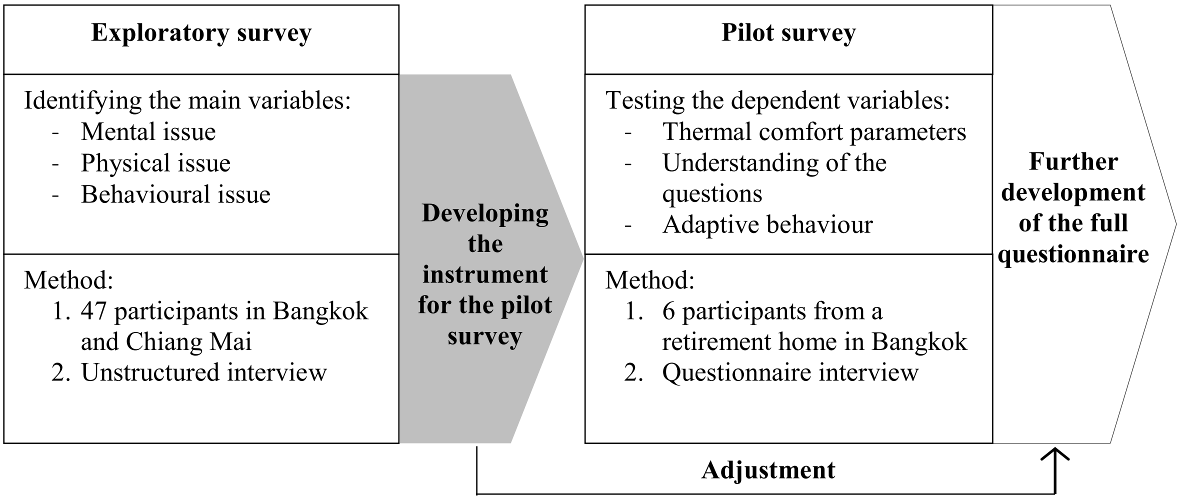
***Table 2** Subjective perception: thermal environment (cont.)*

Parameters	Standards/ Reference	Interview questions used	Scale	Scale details	Researchers
Thermal preference					
Thermal preference	ISO 10551, 1995	"Please state, how would you prefer it to be now?"	7-point	Much cooler (-3), cooler (-2), Slightly cooler (-1), Neither warmer nor cooler (0), a little warmer (+1), Warmer (+2), Much warmer (+3)	-
	McIntyre, 1995	"Would like it to be…?"	3-point	Cooler (-1), No change (0), Warmer (+1) or Colder (-1), Not wishing to change (0), Hotter (+1)	De Dear and Brager, 2002; De Dear and Spagnolo, 2005; Hwang and Lin 2007; Jitkhajornwanich, 2007; Haddad, et al., 2012; Lin, De Dear and Hwang, 2011; Yang, Wong and Jusuf, 2013; Zhou, et al., 2013
Thermal acceptability					
Personal acceptability	ISO 10551, 1995	"On a personal level, this environment is for me…?"	2-point	Acceptable rather than unacceptable (0), and Unacceptable rather than acceptable (1)	
	ASHRAE 55, 2010	"How satisfied are you with the temperature in your space?"	2-point	Acceptable, Unacceptable	Hwang and Lin, 2007; Lin et al, 2011; Haddad, 2012; Lin et al, 2013; Yang, et al, 2013
			7-point	Very satisfied (+3), Satisfied (+2), Slightly satisfied (+1), Neutral (0), Slightly dissatisfied (-1), Dissatisfied (-2), Very dissatisfied (-3)	
Weather acceptable	-	"Overall, the weather conditions are acceptable for your activity?"	5-point	Disagree (-2), Slightly disagree (-1), Uncertain (0), Slightly agree (+1), Agree (+2)	Stathopoulos, et al, 2004
Personal tolerance	ISO 10551, 1995	"Is it…?"	5-scale	Perfectly tolerable (0), slightly difficult to tolerate (1), Fairly difficult to tolerate (2), Very difficult to tolerate (3), and Intolerate (4)	

2. Methods

This research draws on qualitative methods to investigate the factors which can impact on thermal comfort. There were three phases to the research as shown in Figure 1: the exploratory survey, the questionnaire development, and the pilot survey, all leading to the development of the full questionnaire. The aim of the exploratory survey was to explore the main factors influencing thermal comfort. The aim of pilot survey was to develop and test variables in the survey instrument for finalizing the questionnaire. The individual phases are examined below.

Figure 1 : The relationship between the three survey phases



2.1 Exploratory survey

The exploratory survey was conducted in February 2014, by using unstructured interviews with 28 questions covering three main issues. Each interview took approximately an hour and included both facility managers and the elderly. The key variables of mental and physical condition and behavioural issues were identified in the exploratory survey to test their influence on thermal comfort assessment. Mental issues refer to the capability of the elderly to conduct a self-assessment. As a result of the combination of physiological and psychological factors, thermal comfort assessment relies heavily on self-assessment (ASHRAE, 2009). It also depends on the personal perceptions of the participant of their environment (Brager and De Dear, 1998). Therefore, the mental status of the participant should be assessed before conducting the interview to establish participants' capacity for self-assessment (Pfeiffer, 1975).

The second category of influences is physical. They refer to the vulnerability of elderly people. Many elderly have chronic diseases which influence their thermal sensitivity and thermal sensations (Novieto, 2013). For example, diabetes, hypertension, heart disease and stroke are commonly known to impact thermal perception. The third category of assessment, behavioural, refers to the activity and response of the participants to thermal stress. Behaviour includes routine and leisure activities. Shared spaces that the activities take place in, are also considered.

In the outdoor environment, solar radiation and wind are greater influencing factors on respondents than either temperature or humidity. Hong Kong researchers (Cheng and Ng, 2006; Ng and Cheng, 2012) strongly recommended that a shaded outdoor environment should be provided to prevent heat stroke. People can tolerate high temperatures in hot-humid climates with wind speeds of 3 m/s, which can bring a temperature above 34°C to acceptable comfort level quickly (Khedari, et al. 2000). On the one hand humidity itself does not directly impact the elderly in hot-humid countries like Singapore, Indonesia and Thailand because they are accustomed to high relative humidity. On the other hand, wetness of skin is a key factor of discomfort, although this is dependent on factors like air speed and individual health condition (Givoni, et al., 2006).

The adaptive behaviour questions were built from available adaptive tactics such as using hand-held fans noted in the exploratory survey. The pavilion and veranda were used for interviewing, since they are shared areas for the elderly. The interviews took place in separate sessions of morning, afternoon and evening to capture a variety of physical environmental conditions.

The outcomes from the exploratory survey led to three sections in the questionnaire for the pilot survey: thermal comfort, adaptive behaviour and the interview procedure.

2.2 Pilot survey

The pilot survey was conducted by using the questionnaire developed from the exploratory survey. Each question was used for testing a different individual variable. For example, the ASHRAE 7-scale thermal sensation vote was applied to determine thermal sensation variable. A 7-point scale was also applied to assess humidity, wind and sun. The 3-point McIntyre thermal preference scale was also applied to assess humidity, wind and sun preference. Lastly, thermal acceptability is a most complicated assessment since it depends on psychology rather than physiology. Consequently, a simplified version of thermal acceptability was adopted for humidity, wind and sun assessment in the pilot stage questionnaire.

The questionnaire contains three parts: A - Mental status, B1 – Thermal comfort and B2 – Adaptive behaviour. . Part A contains 15 questions and Part B has 21 questions; most are multiple choice. The interviews took approximately half an hour per participant. The pilot survey was conducted in November 2014. Participants who were residents of a retirement home in Bangkok were recruited for the pilot. The aim of this survey was to test the comprehension and practicality of the questions, so only six elders were questioned. Each participant was interviewed twice: during the daytime and in the evening.

After taking the pilot survey, all questions were reviewed to reflect the key factors more precisely. For example, questions relating to humidity and sweat perception were added to finalise the questionnaire after conducting the pilot survey.

3. Results and discussion

3.1 Exploratory survey

Outcomes from the exploratory survey can be discussed under the headings mental, physical and behavioural. Each element had a different level of influence on thermal perception in the elderly. Research suggests that culture can also play an important role in adaptive behaviour (Knez and Thorsson, 2006).

Mental factors – According to the retirement home managers, there are three levels of health status. Group A is the healthiest. They can take care of themselves on a daily basis and their intellectual functioning is intact. Group B is generally healthy but may need assisting in a minor activity such as washing clothes or shopping for food. Group B may have chronic physical diseases such as arthritis or heart disease which impacts on daily activity, yet people in this group still have an intact or only mildly reduced intellectual functioning when they were tested on the mini-mental self assessment. Group C is the lowest on the health status list. They may have a severe disease which requires a degree of nursing service, for example for the elderly with dementia. Since the participant needs to assess their thermal perception, their intellectual capacity should be intact or only mildly impaired. Since It is likely that Group C might have a mild intellectual impairment their response may be biased or their self-evaluation may be inaccurate. Therefore, only the A and B groups who are of sound-mind have been selected as participants.

Physical factors – Some chronic diseases affect thermal sensation and sensitivity. Body fitness also influences thermal perception. Physical issues can be identified in two groups, arthritis and heart disease and hypertension. The elderly who have arthritis or heart disease are usually inactive so they prefer staying at home which, ironically, makes them weaker. Their metabolic rate may drop which may also have a slight effect on their thermal perception. Regarding hypertension, elders with high blood pressure will be affected particularly in hot weather. Some of the participants reported a slight to serious headache due to hypertension during summer. Some become upset greatly about the weather which can cause them discomfort in summer more easily than elders without hypertension. Consequently, the questionnaire was adjusted to add a question about the factors that concerned elders when they felt most uncomfortable. The question was also asked “what factors bring a feeling of comfort for you when you feel uncomfortable?”

Behavioural factors – Cultural differences affect behaviour. Even though participants in both surveys are Thai, surprisingly, there are cultural differences among the regions of Thailand which influence adaptive behaviour. A traditional Thai space in both Bangkok and Chiang Mai is the veranda, although Thai attitudes to staying on the veranda are different. The elderly in Chiang Mai prefer staying in the veranda or the shaded outdoors when they feel hot. They expect that a breeze would provide more comfort as opposed to staying indoors. However, those in Bangkok will stay on the veranda when the outside is not too hot. Bangkok residents mentioned that sometimes the outdoors is subject to warm winds and it would be hotter than staying indoors. Moreover, the activity of an individual can lead to discomfort conditions. An active elderly person will manage to perform several activities even in hot weather. Thus, they will experience a higher metabolic rate and feel hotter than those who are inactive. Lastly, some elders tend to avoid drinking too much water to relieve heat. Since they are often afraid of an accident like a fall, they would prefer using fans for cooling rather than drinking water and walking to the toilet often. Consequently, they may feel uncomfortable more readily than those who prefer drinking water. The exploratory survey identified the following typical adaptive behaviours: drinking water, adjusting clothes, showering or washing faces, moving, walking, day napping or sleeping, using a hand-held fan or electric fans, or praying or bearing it until the uncomfortable conditions have gone.

3.2 Pilot survey

The pilot survey and the interview process introduced expected as well as some unexpected issues. The thermal comfort response is an expected outcome which required some adjustments before applying to the full survey. However, cultural differences between regions in Thailand were an unexpected factor and the wording and graphics were modified to support the elders’ understanding of the questions.
Thermal comfort perception – Initially, thermal comfort parameters are the first focus. Then when outdoor environment is considered, other environmental parameters seem to have a stronger impact than just temperature. Wind and solar were reported to have

a stronger effect on outdoor thermal comfort than temperature. Moreover, in hot-humid climate, humidity and sweating level also can create discomfort more than just high temperatures. The pilot survey found that humidity and skin wetness affected thermal discomfort. One-third of participants responded that their discomfort feeling derived from skin wetness.

The results suggest that the five-point thermal perception scale may not be sensitive enough to differentiate responses from older adults from those of adults in general. Research suggests that the ASHRAE 7-point scale can be applied to the elderly and in this case, the pictures can assist their understanding. However, regarding wind, solar, and humidity sensations, a five-point assessment is preferred for ease of discrimination between points by elderly respondents.

The pilot survey shows that McIntyre's thermal preference assessment is suitable for the elderly, but not for personal acceptability. Although asking for a direct answer to whether conditions are 'acceptable' or 'unacceptable' is the most practical evaluation, the pilot survey shows that the Thai elderly are more likely to accept every weather condition, including temperature, wind, solar and humidity. The pilot survey also shows that acceptability is influenced by a cultural perspective as well as a thermal perception. All respondents accepted the prevailing environmental conditions; One mentioned that since we cannot change nature, we have to accept it, even though we are uncomfortable.

Consequently, the questionnaire was adjusted i) to identify degree of overall acceptability, defined in five levels from 'Unacceptable' to 'Acceptable'. Also, ii) regarding the ambiguity of the term 'acceptability', the elderly should also be briefed on terminology. For example, in the questionnaire, "Unacceptable" means what happens when they feel uncomfortable with the weather and need some adjustments to be more comfortable such as using fans. "Acceptable", on the other hand, refers to the feeling of comfort without any adjustments.

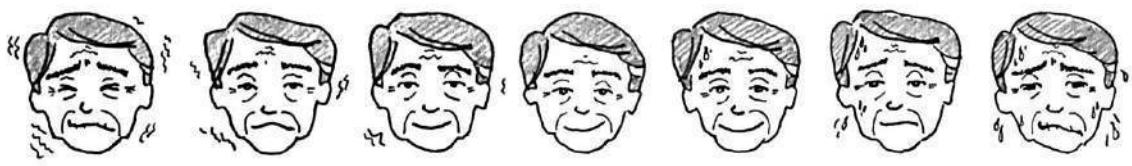
Adaptive behaviour – Some adaptive behaviour alternatives are more frequently applied than others. For instance, 'opening the window' is a regular answer from all elderly who live in naturally ventilated rooms. Windows are closed only when it rains heavily. The frequency of individual adaptive techniques is calculated as a percentage of the total possible options. The response 'using mechanical fans' is in the second choice, at 60%. Moving to a cooler place and taking a shower are other common choices, at 50%. Drinking water is less common, at 40%. Apart from these, the frequency of adaptive responses using a hand-held fan – 25%; walking – 20%; day napping – 11%; and adjusting clothes – 5%. Unexpectedly, on one selected praying or bearing until it has gone as their heat relief technique.

Clothing which is another factor to determine thermal comfort, is greatly influenced by local culture. The elderly in Thailand are conservative, particularly females. They usually believe that the proper clothes relate to a well-mannered personality. Even though the environment is extremely hot, it is important for them to wear proper clothing in public. Therefore, the average clothing insulation for the female elderly is higher than that of males, at 0.32 clo with bra, blouse, panties and pants, and at 0.24 clo with a t-shirt and pants, respectively.

Interview procedure – There are many factors related to interviewing the elderly. The level of communication such as education level and language skills can lead to misunderstanding. Most elderly who live in retirement homes are not well educated. Half graduated from primary school Grade 4 which was the extent of compulsory education in their era. Therefore, interview procedures and wording need to not only be easily understandable but also acknowledge their context.

The use of language and wording has been modified and tested several times for the most effective response. For example, the word "acceptable" means you are happy with a condition without any difficulties, yet in Thai language, it means you can accept a condition with or without any trouble, until it becomes intolerable, then you will say unacceptable. Graphics can deliver answers quicker than long verbal explanations due to the precise expression in their context (see Figure 2). A similar approach has been used in a thermal comfort questionnaire for Iranian children (Haddad et al., 2012). The graphic was also applied for wind, solar radiation humidity and sweat sensations assessments. An example is the thermal sensation vote using a 7-point scale and illustrated in following graphic (Figure 2).

Figure 2 : An example of graphics to support the thermal sensation 7-scale question



Cold	Cool	Slightly cool	Just right	Slightly warm	Warm	Hot
-3	-2	-1	0	+1	+2	+3

3.3 Discussion

Three levels of humidity perception have been mentioned as relative humidity, sweating sensations and wetness of skin. The pilot survey shows that the sweating level can play an important role in discomfort in a hot-humid climate. Moreover, deterioration of sweat gland mechanisms in the elderly (Buono, McKenzie and Kasch, 1991; Kenney and Munce, 2003; Tortora and Derrickson, 2006), tend to limit heat loss by sweating, leading to increased feelings of heat. Therefore, sweating perception of the elderly should be assessed in the questionnaire.

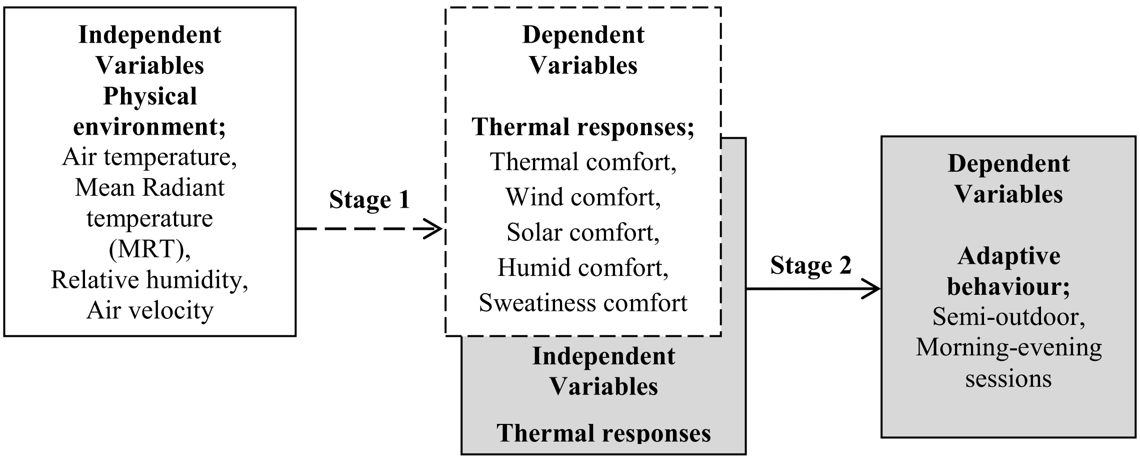
Furthermore, Picard (2014), has invented a physiological instrument that can measure the stress level of people. The sensor includes electrodermal activity (EDA) or skin conductance response (SCR) which spontaneously detects moisture from sweat glands on the skin. More skin moisture creates a higher conductance response. This instrument is able to sensitively detect changes across a range of stress levels.

Thermal comfort is a combination of physiology and psychology, and both need to be measured simultaneously. Conventionally, psychological responses can be assessed on site by using a Likert scale such as ASHRAE thermal sensation scale. Physiological responses can be evaluated by comparing the psychological data and the physical environmental profile later. Not much thermal comfort research has measured a direct physiological response. Since it is a direct measurement, the SCR could provide physiological evidence of discomfort feeling from heat. Therefore, if this device is combined with the subjective thermal comfort assessment, it can probably produce a more reliable result than the traditional method, by providing quantitative data and reducing interpretation bias in the interview process.

Therefore, the next stage of this study will apply both relative humidity and sweating sensation to interpret humidity perception. Although it has been suggested that humidity may not strongly impact on thermal comfort of people in hot-humid climates, the future survey will enable a better explanation of the relationship between skin wetness and discomfort among Thai elderly. To be clear, sweating level should be measured simultaneously with the subjective perception of sweatiness.

Regarding the analysis process in the next stage, Figure 3 shows the analytical model which distinguishes the relationship between the physical environment parameters and the subjective parameters of thermal responses, including how people react to both sets of parameters. First, physical parameters as independent variables will test the correlation with the thermal responses. As a dependent variable of Stage 1, thermal responses will become an independent variable for the second stage. Thermal responses will also be correlated with another dependent variable, adaptive behaviour.

Figure 3 : The overall analytical model of this research



Conclusion

The methodology to investigate thermal comfort for improving the sustainable living of the elderly included an exploratory survey, developing the instrument and conducting a pilot survey. The exploratory survey involved the main mental, physical and behavioural factors. The pilot survey suggested that thermal comfort perception, adaptive behaviour and interview procedures needed to be adjusted in the questionnaire. Physical and mental health factors, including education level also influence thermal responses. Consequently, the questionnaire was modified by adding explanatory graphics. Finally, the next step will use the analytical model to process the survey results. In addition, the model may well be useful for researchers in general who are exploring the relationships between the physical environment and the subjectivity of thermal responses.

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Optimum Co-digestion Conditions for Methane Production from Chicken Manure and Napier Grass by Single Stage Digestion

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Abstract
The purpose of this research was to examine optimum co-digestion conditions for methane production from inoculums, chicken manure and Napier grass by single stage digestion. Combined Mixture Process Design was used to determine the optimum methane production. The experiment consist of different level of factors which were temperature, inoculums, chicken manure and Napier grass with fermentation volume of 100 ml in glass bottle, hydraulic retention time (HRT) of 28 days, and total solids (TS) of 1.5%. The results showed that the optimum condition yielded biogas volume of 101 ml and methane of 73.6% when the temperature was controlled at 49 ^{o}C and ratios of inoculums : chicken manure : Napier grass was 46 : 3 : 52 of %TS. The experiment result was validated the optimum methane production by five confirmation experiments which their results were closely agreed with the theoretically predicted value.

Keywords: Methane production, Co-digestion, Chicken manure, Napier grass, Combined Mixture Process Design

Introduction

Energy is one of the factors that affect to human living in household to the global level. As energy consumption trends to increase steadily, in some countries are experiencing energy shortage and importing energy from other countries. Renewable energy i.e., biogas, wind power, hydro power is promising an alternative energy. Biogas energy is a waste-to-energy technology as a consequence; it is an interesting clean energy. Single material of organic waste fermentation e.g., food waste, crop waste, cow dung, livestock manure is a conventional fermentation but its characteristic of each material is inappropriate for methane fermentation. Organic waste which has carbon to nitrogen (C/N) ratio of 20-30:1 is a suggestion proportion for biogas fermentation because it is an ideal proportion for methane former bacteria growth. In general, crop waste which has high fiber show a high C/N ration while livestock manure show a low C/N ration. There is a report of chicken manure and Napier grass C/N rations which are 7.6 and 43.6, respectively [1]. As a consequence, it is possible to achieve high methane production yield by co-digestion of two different organic materials. The objective of this study was to find out an optimum co-digestion condition for methane production from two organic materials i.e., chicken manure and Napier grass. Besides the C/N ratio, there are other factors that contribute to methane yield i.e., pH, alkalinity, temperature, volatile organic acid (VOC), hydraulic retention time (HRT), and agitation. When an experiment deals with many factors: Design and Analysis of Experiment (DOE) is an effective technique to determine optimum conditions and the technique was used in this study.

Experimental Study

Materials Characterization

- Inoculums: seed sludge from biogas fermentation pond, Sriviroj Farm, Khon Kaen, Thailand.
- Chicken manure: layer chicken manure from Sriviroj Farm, Khon Kaen, Thailand.
- Napier grass: harvested age about 45 days and crushed to a size 0.5-2 cm.

Chemical and physical characteristics of all materials were characterized as follow: moisture, total solid (TS), Volatile Solid (VFA), Alkalinity (Alk), Volatile Fatty Acid (VFA), Chemical Oxygen Demand (COD), Nitrogen (N), total carbon (C), and C/N Ratio. Material characterization were followed by Analytical standards APHA AWWA,WEE, 2005 [2] and AOAC,1995 [3].

Design and Analysis of Experiment: DOE

Factors and levels were comprised of inoculums, chicken manure, Napier grass, and temperature (Table 1). Combined Mixture Process Design was used to apply for this experiment because it capable for finding out both of ration and optimum condition [4]. This research came up the 22 treatments with randomization of run order (Table 3). The experiments were done in glass bottles of 120 ml with fermentations volume of 100 ml, 28 day of fermentation, and TS of 1.5%. To validate the optimum condition of variables, five confirmation experiments were conducted at selected optimal levels.

Table 1 Factors and levels of experimental design.

Factors	Level		Units
	Low	High	
Inoculums	0	100	%TS
Chicken manure	0	100	%TS
Napier grass	0	100	%TS
Temperature	30	60	Celsius

Results and Discussion

Materials Characterization

Characterization of three materials i.e., inoculums, chicken manure, and Napier grass are presented in Table 2, it is clear that chicken manure and Napier grass capable to be a co-digestion because chicken manure contained a low C/N of 7.84 chicken manure while Napier grass shown a high C/N of 39.11.

Design and Analysis of Experiment: DOE

Combined Mixture Process Design and result of 22 treatments present on Table 3, it revealed that biogas volumes resulted in range of 4.5 – 95 ml and methane were about 0.20 – 63.76%. Statistical analysis of the experiments explained that inoculums, chicken manure, Napier grass, and temperature affected to biogas volume and methane percentage due to significant level of *P*-value less than 0.05 ($\alpha = 0.05$). In addition, R-squares of biogas volume and methane percentage were 0.9273 and 0.9212, respectively. The examinations of residuals illustrated that the residuals, biogas and methane, generally fell on a straight line, these imply that the error were distributed normally (Figure 1). The plots of the residuals versus biogas, methane, inoculums, and chicken manure explained that there were no obvious pattern and unusual structure (Figure 2).

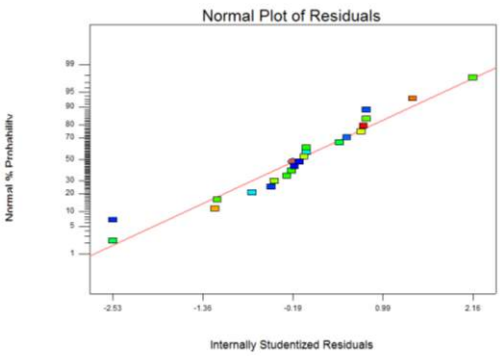
Table 2 Chemical and physical characteristics of materials.

Parameters	inoculums	chicken manure*	Napier grass **
1. Moisture ,%	-	28.47	83.07
2. Total Solid (TS) ,%	10.63	71.53	16.93
3. Volatile Solid (VS) ,%	6.63	44.06	14.83
4. Alkalinity (Alk) ,mg/l as $CaCO_3$	2,960	1,580	278
5. Volatile Fatty Acid (VFA), mg/l	1,250	625	187.5
6. COD ,mg/l	12,511	9,957	4,213
7. Total Carbon (C) ,%	2.21	24.48	8.24
8. Total Carbon (N) ,%	0.41	3.12	0.21
9. C/N	5.36	7.84	39.11

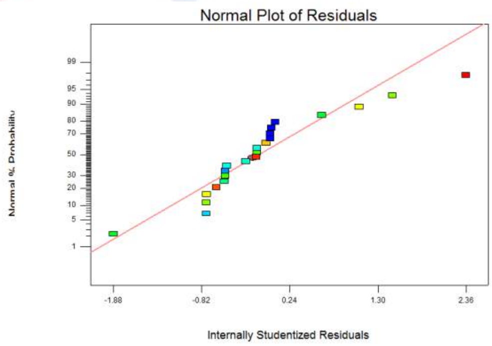
* % of dry weight, **% of wet weight

Table 3 Combined Mixture Process Design and result of 22 treatments.

Standard order	Run order	%TS			Temperature (°C)	Biogas (ml)	Methane (%)
		inoculums	chicken manure	Napier grass			
1	14	42	42	17	60	53	19.20
2	19	42	17	42	60	80	51.53
3	16	42	17	42	30	64	58.54
4	22	17	42	42	60	27.5	13.82
5	12	17	42	42	30	52	41.33
6	10	0	0	100	60	4.5	0.22
7	9	42	42	17	30	55.5	47.58
8	3	100	0	0	30	42.5	36.78
9	8	100	0	0	60	8.5	18.26
10	17	0	100	0	30	58	36.22
11	7	0	100	0	60	11.5	9.15
12	13	0	0	100	30	9.5	0.23
13	4	67	17	17	45	85	63.76
14	5	0	100	0	45	25	28.82
15	11	0	0	100	45	13.5	0.65
16	1	17	42	42	45	43.5	40.41
17	15	100	0	0	45	56	24.30
18	21	42	42	17	60	52.5	17.82
19	6	42	17	42	60	95	47.23
20	18	42	17	42	30	67	61.44
21	20	42	42	17	30	70	29.78
22	2	0	0	100	60	5	0.20

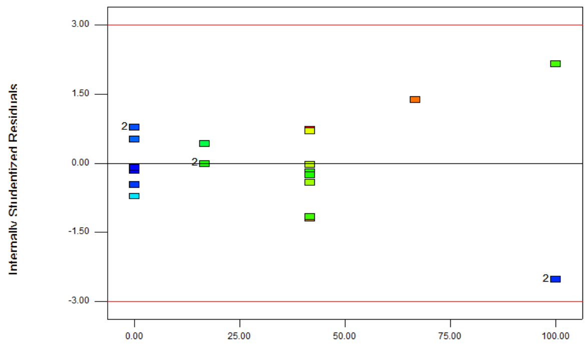


(a) biogas

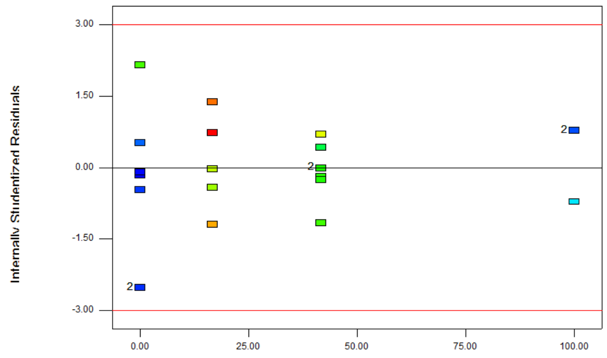


(b) methane

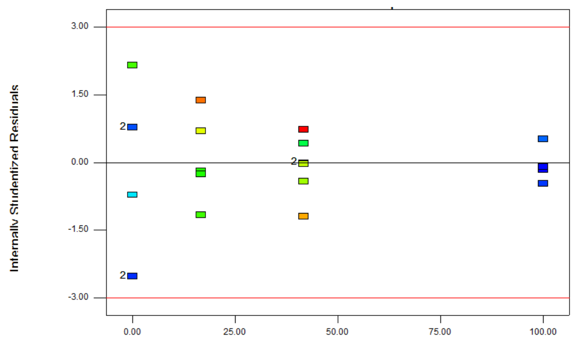
Figure 1: Normal distribution of residuals; (a) biogas and (b) methane



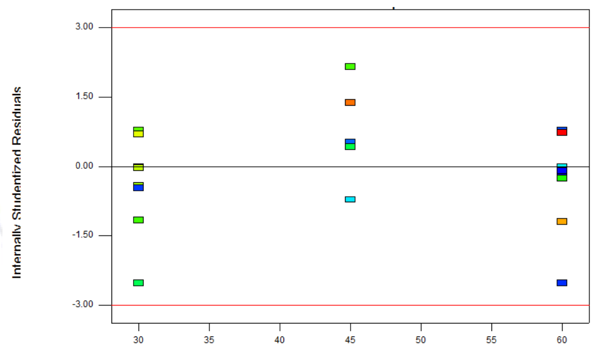
(a) inoculums



(b) chicken manure



(c) Napier grass



(d) temperature

Figure 1: Normal distribution of residuals; (a) inoculums, (b) chicken manure, (c)Napier grass, and (d)temperature.

The optimum conditions result shown that the optimum ratio of inoculums: chicken manure: Napier grass was 46 : 3 : 52 of %TS and temperature of 49 ^oC. This condition yielded biogas volume of 101 ml and methane of 73.6%. Then, this result was selected to validate the optimum combination of each material; five confirmation experiments were conducted at selected optimal levels and the results shown that the optimum ratio strongly agreed with the theoretically predicted value both of biogas volume and methane percentage (Table 3); biogas volume were in the range of 95 – 110 ml and methane fell in the range of 71.31 – 74.29% which was closely to the perdition result.

Table 3 Confirmative values of biogas volume and methane percentage.

Test no.	Biogas (ml.)	Methane (%)
1	95	71.31
2	98	72.28
3	100	72.75
4	102	73.83
5	110	74.29

Conclusion

Combined Mixture Process Design with 22 treatments was varied ratios of materials with various temperature form 30-60 ^{o}C and hydraulic retention time was controlled at 28 days. This method was successful to achieve the optimum ratio of inoculums: chicken manure: Napier grass which was 46 : 3 : 52 of %TS and temperature of 49 ^{o}C. This condition yielded biogas volume of 101 ml and methane of 73.6%. Statistical analysis both of R-square and normal plot confirmed that all experiments were accurate and reliable data. The validation experiment also confirmed that it was closely to the perdition result.

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Crude Oil Intensity, Production Efficiency and Adaptability to Energy- Evidence from an Economy with a High Dependence on Energy Imports

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Abstract
Taiwan is an economy with highly dependent on energy imports. Change in oil price not only affects the cost of production, but also on the economic growth. Due to the international crude oil prices being relatively stable with low price except the first two oil crises, it has brought up Taiwan's economic growth. However, after 2000 the crude oil price has risen and become an unstable factor for economic development. Taiwan is facing an industrial restructuring. Energy-saving technologies and improved efficiency might play an important role. Additionally, Kyoto Protocol to the United Nations Framework Convention on Climate Change in 1997 was to set CO_2, CH_4, N_2O, HFC_s, PFC_s and SF_6 reduction targets as the improvement of global warming climate. As a member of international society, it is necessary to improve the industrial productivity to contribute to the global warming problem. From crude oil intensity and spillover effects of change in crude oil price, we might detect whether industrial production efficiency and adaptability to energy improves or not. Based on the input-output table during the periods of 1981 to 2011, the present study employs the factor decomposition model to investigate change in Taiwan's reliance on crude oil through the index of imported crude oil intensity. The empirical results show that although some progress was made in savings on imported crude oil inputs, the negative effects of the structural efficiency of production and domestic market demand substantially increased imported crude oil intensity and price responsiveness, again revealing the vulnerability of Taiwan's production.

Keywords: Factor Decomposition, Economic Spillover Effects, Crude Oil Price, Crude Oil Intensity

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1. Introduction

After two crude oil crises in the 1970s, which upset the economy in Taiwan, the international prices of crude oil remained relatively stable, driving Taiwan's economic development. Following 2000, international crude oil prices rose gradually, peaking in July 2008 before beginning to fluctuate wildly. Nevertheless, crude oil prices remain high. However, these price increases differ from those during the oil crises in the 1970s. Newly industrialized countries and an expanding global supply chain are driving the rapid growth in oil demand. In addition, the development of international financial markets is also increasing speculative demand in the oil market.

Taiwan lacks oil production, depending almost entirely on imports to supply oil for various economic activities. The stability of crude oil prices influences production costs and has become a key factor in its economic development, affecting its future economic growth. Therefore, the government and businesses have been investing heavily in new energy technology, endeavoring to adjust the industrial structure. After Taiwan joined the World Trade Organization (WTO) in 2002, trade liberalization has expanded the scale of trade, increasing domestic production and exports and fueling the demand for international crude oil. Despite this, overall industrial energy intensity has improved gradually, falling from 9.45 (liters of oil equivalent(LOE)/NT$$10^3$) in 2003 to 7.52 (LOE/NT$$10^3$) in 2014. The energy intensities of the three main industries, the agricultural sector, the industrial sector, and the service sector, fell from 7.4 (LOE/NT$$10^3$), 18.9 (LOE/NT$$10^3$), and 1.6 (LOE/NT$$10^3$) in 2003 to 5.0 (LOE/NT$$10^3$), 12.4 (LOE/NT$$10^3$), and 1.4 (LOE/NT$$10^3$) in 2012, respectively. However, compared with that of other advanced countries, Taiwan's energy intensity remains high.

Whether Taiwan's energy efficiency would improve with economic development remains unknown. The efforts of the government and businesses are evident in the annual decline in domestic energy intensity. However, the sustainable development of a country's economy relies on improvements in energy-saving technologies and the efficient response to changes in the international economic environment and to industrial restructuring. Considering the aforementioned concerns, in this study, we examined the influences of changes in international crude oil prices on industry costs and prices over a period during which international crude oil prices doubled. Improvements in industrial crude oil utilization technology were investigated from the perspectives of quantity and price. To achieve these objectives, we employed the industry-related model, estimating the imported crude oil intensity of final demand for a quantity analysis and the price responsiveness toward the crude oil price for a price analysis. These analyses facilitated observing the changes in crude oil dependence by Taiwanese industries and the responsiveness to crude oil prices over 30 years.

In 2008, the global financial crisis severely affected the economies of Europe and North America. Because nearly 70% of Taiwan's economic growth depends on trade, Taiwan could not evade the impact of this crisis. The capital transfers that accompanied the financial crisis accelerated a rapid rise in international crude oil prices, compounding Taiwan's economic difficulties. Unlike most previous studies conducted in Taiwan that used domestic energy intensity to address dependence on oil, in this study, the import intensity of final demand is employed to examine the dependence of Taiwanese industries on oil imports. We used the price responsiveness to investigate the response of domestic production costs and prices to changes in crude oil prices. In addition, a factor decomposition model was also applied to investigate the factors affecting the responsiveness to crude oil prices. These methods contrast with those reported in the literature (i.e., primarily using statistical methods to forecast energy price elasticity). These results of the present study afford an understanding of the properties and production technologies of various industries in Taiwan.

2. Literature Review

Numerous studies have revealed that fluctuations in energy prices result in substantial economic losses (Bruno & Sachs, 1985; Hamilton, 1983, 1996; Davis & Haltiwanger, 2001; Lee & Ni, 2002). This phenomenon has not changed in the twenty-first century because the economic growth of newly industrialized countries has substantially increased energy demand, prompting speculation in energy futures markets and also increasing the instability of international energy prices (Barsky & Kilian, 2004; Blanchard & Gali, 2007; Hamilton, 2003, 2011). In addition, to maintain continued economic growth, newly industrialized countries respond to rises in crude oil prices by implementing subsidies. Studies have applied energy price elasticity to investigate the relationship between energy demand and prices (International Energy Agency, Organization of the Petroleum Exporting Countries, Organization for Economic Co-operation and Development [OECD], and World Bank, 2010). In particular, numerous studies have explored the price elasticity of China’s energy demand or changes in income elasticity (Fan et al., 2007; Hang & Tu, 2007; Asadoorian et al., 2008; Ma et al., 2008; Lin & Zhujun, 2011). Because globalization has developed rapidly, exchange rates have also become a major factor influencing energy prices and increasing the impact on energy prices (Kilian, 2008; Kilian & Park, 2009; Fukunaga, Hirakata, & Sudo, 2011).

Economic development and globalization have destabilized international energy prices. Numerous studies have analyzed the effects of changes in crude oil prices on economic development and societies from various perspectives, focusing on the extent to which asymmetries in energy price elasticity have affected economic growth rates and domestic prices. Price asymmetries can be used to estimate the direction of changes in economic variables (Dargay, 1992; Gately et al., 1993; Haas et al., 1998; Madsen et al., 1998; Gately et al., 2002; Adeyami et al., 2007; Fan et al., 2007; Ma et al., 2008; Neto, 2012; Inglesi-Lotz, 2011; Sentenac-Chemin, 2012). Alternatives between factors of production have also been used to analyze asymmetries (Fan et al., 2007; Ma et al., 2008; Roy et al., 2006). Dowlatabadi et al. (2006) and Boone et al. (1996) have used technological advances to investigate asymmetries in energy prices, endogenizing rates of technological progress to construct energy demand functions. By contrast, Kumar et al. (2009) used the relationship between technological advances and energy prices to divide the productivity of the energy sector into efficiency change effects and rates of change in technology.

Various researchers have used menu costs caused by increases in oil prices to analyze asymmetries. Madsen et al. (1998) analyzed manufacturing and retail businesses and found that businesses can benefit from price adjustments even when asymmetries exist in energy prices. However, Blinder (1994) maintained that product prices tend to be rigid. Studies have also investigated the causes of energy price asymmetries and various factors have been observed during different periods (Wirl, 1988; Grubb, 1995; Sentenac-Chemin, 2012). Nordhaus (1977) compared income changes with the energy demand response generated by energy price changes and assessed the time adjustments of oil crises. Boone et al. (1996) created an OECD energy demand function, noting that when technological advancement was included in the function, the long-term price elasticity decreased. Hunt et al. (2003) reported the same results (as did Popp, 2001; Griffin et al., 2005; Huntington, 2006; Kumar et al., 2009; and Dowlatabadi et al., 2006).

The econometric model was popular in the 1980s for analyzing the effects of crude oil price changes (Hickman et al., 1987). Beenstock (1995) examined developing countries that imported oil, applying a macroeconometric model to analyze the influence of increases in crude oil prices on import prices and production costs. In addition, multiple studies have analyzed the relationship between changes in crude oil prices and changes in business cycles (Finn, 2000; Rotemberg & Woodford, 1996; Kim & Loungani, 1992; Miguel et al., 2003). Finn (2000) maintained that energy input affects the level of capital accumulation and estimated the influence of increases in crude oil prices on gross domestic product (GDP).

Burbidge and Harrison (1984) analyzed the relationship between macroeconomic changes and crude oil prices. Mork (1989) examined the influence of fluctuations in crude oil prices on GDP, observing asymmetries between the two. The results of a study by Mory (1993) also supported this conclusion. Lee et al. (1995) used the generalized autoregressive conditional heteroskedasticity model to analyze volatility in crude oil prices and confirmed the presence of asymmetries. The relationship between crude oil prices and macroeconomic indicators was investigated by Hooker (1996a), who confirmed Granger causality between the two; Hamilton (1996) confirmed this conclusion. According to the premise that the relationship between crude oil prices and GDP is nonlinear, Hamilton (2003) performed econometric analysis. Bernanke et al. (1997) indicated that appropriate financial policies can be implemented to reduce the impact of crude oil prices. Balke et al. (2002) used the VAR model to analyze asymmetries in crude oil prices and indicated that adjustment costs and financial policies cause asymmetries. However, Hamilton and Herrera (2004) reported contrasting results. Dalsgaard et al. (2001) and Hunt et al. (2001) analyzed the influence of changes in international crude oil prices on the global economy, estimating that the elasticity values of each country's GDP in response to oil prices were between −0.01 and −0.02. Bohi (1991) maintained that rises in energy prices reduce enterprise production and GDP; this reduction is attributable to the direct impact and the indirect influence of capital and labor substitution effects.

In addition, changes in international crude oil prices produce various economic effects on each country. Mork et al. (1994) extended the work of Hamilton (1983), Burbidge and Harrison (1984), and Mork (1989) by analyzing and comparing the relationship between crude oil prices and GDP of the United States, Canada, Japan, Germany, France, the United Kingdom, and Norway. Bjørnland (2000) analyzed the influence of crude oil price shocks in the 1970s on Germany, the United Kingdom, the United States, and Norway. The results indicated that the price shocks exerted short-term negative effects on all of the countries except Norway. Abeysinghe (2001) analyzed newly industrialized countries. Numerous studies have also examined the influence of changes in international crude oil prices on industrial production and prices (Federer, 1996; Nagano, 2004; Klein, 2005; Ono, 2005; Fuzikawa et al., 2007; Fukuda & Kondo, 2009; Fukunaga et al., 2009).

3. Empirical Model

The data for every 5 year and every 3 year from 1981-2011 in the present study is drawn from the publication of input-output table compiled by Directorate General of Budget, Accounting and Statistics (DGBAS), Executive Yuan, Taiwan. We aim to estimate the imported crude oil intensity of final demand and the responsiveness of domestic price level toward crude oil price. The following are the empirical model.

3.1 Measurement of Import Intensity of Final Demand

The measurement of import intensity of final demand ($\overline{\mathrm{m}}$) for individual industry is

$$\overline{\mathrm{m}} = \mathrm{MA}\,\bar{x} = \mathrm{MAB}\,\overline{f_d} \tag{1}$$

Equation (1) stands for imports per unit final demand production for individual industry in which it is focused on the imported crude oil intensity in the present paper. Where $\bar{x}$ represents final demand production of individual industry; B is a Leontief inverse matrix. M and A stand for import coefficient and input coefficient for individual industry, respectively. $\overline{f_d}$ represents the ratio for individual sector as change in one-unit domestic final demand. It could be stated as

$$(1,\ldots,1)\,\overline{f_d} = 1 \tag{2}$$

3.2 Responsiveness of the Domestic Price toward Crude Oil Price

Based on the industry-related price model, the responsiveness of the domestic price ($\overline{\mathrm{P}}_\mathrm{d}$) toward imported price of crude oil ($\overline{\mathrm{P}}_\mathrm{m}$) could be measured as equation (3)

$$\overline{\mathrm{P}}_\mathrm{d} = \overline{\mathrm{P}}_\mathrm{m}(\mathrm{MA})(\mathrm{B}_\mathrm{d}) \tag{3}$$

where MA is the coefficient matrix of imported input and B_d denotes the Leontief inverse matrix.

3.3 Factor Decomposition Model for Sensitivity of Domestic Price toward Imported Crude Oil Price

In order to uncover the determinants of responsiveness of domestic price toward imported crude oil price, $\overline{P}_d$ could be decomposed at two periods. We could obtain equation (4) as follows:

Assuming the change in domestic price(d$\overline{P}_d$) from period 0 to period 1 as follows:

$$
\begin{aligned}
d\overline{P}_d &= \overline{P}_d(1) - \overline{P}_d(0) \\
&= \overline{P}_m(1)M(1)A(1)B_d(1) - \overline{P}_m(0)M(0)A(0)B_d(0) \\
&= \overline{P}_m(1)M(1)A(1)B_d(1) - \overline{P}_m(1)M(1)A(1)B_d(0) \\
&\quad + \overline{P}_m(1)M(1)A(1)B_d(0) - \overline{P}_m(0)M(0)A(0)B_d(0) \\
&= \overline{P}_m(1)M(1)A(1)B_d(1) - \overline{P}_m(1)M(1)A(1)B_d(0) + \overline{P}_m(1)M(1)A(1)B_d(0) \\
&\quad + \overline{P}_m(1)M(0)A(0)B_d(0) - \overline{P}_m(1)M(0)A(0)B_d(0) - \overline{P}_m(0)M(0)A(0)B_d(0) \\
&= [\overline{P}_m(1) - \overline{P}_m(0)]M(0)A(0)B_d(0) + \overline{P}_m(1)[M(1)A(1) - M(0)A(0)]B_d(0) \\
&\quad + \overline{P}_m(1)M(1)A(1)[B_d(1) - B_d(0)] \qquad (4)
\end{aligned}
$$

Since the individual industries accounted for the different weight in the whole economy and the price responsiveness toward imported input price is not the same, equation (4) could be restated after considering the weight of individual industry as equation (5).

$$
\begin{aligned}
&W(1)\overline{P}_d(1) - W(0)\overline{P}_d(0) = (W(1) - W(0))\overline{P}_d(0) + W(1)(\overline{P}_d(1) - \overline{P}_d(0)) \\
&= (W(1)-W(0))\overline{P}_d(0) + W(1)[\overline{P}_m(1) - \overline{P}_m(0)]M(0)A(0)B_d(0) + W(1)\overline{P}_m(1)[M(1)A(1) \\
&\quad - M(0)A(0)]B_d(0) + W(1)\overline{P}_m(1)M(1)A(1)[B_d(1) - B_d(0)] \qquad (5)
\end{aligned}
$$

where $[\overline{P}_m(1)-\overline{P}_m(0)]M(0)A(0)B_d(0)$ stands for the effects of adjustment in the initial price of imported inputs (crude oil); $\overline{P}_m(1)[M(1)A(1) - M(0)A(0)]B_d(0)$ is the effects of adjustment in technology for imported inputs; $\overline{P}_m(1)M(1)A(1)[B_d(1) - B_d(0)]$ is the effects of adjustment in domestic production structure and technology.

4. Empirical Results

4.1 Changes in Import Intensity of Final Demand

In Table 1 overall, the ratio of imports required for every incremental increase in final demand production in Taiwan increased from 25.55% in 1981 to 26. 62 % in 2011. However, according to the long-term trends, the year 1981 was just one year after the second oil crisis, during which Taiwan was forced to improve production efficiency and reduce energy dependence. Therefore, industrial restructuring became the economic policy. Between 1986 and 2001, import intensity decreased annually, indicating that Taiwan’s industrial restructuring improved production efficiency.

Table 1 Import Intensity of Final Demand

Sector	1981	1986	1991	1996	2001	2006	2011
Fishery products	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Other poultry production	0.08	0.08	0.05	0.04	0.02	0.01	0.01
Feed	0.21	0.19	0.14	0.11	0.07	0.06	0.07
Crude Oil and Natural Gas	6.64	2.03	1.54	1.6	2.65	4.92	5.25
Petrochemical	1	1.29	1.31	1.24	0.89	1.59	1.63
Chemical fertilizers	0.08	0.03	0.02	0.02	0.01	0.03	0.04
Synthetic fiber	0.12	0.13	0.05	0.04	0.03	0.03	0.03
Plastics	0.37	0.37	0.43	0.38	0.32	0.24	0.3
Petroleum refining	0.96	0.69	0.72	0.51	0.62	0.93	1.63
Transportation	0.12	0.2	0.24	0.25	0.21	0.08	0.09
Pig iron and crude steel	0.81	0.83	0.74	0.48	0.56	1.09	1.03
Electronic products	0.86	1.41	1.23	2.2	3.3	0.47	3.2
Food service	0.07	0.03	0.03	0.03	0.03	0.08	0.07
Hospitality services	0	0.12	0.2	0.14	0.11	0.39	0.35
Electricity	0	0	0	0.01	0	0.01	0.01
Communication	0.08	0.09	0.11	0.1	0.06	0.05	0.25
Financial industry	0.02	0.03	0.02	0.03	0.03	0.03	0.12
Total industry	25.55	19.1	19.41	19.29	18.8	24.68	26.62

Data Source: this study.

Import intensity increased substantially between 2006 and 2011, reflecting an increase in Taiwan's imported dependence that was caused by a rapid increase in international crude oil prices after 2004 and Taiwan's imports increased substantially after it joined the WTO in 2002. As for the crude oil and gas sector, import intensity in 1981 was 6.64%; dependence on crude oil was high compared with that in other industries, but declined substantially between 1986 and 2001, demonstrating that the industry's energy efficiency improved slightly. Nonetheless, the import intensity of the crude oil and gas sector again increased substantially between 2006 and 2011, reaching 5.25% by 2011. We conducted this study based on the input-output table for 2011, so there was a gap of more than 3 years, and the current crude oil import intensity might be even higher.

4.2 Sensitivity of Domestic Price toward Crude Oil Price

Table 2 reports the sensitivity of domestic price for individual industries toward volatility in crude oil prices. In the present study, we assumed that international crude oil prices doubled in the estimation of the impact on domestic price. Between 1983 and 2004, crude oil prices remained mostly under US$40 per barrel. During this period, the sensitivity of domestic price toward crude oil price was also relatively low. International crude oil prices began climbing rapidly in 2005, peaking at US$134.78 per barrel in June 2008. The extent to which crude oil prices affected overall industry prices was 1.176% in 1981, before the prices declined slightly. However, this increase was not substantial. After 2006, sensitivity increased, rising to 4.004% and 7.58% in 2006 and 2011, respectively. This increase indicates that domestic prices became more sensitive toward international crude oil prices. Sensitivity was 6.448 times higher in 2011 than it was in 1981.

Table 2 Responsiveness of Domestic Price toward Crude Oil Price for Individual Industries

Sector	1981	1986	1991	1996	2001	2006	2011	2011/1981
Fishery products	1.528	1.390	1.116	1.101	1.694	4.981	12.678	8.296
Other poultry production	0.278	0.246	0.295	0.318	0.387	0.753	2.075	7.471
Feed (food for farm animals)	0.240	0.220	0.227	0.230	0.292	0.615	1.441	5.995
Petrochemical	3.167	2.509	2.049	2.638	6.247	1.004	2.465	0.778
Chemical fertilizers	1.661	1.035	0.608	0.558	0.894	1.902	5.084	3.062
Synthetic fiber	1.721	1.070	0.730	0.917	0.894	4.770	13.336	7.749
Plastics	0.989	0.658	0.913	0.995	2.620	5.121	13.619	13.765
Petroleum refining	0.595	0.591	0.578	0.432	0.591	2.781	7.798	13.097
Pig iron and crude steel	0.811	0.480	0.405	0.512	0.382	1.056	2.666	3.286
Electronic Products	0.376	0.234	0.203	0.265	0.322	0.783	4.199	11.181
Food Service	0.569	0.340	0.289	0.304	0.329	1.057	3.342	5.878
Hospitality services	0.795	0.393	0.299	0.265	0.399	1.307	4.508	5.671
Air transportation	3.470	2.174	1.806	2.697	2.569	6.916	20.650	5.951
Transportation	0.175	0.471	0.423	0.527	0.587	1.300	3.529	20.164
Communication	0.224	0.112	0.080	0.060	0.105	0.294	1.028	4.592
Financial sector	0.085	0.107	0.070	0.045	0.058	0.170	1.026	12.038
Total industry	1.176	0.789	0.854	0.602	0.756	4.004	7.580	6.448

Data Source: this study.

The price sensitivity in each sector toward changes in imported crude oil prices varies. The price in the petrochemical and air transportation sectors are the most sensitive before 2011. However, after 2011 the price sensitivity in the air transportation sector had the highest one(20.65%), followed by those in the plastic sector(13.619%), synthetic fiber sector(13.336%), and fishery products sector(12.678%). Comparison the sensitivity toward changes in crude oil price between 1981 and 2011 illustrating that the sensitivity of the price in the air transportation service sector increased the most, growing by 20.164 times, followed by the sensitivities of the plastic and petroleum refining sectors, which grew by 13.765 and 13.097 times, respectively.

4.3 Factor Decomposition of Domestic Price Sensitivity

With the exception of in 1981-1984, although the effect of the initial imported prices of crude oil was the most critical factor affecting the increase in domestic price level, this phenomenon was inevitable for Taiwan, which is virtually entirely reliant on energy imports. Between 1986 and 1989, the effect of the initial imported price of crude oil was 1.3821%. However, the effects of imported inputs in technology and industrial restructuring reduced the sensitivity toward imported crude oil price. This reduction reflects the effectiveness of progress in energy-saving technologies and industrial restructuring during this period.

Table 3 Factor of Adjustments in Responsiveness toward Imported Crude Oil Price

Factor / Period	adjustment in the initial price of imported crude oil(1)	adjustment in technology for imported inputs (2)	adjustment in domestic production structure and technology (3)	(4)=(1)+(2)+(3)
1981-1984	0.0014	0.0430	0.7894	0.8338
1986-1989	1.3821	-0.1690	-0.5210	0.6922
1991-1994	0.7135	0.0731	0.1502	0.9368
1996-1999	0.6975	0.4312	0.4156	1.5442
2001-2004	0.9788	-0.2634	0.0540	0.7694
2004-2006	0.0258	0.0156	0.0030	0.0443
2006-2011	1.1057	-0.8149	0.9069	1.1978

Data Source: this study.

During the periods from 2001 to 2004 and from 2006 to 2011, the effect of adjustment in technology for imported inputs continued to be a factor mitigating the rise in domestic price level. Although the factor of adjustment in production structure and technology remained positive, it improved gradually compared with those of the previous three periods. International crude oil prices remained high between 2006 and 2011. The price sensitivity increased substantially to 1.1978%, and Taiwan encountered a new stage of industrial restructuring, the effect of which deteriorated. During this stage, technical level of imported inputs was the key factor suppressing increases in domestic prices.

5 Conclusion

Domestic energy intensity has declined annually. On the contrary, import intensity has increased. In particular, after Taiwan joined the WTO, a rise in international trade has increased energy dependence to approximately 30%-40%. In addition, energy dependence is also reflected in responsiveness to international crude oil prices. Price responsiveness toward crude oil price has increased by a factor of approximately 5 to 10 since Taiwan joined the WTO, illustrating that globalization has intensified the effects of crude oil price fluctuations on production and daily life in Taiwan.

Stable international energy supply is a critical factor affecting Taiwan's economic growth. Although efforts have been made to advance technology and improve energy dependence, the empirical results of this study indicate that imported crude oil intensity and price responsiveness have actually increased. Thus, the speed of improvement in energy technology is insufficient to keep up with the extent of economic growth. The present study derives a preliminary solution through a factor decomposition model. During the period after the second oil crisis and before Taiwan joined the WTO, improvements in the savings of imported crude oil inputs and the structural efficiency of domestic production decreased imported crude oil intensity and price responsiveness. In Taiwan, which lacks natural resources, economic development requires increased efficiency in domestic production and technology, in addition to savings on direct energy investments. Although some progress was made in savings on imported crude oil inputs, the negative effects of the structural efficiency of production and domestic market demand substantially increased imported crude oil intensity and price responsiveness, again revealing the vulnerability of Taiwan's production.

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Energy Efficiency Application in Yanbu Industrial City

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Abstract
The Industrial City of Yanbu was established by Royal Commission of Yanbu (RCY) on the Red Sea to develop major energy intensive industries on petrochemicals. Oils from Eastern province are sent to the industrial city to save time and fuel during oil export. Saving time & energy is one of the commitment of today's modern city of Yanbu and be a model amongst the industrial city for energy efficiency. The city is dedicated to attract energy saving industries, support efficient use of land community zoning, develop carbon footprint calculation system, promote green technologies, encourage energy efficient industrial land use, and support industries that promote technology that are fuel efficient. The existing infrastructure, housing & building facilities in the city is energy efficient and likewise advocate the use of renewable solar energy. Funding is provided for renewable wind energy project. The overall energy design concept is the blueprint of RCY to achieve an energy efficient industrial city.

1. Introduction

The Industrial city of Yanbu near the coast of the Red Sea was conceived in 1975. One of its mission was to develop and promote investment in petrochemical market aside from oil export. Oil from eastern province of Saudi Arabia are sent thru pipe to the industrial city to save time and fuel energy in transporting oil for export to Europe via the Suez Canal. Saudi Arabia is exporting millions of barrel of oil in response to the world growing energy demand. The global energy needs likewise is projected to increase enormously thus as the world economy expand, it needs more power energy. Since the source of energy is from fossil fuel or nonrenewable, there is a growing concern about energy efficiency, pollution, greenhouse effect and climate change within the kingdom. Recently, it launch the Saudi Arabia‘s Energy Efficiency Center (SEEC) with the goal of reducing power energy thru audits, load management, regulation and education and re channel the domestic fuel consumption for export to generate more revenue. One of the leading government entities is the RCY Industrial City. It has been committed in implementing energy efficiency thru regulation, infrastructure, land use and education thru environmental awareness program.

2. Policy

The government of Saudi Arabia spends billions of dollars in subsidizing the power energy need of the country. Studies have shown that 20% of the budget goes to domestic consumption. In addition, housing and private transportation are the two main cause of energy waste [1]. Houses are not properly insulated while there are so many private cars in the country since public transportation is not well develop. In other countries who experience oil price shock in early 70’s have develop a comprehensive policy and regulation to encourage energy efficiency thru tax credit, & incentives [12] while others develop and promote technologies that can make some household more energy efficient [2]. Recently the government launches strict implementation of regulation and mandated all government agencies to conserve power energy and tap the renewable energy abundantly present in the country [6]. The energy policy of the Royal Commission of Yanbu is the system used to address issues on energy production, distribution and local consumption. It is mandated to implement environmental policy at the industrial city of Yanbu. This is done thru the strict implementation of regulation RCER 2010 that various industries to follow as guidelines to ensure a cleaner environment and reduce $CO2$ emission. Likewise the Saudi Energy Efficiency Center (SEEC) was created in 2010 for development of energy efficiency and conservation policy and such regulation are now strictly implemented for any house related innovation.

3. Definition & Benefits

To reduce power energy consumption in Saudi Arabia the Saudi Building Council was created in 2009 to promote housing design conducive to Arab culture but at the same time ecofriendly and energy efficient. In general, housing mainly consume much of the power energy produced [3],[8]. The housing or buildings consume much energy to keep the atmosphere inside relaxed through cooling, ventilation, and heating. It needs power for the use of home appliances, lighting systems, and other electronic equipment [10]. There is a need to improve the housing design to reduce the power energy needs to prepare its spaces (cooling, heating, and ventilating).

Replacing old appliances and using the LED or CFL lamps will help in reducing the power consumption and improve energy efficiency [4], [5]. Hence all efforts were mainly focused in reducing the power consumption of housing thru house innovation and the use of power saving appliances. Most of the houses are now properly insulated and well ventilated and installed with water efficient equipment while appliances with high energy efficient rating were mostly recommended for government housing program. In 2010, appliances that do not conform to energy efficiency are now being phase out or not allowed in the market [11]. In addition some industrial waste produced was recommended for recycling and use as building materials within the kingdom. Installation of water-efficient equipment and appliances in kitchens and bathrooms were implemented to reduce water consumption

4. Application

4.1 Building Design- Compliant to Saudi Green Building Council Requirement
4.2 Road Network System- Smart traffic system & modern road network
4.3 City Bus Service-encourage residents to take public transportation to reduce cars on the road.
4.4 Mosque Construction- Design allows natural light and efficient use of cooling system.
4.5 Energy Efficiency & Education- promote and provide funding for project related to renewable energy.
4.6 Implementation of Sustainable Development-encourage future innovations to sustain energy efficiency
4.7 Green Regulation & Technologies - promote residents to go green
4.8 Attract new innovative technologies & select best conceptual energy efficient design-incentives are given to various industries that promote new technology.
4.9 Houses and Urban planning-ecofriendly and energy efficient houses are built in RCY to reduce waste energy and reduce power energy consumption.

5. Goals

In the recent survey of power consumption in Saudi Arabia, it was shown that electricity consumption is increasing and the housing sector consumes almost half of the total. As a result the government spent billions for power generation. This can be reduced if energy efficiency can be applied to all housing construction development by installing proper insulation, housing design that can use natural light rather than artificial light and optimum use of air condition for cooling. In this way power consumption in can be reduced and will save millions of dollars in saving.

Thus it is the goal of the Saudi government to tap other source of renewable energy so that by 2020, the country‘s consumption of power energy from oil can be reduce and can be exported to generate revenue. Construction of solar power has been initiated to tap this vast renewable energy [6],[7]. Likewise research had been on going in some university to tap the wind energy. The country had been replacing the use of incandescent lamp to CFL or fluorescent lamp or LED lamp. Street lamp and some communication equipment have been powered by solar. Thus it is the aim of the government that by 2020 consumption of power energy from fossil fuel will be drastically reduced as shown in Figure 1. Lately landscaping project has been expanded and implemented in the city that resulted in increase of shade. This resulted in cooling the surrounding area since trees can absorb the heat energy coming from the sun. Although the landscaping project entails more water consumption, the RCY recycle the domestic waste water as irrigation water.

RC-Yanbu Solar & Renewable Energy Goals 2020

- Royal commission Yanbu's goal is 10% renewable energy by 2020.
- 3% of energy demand from renewable sources.
- 7% to be achieved through energy efficiencies.

Power User	2010 MW Demand	2020 MW Demand	Renewable Energy & Energy Efficiency by 2020, MW	2020 Solar & Renewable ENERGY Goal, MW	Target Energy % Goal by 2020
Primary and Secondary Industries	655	1,000	21+49	70	7
Light industry	12	20	0.9+2.1	3	15
Community	120	190	11.7+27.3	39	20
Marafiq Plant	58	90	5.4+12.1	18	20
Total, MW	845	1,300	39+91	130	10

Energy Efficiency Application in RCY

Figure 1. RCY proposed target to reduced power demand thru energy efficiency in the city.

6. Results

Implementing energy efficiency within the industrial city of Yanbu particularly on the housing sector will increase the value of the property since this property will be in great demand on leasing sector. In addition, the housing design with reduced power consumption will contribute in CO2 reduction as well as in maintenance cost in the future. Figure 2 shows the benefits that can be derived in reducing the power consumption.

Figure 2. Result on the implementation of energy efficiency in RCY

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Land Use Change with Externalities in the Fringe of Jakarta Metropolitan: Spatial Tobit Model

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Abstract

Among many other factors, land use externalities became more significant factors which drive land use change. The theoretical land use change model with externalities indicates that the competing externalities contribute to the sprawled development pattern in an urban area. This theory is empirically supported by the result of a study of land use change in the fringe of Jakarta Metropolitan. There are some evidences that sprawl in this area has been driven by interaction of competing land use externalities. This type of development is considered inefficient. It gives more pressure to the conservation area and the productive agricultural sites in the southern fringe. It motivates this study to analyze the extent of those externalities and their role in shaping the recent development pattern based on spatial econometric models. The model will be useful to predict the effect of future land use change on the conservation area and productive agricultural sites. Two models are considered namely Spatial of Lag X (SLX) Tobit Model and Spatial Durbin (SD) Tobit Model. Two variables (density and area proportion of agricultural activity) at district level are used to capture the competing externalities (social and green externalities) of land use. The proportion of developed area per district serves as a proxy for the development land value. The model confirms the significant role of the spatial externalities on the development activities, even though only the social externalities that can extend locally. The natures of externalities are in line with predicted effect of land use change.

Keywords: externalities, land value, sprawl, spatial model

Introduction

The fundamental concept underlying the essence of regional science has been determined by the importance of space. Among many other issues faced by cities and regions, land use change problem has been addressed by formulating empirical as well as theoretical model of human or agent spatial behavior. The theoretical model must be specified in a formal mathematical model, and validated based on the empirical model. In the empirical model, variables need to be given meaning in the context of available data and measurements. In this case, the data (e.g. land value, land use, density, distance to CBD, etc) must have spatial reference, so called spatial data. They are used further to estimate the model parameters, test the hypotheses and predict the effect of various scenarios under study. This is typically conducted based on a statistical or econometric methodology.

The main characteristics of spatial data are spatial dependence and spatial heterogeneity. Spatial dependence is a functional relationship between situation in one space and situation elsewhere. In terms of land use change, it defines the situation in which land use type in one location depends on land use type in the nearby location. It is a fundamental concept due to the existing spatial interaction phenomena. On the other hand, spatial heterogeneity refers to variance changes across the spatial data sample. These spatial effects are the main interest of the analysis, but they may violate the Gauss Markov assumption in a standard OLS based econometric model. Therefore alternative estimation methods, such as maximum likelihood (ML) (Ord 1975), quasi maximum likelihood (QML) (Lee 2004), instrumental variable (IV) (Anselin 1988), generalized method of moments (GMM) (Kelejian and Prucha, 1998, 1999) or Bayesian Markov Chain Monte Carlo Methods (Bayesian MCMC), are needed (Anselin 1988; LeSage and Pace 2009). Those techniques are considered to be the domain of spatial econometrics. The last method is particularly useful to deal with some problems (e.g. a heteroscedastic error structure, or a limited dependent variable) in which the standard methods cannot work properly, due to the characteristics of spatial data.

The traditional monocentric city model from Alonso (1964) is the initial model of land value, in which distance from CBD is the main determinant of land value. It predicts that the pattern of development will be the compact ring of developed land surrounds the CBD, followed by agricultural land in the outskirt of the city. Clearly, it does not explain very well the emergence of sprawl in many metropolitans around the world including Jakarta Metropolitan and its fringe area (BoDeTaBek: Bogor, Depok, Tangerang and Bekasi) (Douglass 2000).

Sprawl is the type of discontinuous pattern of urban development in the fringe of urban center. It is considered as an inefficient development activity, with higher costs than benefits. In the fringe of Jakarta, one of the costs is the premature conversion of productive agricultural sites or any conservation areas (Firman 2004). A recent study (Fitriani and Harris 2011) indicates that in this area, in addition to some other driving forces, sprawl has been mainly dictated by the interaction of two competing land use externalities: (1) social type of externality which represents the urban agglomeration, and (2) green type of externality which captures the preference for surrounding open space. The study shows that this type of development has increased the development value of the conserved and the productive agricultural sites in the southern fringe.

Even worse, the recent land use policy has not been enforced effectively, such that the environmentally important sites in this area have been converted for urban use (Firman 2004). Consequently, the main Jakarta and the surrounding regions have suffered serious environmental problems, e.g. flood, water quality degradation (Douglass 2005). Some studies indicate that the negative consequences of sprawl (Irwin and Bockstael 2004; York and Munroe 2010; Fitriani and Harris 2012) can be reduced by applying proper land use policy (e.g. urban growth boundary, incentive based policy or zoning) based on the most dominant type of externalities. It is expected that the policy can reduce the development pressure on the sites which are environmentally sensitive. It motivates this study to analyse the extent of those externalities and their role in the recent development activities in the area based on a model of land value with externalities: Residential Choice of Location model with Externalities from Fitriani (2011).

It is clear that in the case of land value, spatial externalities which are the product of interaction of spatially distributed agents (households, farmers) (Caruso, Peeters et al. 2007), lead to spatial dependency of land use between neighbouring locations. Therefore the significance of each type of externalities will be tested based on one of the spatial econometric models. Two spatial econometric models will be considered, namely Spatial Durbin (SD) Model and Spatial Lag of X (SLX) Model.

Specifically for the case of Jakarta, since there is no formal land market, it is not possible to obtain land value explicitly in term of price. For that reason this study use per district development proportion as a proxy of land value. Unfortunately, this approach leads to the limited nature of the dependent variable, which motivates the use of SD Tobit Model and SLX Tobit Model. The result will be useful as a reference to formulate proper policies and predict their effect on the land value.

Spatial Econometric Models: Spatial Durbin (SD) Tobit Model and Spatial Lag of X (SLX) Tobit Model for Limited Dependent Variable

This section initially presents a general characteristics for spatial econometric models, which is then followed by a more specific approach in which the dependent variable is limited.

The main difference between spatial model and other statistical models is that the used of location index for every unit of observation, describing their spatial arrangement geographically. The location index plays an important role in defining the “neighbors” in which a particular location has spatial dependencies on. The definition of neighbors has been translated into a spatial weight matrix $\boldsymbol{W}$ which describes the spatial arrangement. The spatial weight matrix is commonly formed based on one of the following schemes (i) spatially contiguous neighbors, (ii) inverse distances, (iii) length of shares borders, (iv) bandwith as the n-th nearest neigbhbor distance, (v) ranked distances, (vi) constrained weight, (v) all centrois within distance d, (vi) constrained weight for an observation equal to some constant (Elhorst 2014).
In this study, the spatial weight matrix will be formed based on the assumption that the externalities can extend to a certain radius (d). Beyond the specified distance, the effect of externalities will be diminished. The particular distance should be chosen based on the characteristic of land use change in the area under study. Fitriani and Sumarminingsih (2015) determine the distance (d) specifically for the case of the

fringe of Jakarta Metropolitan, based on a semivariogram analysis. They conclude that the social externalities reach to a shorter distance than the green externalities. It motivates the use of different distances, i.e. different spatial weight matrices for each type of externalities. The two locations are considered neighbors if their distance is less than the specified distance (*d*). The *ij*th element of the non-normalized spatial weight $n \times n$ matrix will be 1 if observation *j* is neighbor to observation *i*, and 0 otherwise, with *n* as the number of region/observation under study. For the ease of interpretation, the normalized matrix (the elements of each column is sum to one) is commonly used.

Two models representing the assumed types of spatial dependency are considered. First, it is assumed that land development value (***Y***) between locations interact globally. In this case the externalities (***X***) offered by a certain location have been capitalized into the land development value of its neighbors, which in turns have also affected the land development value of their neighbors. This might be due to the time dependence of land use decision or the exclusion of other spatially dependent explanatory variables (LeSage and Pace 2009). It motivates the use of SDM, in which the interaction effects are captured by **WX** for the externalities and **WY** for the land development value, which is defined as follows:

$$\mathbf{Y} = \rho\mathbf{WY} + \mathbf{X}_1\boldsymbol{\beta} + \mathbf{WX}_2\boldsymbol{\theta} + \boldsymbol{\varepsilon} \qquad \textbf{(0.1)}$$
$$\mathbf{Y} = (\mathbf{I} - \rho\mathbf{W})^{-1}(\mathbf{X}_1\boldsymbol{\beta} + \mathbf{WX}_2\boldsymbol{\theta} + \boldsymbol{\varepsilon}).$$

In (2.1) the magnitude of interaction effect for externalities and land development value are represented by $\boldsymbol{\theta}$ and ρ respectively.

The second assumption is that the interaction of land development value between neighboring locations, comes locally through the explanatory variable defining each type of externalities. In other words, the land development value of a particular location depends on the externalities offered by its neighbors. It leads to the use of (SLX) in which the interaction effects are captured by **WX** (LeSage and Pace 2009), based on the following form:

$$\mathbf{Y} = \mathbf{X}_1\boldsymbol{\beta} + \mathbf{WX}_2\boldsymbol{\theta} + \boldsymbol{\varepsilon}. \qquad \textbf{(0.2)}$$

In (2.1) and (2.2) $\mathbf{Y}$ is the $n \times 1$ vector of response variable, $\mathbf{X}_1$ is the $n \times k_1$ matrix of k_1 spatially independent explanatory variables including the constant term, $\mathbf{X}_2$ is the $n \times k_2$ matrix of k_2 spatially dependent explanatory variables and $\boldsymbol{\varepsilon}$ is the $n \times 1$ vector of the error terms.

The models defined in (2.1) and (2.2) assume that all dependent as well as independent variables are known for the entire sample. In a certain situation the sample is limited by censoring (Long 1997). It occurs when the independent variables are observed for the entire sample, but the information of the dependent variable are limited. This type of dependent variable is called a latent variable (Y_i*). For example, when per district development proportion (Y_i*) is used as the proxy for land development value, it is only observed for a certain range of value (e.g. $0 \leq Y_i^* \leq 1$). The observed 0 value of Y_i* also represents the unobserved negative values, which are censored at 0. On the other hand, the observed 1 value of Y_i* also represents the unobserved greater than 1 values, which are censored at 1. Therefore, Tobit model should be used instead. By still accommodating the assumed spatial dependencies, the SD Tobit model can be defined as (LeSage and Pace 2009):

$$\mathbf{Y}=\begin{cases}0, & \text{if} \quad \mathbf{Y}^*<0\\ (\mathbf{I}-\rho\mathbf{W})^{-1}(\mathbf{X}\boldsymbol{\beta}_1+\mathbf{W}\mathbf{X}\boldsymbol{\beta}_2+\varepsilon), & \text{if} \quad 0\le\mathbf{Y}^*\le 1\\ 1, & \text{if} \quad \mathbf{Y}^*>1\end{cases} \tag{0.3}$$

and the SLX Tobit model as:

$$\mathbf{Y}=\begin{cases}0, & \text{if} \quad \mathbf{Y}^*<0\\ \mathbf{Y}^*=\mathbf{X}\boldsymbol{\beta}_1+\mathbf{W}\mathbf{X}\boldsymbol{\beta}_2+\boldsymbol{\varepsilon}, & \text{if} \quad 0\le\mathbf{Y}^*\le 1\\ 1, & \text{if} \quad \mathbf{Y}^*>1\end{cases} \tag{0.4}$$

The models in (2.3) and (2.4) indicate that any change of an explanatory variable at location *i* affect not only the response at the same location (Y_i*) but also the respone at other locations (Y_j*, $i\neq j$). In terms of marginal effect, for a general spatial econometric model, the two effects are called direct and indirect (or spillover) effects, respectively. Specifically for SD Tobit model in (2.3) the direct and indirect effects because of the change of variable $X_{1k}, k=1,\dots,k_1$ are the diagonal elements and off diagonal elements of $(\mathbf{I}-\rho\mathbf{W})^{-1}\beta_k$, respectively. The direct and indirect effects due to the change of variable $X_{2k'}, k'=1,\dots,k_2$ are the diagonal elements and off diagonal elements of $(\mathbf{I}-\rho\mathbf{W})^{-1}\mathbf{W}\theta_{k'}$, respectively (Elhorst 2014). Both effects are presented as an average of elements which correspond to the desired effect. Since SLX Tobit model in (2.4) is the version of (2.3) when $\rho=0$, the diresct effect will be simply β_k (due to change of the spatially independent explanatory variables) and the indirect effect will be $\theta_{k'}$ (due to the change of spatially dependent explanatory variables). In addition to the significant test for the estimated parameters, the estimated indirect effects should also be used to test the hypothesis whether the spatial interaction is significant.

Bayesian MCMC Estimators for Spatial Tobit Model

Due to the limited nature of the available dependent variabel, this study uses SD and SLX Tobit Models. In a non spatial model, it is assumed that the limited dependent variable has a censored normal distribution, and use it to derive the estimators which maximize the likelihood (MLE). But, in the Spatial Tobit model, the spatial interdependence leads to the use of Multivariate Truncated Normal Distribution (TMVN). With this assumed distribution, MLE would require more technical difficulties as well as computational time. Therefore MCMC is proposed to handle the issues.

In general, the observations are divided into two blocks, one block of n_1 “censored” observations and another block of n_2 “observed” observations. According to the defined models in (2.2) and (2.3), the observations are censored if $Y_i^*<0$ or $Y_i^*>1$. Whereas the observations falls into the “observed” block if $0 \le Y_i^* \le 1$. An $n_1\times 1$ vector of the “censored” observations is defined as $\boldsymbol{Y}_1^*$ and an $n_2\times 1$ vector of the “observed” observations is defined as $\boldsymbol{Y}_2$. The conditional posterior distribution for the n_1 “censored” observations is TMVN with certain mean and variance covariance:

$$
\begin{aligned}
&\mathbf{Y}_1{*} \sim TMVN\left(\boldsymbol{\mu}_1^*, \boldsymbol{\Omega}_{1,1}^*\right)\\
&\boldsymbol{\mu}_1^* = \boldsymbol{\mu}_1 - \left(\boldsymbol{\Psi}_{1,1}\right)^{-1}\boldsymbol{\Psi}_{1,2}\left(\mathbf{Y}_2 - \boldsymbol{\mu}_2\right)\\
&\boldsymbol{\Omega}_{1,1}^* = \boldsymbol{\Omega}_{1,1} + \left(\boldsymbol{\Psi}_{1,1}\right)^{-1}\boldsymbol{\Psi}_{1,2}\boldsymbol{\Omega}_{2,1}
\end{aligned}
$$

with the following definitions for the SD Tobit model:

$$
\begin{aligned}
&\boldsymbol{\Omega} = \sigma_\varepsilon^2\left[\left(\mathbf{I} - \rho\mathbf{W}\right)'\left(\mathbf{I} - \rho\mathbf{W}\right)\right]^{-1},\\
&\boldsymbol{\Psi} = \boldsymbol{\Omega}^{-1}\\
&\boldsymbol{\mu}_1 = \left(\mathbf{I} - \rho\mathbf{W}\right)_{1,1}^{-1}\left(\mathbf{X}_1\boldsymbol{\beta}_1 + \mathbf{W}\mathbf{X}_1\boldsymbol{\beta}_2\right)\\
&\boldsymbol{\mu}_2 = \left(\mathbf{I} - \rho\mathbf{W}\right)_{2,2}^{-1}\left(\mathbf{X}_2\boldsymbol{\beta}_1 + \mathbf{W}\mathbf{X}_2\boldsymbol{\beta}_2\right)
\end{aligned}
$$

and for the SLX Tobit model:

$$
\begin{aligned}
&\boldsymbol{\Omega} = \sigma_\varepsilon^2,\\
&\boldsymbol{\Psi} = \boldsymbol{\Omega}^{-1}\\
&\boldsymbol{\mu}_1 = \mathbf{X}_1\boldsymbol{\beta}_1 + \mathbf{W}\mathbf{X}_1\boldsymbol{\beta}_2\\
&\boldsymbol{\mu}_2 = \mathbf{X}_2\boldsymbol{\beta}_1 + \mathbf{W}\mathbf{X}_2\boldsymbol{\beta}_2
\end{aligned}
$$

The subscripts 1 and 2 are used to denote an $n_1 \times n_2$ matrix, such that for example $\boldsymbol{\Omega}_{1,1}$is an $n_1 \times n_1$ sub matrix of $\boldsymbol{\Omega}$ and $\boldsymbol{\Omega}_{2,2}$is an $n_2 \times n_2$ sub matrix of $\boldsymbol{\Omega}$.

In order to obtain the Bayesian MCMC estimators a Gibbs sampling procedure is applied. Using the initial values of the model parameters $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, σ, and ρ, the assumed TMVN is used only to generate the "censored" observations $\boldsymbol{Y}_1$*. The full sample ***Y**** =($\boldsymbol{Y}_1$*', $\boldsymbol{Y}_2$')' is then used to sample from the conditional posterior distribution for the remaining model parameters $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, σ, and ρ, such that the first set of parameter estimates are found. It is used then to generate the "censored" observation for the second round, and so on. The procedure will stop until it converge at the required model parameter.

The Study Area and Data Specification

The study area covers the fringe of the Jakarta Metropolitan Area: Bogor Regency, Bogor Municipality, Depok, Bekasi Regency, Bekasi Municipality, Tangerang Regency and Tangerang Municipality. Each region has some districts at the lower administration level, leading to 83 districts in overall. District will be the unit of study. The map of the regions and the planned important urban centres is depicted in Figure 1. The spatial information of each district is extracted from the map of the study area provided by BIG (Geospatial Information Agency) Indonesia. The land use related variables of the districts are available from "Regions in Numbers" by *BPS* (Central Statistics Biro) Indonesia for situation in 2010.

The empirical model of land value for development in this study is based on the Residential Choice of Location with Externalities from Fitriani (2011). In that theoretical model, land rent is a function of a vector of specific location characteristics (e.g. distance to the CBD ($Dist_i$), and neighbourhood land use externalities) and the development costs. The distance negatively affects land value, and conversely the neighbourhood land use externalities positively affect land value. Whereas the higher the development costs the lower the rent will be.

Since the land market in the area has been dominated by informal sector, information of land rent in terms of price is limited. Therefore, the development proportion per district (Dev_i) is used as a proxy for development rent or land development value. The small proportion of development in a district implies that the particular district is less likely to be developed or it has low development value. On the other hand, the higher the proportion of development in a district represents its potential for development or its high development value.

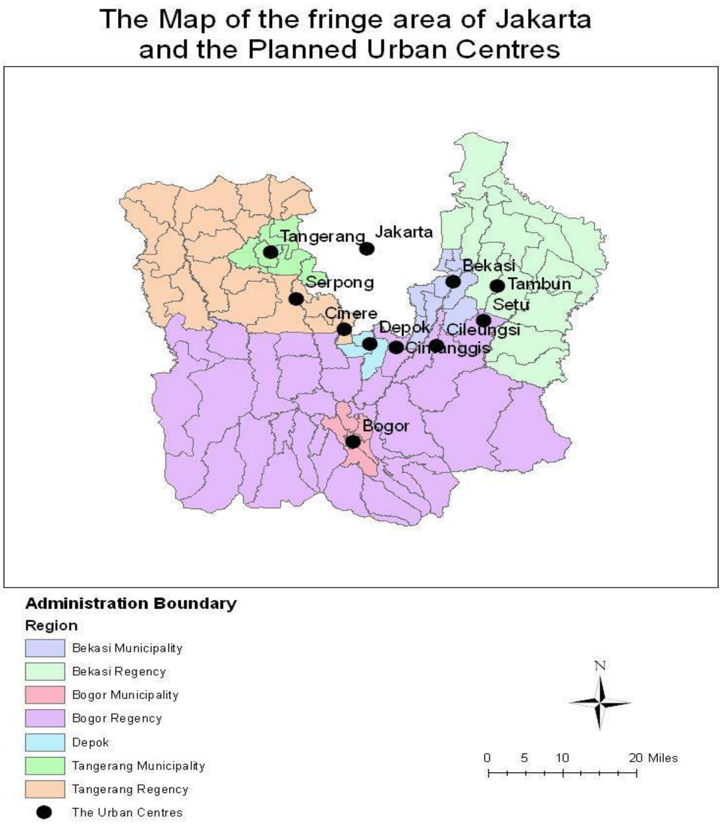

Figure 1: The map of the study region: the fringe area of Jakarta metropolitan and the Planned urban centres.

The proxy of development value is considered as a limited variable, since it is observed only for value in between 0 and 1. An observed 0 proportion of development in a certain district might also represent negative development value. On the other hand, an observed 1 proportion of development in a certain district might represents a high intensity development. This type of development is the implication of a considerably high development value of the district.

Two variables are used to capture the competing externalities of land use, indicated as the causes of sprawl development pattern in BoDeTaBek. They are density (1000 people/km^2) per district and proportion of land use for agricultural activity per district. Following the previous study (Fitriani and Sumarminingsih 2015), density per district ($Dens_i$) is chosen as a proxy of social type of externalities since it represents the intensity of social interaction in a particular district. Whereas, each district proportion of agricultural area (Agr_i), which defines per district amount of agricultural activity, represents the green type of externalities.

This study differentiates the definition of neighbors for each type of externalities. It is motivated by the result of semivariogram analysis in Fitriani and Sumarminingsih (2015), in which each type of externalities can be enjoyed by districts (neighbors) within radius 29 km and 21 km respectively for green and social externalities. Therefore, the 83×83 spatial weight matrix for the green externalities ($\mathbf{W_1}$) is designed such that every two districts will be neighbors if their distance is less then 29 km, whereas the 83×83 spatial weight matrix for the social externalities ($\mathbf{W_2}$) is designed such that every two districts will be neighbors if their distance is less then 21 km. In addition to $\mathbf{W_1}$ and $\mathbf{W}_2$, a spatial weight matrix for the development proportion per district (Dev_i) is also defined. It is assumed that land development value in a certain location is affected by the land development value of neighboring districts. Rook Contiguity matrix (**W**) is used in this case, such that only border sharing districts are considered as neighbours. It is an 83 × 83 matrix with 1 as the *ij*-th element, if the *i*-th and *j*-th districts are neighbours, and 0 otherwise. Using this setting, the main diagonal elements are zeroes. Both matrices are used in their normalized forms.

This study also uses the geographical condition, defined as:

$$Geo_i = \begin{cases} 1, & \text{if above 50\% of district } i \text{ is flat} \\ 0, & \text{otherwise (hill, swamp or mountain area)} \end{cases}$$

as a proxy for the development costs. The mostly flat region (Geo_i = 1) is more suitable for development such that it is predicted to have higher development rent. Together with distance to CBD ($Dens_i$), they form an 83×3 matrix of spatially dependent explanatory variables (including constant):

$$\mathbf{X} = [\mathbf{Dist} \quad \mathbf{Geo} \quad \mathbf{1}].$$

Two spatial econometric models, with limited dependent variable, SD Tobit model in (2.3) and SLX Tobit model in (2.4) are considered. The simpler model is the second one. The model assumes that land development value in a certain location/district has been driven by its distance to the CBD and two competing externalities offered by its neighboring districts. This study differentiates the definition of neighbors for each type of externalities. It is motivated by the result of semivariogram analysis in Fitriani and Sumarminingsih (2014), in which each type of externalities can be enjoyed by districts (neighbors) within radius 29 km and 21 km respectively for green and social externalities. Therefore, the 83×83 spatial weight matrix for the green externalities ($\mathbf{W_1}$) is designed such that every two districts will be neighbors if their distance is less than 29 km, whereas the 83×83 spatial weight matrix for the social externalities ($\mathbf{W_2}$) is designed such that every two districts will be neighbors if their distance is less than 21 km. Both matrices are used in their normalized forms. The SLX Tobit model in terms of the operational variables is defined as:

$$\mathbf{Dev} = \begin{cases} 0, & \text{if } \mathbf{Dev^*} \le 0 \\ \mathbf{Dev^*} = \mathbf{X\beta_1} + \mathbf{W_1 A}\beta_2 + \mathbf{W_2 Dens}\beta_3 + \varepsilon, & \text{if } 0 < \mathbf{Dev^*} < 1 \\ 1, & \text{if } \mathbf{Dev^*} \ge 1 \end{cases} \quad (0.5)$$

On the other hand, SDM, in addition to all the above specifications, also assumes that land development value in a certain location is affected by the land development value of neighboring districts. Rook Contiguity matrix (***W***) is used in this case. In terms of the operational variables, the definition of SD Tobit model is:

$$\mathbf{Dev} = \begin{cases} 0, & \text{if } \mathbf{Dev^*} \le 0 \\ \mathbf{Dev^*} = (\mathbf{I} - \rho\mathbf{W})^{-1}(\mathbf{X}\boldsymbol{\beta}_1 + \mathbf{W}_1\mathbf{A}\beta_2 + \mathbf{W}_2\mathbf{Dens}\beta_3 + \varepsilon), & \text{if } 0 < \mathbf{Dev^*} < 1 \\ 1, & \text{if } \mathbf{Dev^*} \ge 1 \end{cases}, \quad (0.6)$$

Results and Discussion

The Bayesian MCMC estimators for both models are depicted in Table 1. Only for the SLX Tobit model, the *t test* for distance – *Dist* to the CBD and neighborhood density – *Dens* (social externalities), significantly affect land development value. While the effect of neighborhood agricultural activity – *Agr* (green externalities) is not significant in all models. However, the result for every model confirms the individual effect predicted by theoretical land value model in which distance to the CBD negatively determine land development value (negative coefficient of *Dist*), the externalities exert positive effects on development land value (positive coefficients of *Dens* and *Agr*) and region with lower development costs (mostly flat) has higher development land value (positive coefficient of *Geo*). But, the structure of the assumed spatial models (in (4.1) and (4.2)) implies that each of the coefficient estimates does not represent the marginal effect of each explanatory variable. In fact, the marginal effect consists of the effect on the same location (direct) and the effect on other locations (indirect). Therefore the coefficient estimates cannot be used alone if the objective of the study is to analyze the significance of the spatial spillover or externalities. The empirical model of land development value assumes the existence of spatial spillover through its explanatory variables. This assumption can be tested based on the estimates of the indirect effects. The 95% and 99% confidence intervals of the indirect effect of each variable, provided by the Bayesian MCMC estimation procedure, will be useful for that purpose.

The result in Table 1 shows that, the SD Tobit model produces direct and indirect effects of all variables. But the confidence intervals indicate that only the direct and indirect effects of distance – *Dist* that is different from zero. On the other hand the SLX Tobit model produces indirect effects of the neighborhood externalities variables (*Dens* and *Agr*), but only the effect of the neighborhood density – *Dens* that is different from zero. The structure of SLX implies that even though the direct effect of distance to the CBD – *Dist* on land development value is significant, it does not affect the neighbors land development value.
One main question is, among the two assumed models, which model best describes the data. As mentioned earlier, the SLX Tobit model is nested in SD Tobit model, in which SLX Tobit model is the version of SD Tobit model when the when $\rho = 0$. The estimated coefficients in Table 1 indicate that indeed that is the case, the estimated coefficient for development value spatial interaction (ρ) in SD Tobit model is not significant. Therefore SLX Tobit model is considered as a more representative model for the land development value with externalities in BoDeTaBek. The Bayesian Information Criterion (BIC) of the two models are in accordance with this choice. BIC is the measure of model fitness based on the residual sum of square of the model

and the number of explanatory variables. Therefore the better the model fit the data, the smaller residual sum of square will be. Furthermore the simplicity of the model is indicated by fewer explanatory variables used. In overall, the better the model the smaller the BIC is. In this case, based on the presented BICs of the two models in Table 1, SLX is indeed the better model.

Table 1 The Bayesian MCMC Estimators for SDM and SLX to Explain Land Development Value

Variable	SD Tobit Model	SLX Tobit Model
Constant	0.460429 (0.102)	0.775622 (**) (0)
Dist	-0.009135 (0.104)	-0.017871 (**) (0)
W_1. Dens (social externalities)	0.000012 (0.171)	0.000021 (**) (0)
W_2. Agr (green externalities)	0.059841 (0.486)	0.45372 (0.142)
Geo	0.097456 (0.164)	0.091057 (*) (0.097)
ρ	0.393802 (0.102)	-
s^2	0.0377	0.0288
Residual Sum of Square	2.9029	2.2464
BIC	114.967	89.268

** Significant at 5%; * Significant at 10%; p value of the t-test in parentheses

Direct Effect	**SD Tobit Model**	**SLX Tobit Model**
Dist	-0.009622 (**)	-0.017871 (**)
Dens (Social Externalities)	0.000012	-
Agr (Green Externalities)	0.065435	-
Geo	0.10254	0.091057 (*)
Indirect Effect	**SD Tobit Model**	**SLX Tobit Model**
Dist	-0.006331 (**)	-
Dens (Social Externalities)	0.00008	0.000021 (**)
Agr (Green Externalities)	0.312483	0.45372
Geo	0.068762	

** Significant at 1% based on 99% confident interval; * Significant at 5% based on 95% confident interval

Theoretically, sprawl exists when a development decision has been influenced by the equal need between the social externalities (to be surrounded by other development) and the green externalities (to be surrounded by open space). The coefficient estimates as well as indirect effects estimate of SLX Tobit model are the tools to discover the relative importance between the two types of externalities for the development decision, leading to sprawl in BoDeTaBek. In general the SLX Tobit model confirms that based on 2010 land use data, the empirical land development value model of BoDeTaBek does not deviate from the theoretical model. Distance to CBD is negatively determined land development value. The further the location from the CBD is, the lower the land development value is. In addition to distance, the empirical model indicates that the two competing types of neighborhood externalities positively determined the development land value. However, only the coefficient estimates of social externalities, which is significant, individually as well as indirectly. It gives some evidence that in BoDeTaBek, sprawl is indeed partly driven by interaction between the two competing externalities. The fact that SLX Tobit model is the chosen empirical model implies that the spatial externalities, especially the social externalities, offered by a certain district can be extended locally for its immediate neighbors. The new development in a certain location affects the land value of its immediate neighbors. The SLX Spatial Tobit model is then used to predict per district development proportion. The comparison between per district prediction and the current condition is depicted in Figure 4. By comparing per district agriculture proportion in Figure 2, and per district density in Figure 3, Figure 4 indicates that the rate of development will be faster for districts in proximity to urban centers, with mixed uses between agriculture activity and development. The local characteristic of social externalities explains this situation. The higher rate of development occurs as well in the southern fringe districts, near Bogor, which originally designated for conservation and water recharge area.

Concluding Remarks

The characteristics of land development value with externalities require the accommodation of spatial dimension to develop the empirical model. It is in the context of spatial econometric models. Among many spatial econometric models, when spatial spillover of land development value is assumed, SLX is the model which suits the situation for the case of BoDeTaBek. This study uses a limited type variable as a proxy for the development value, which leads to the application of SLX Tobit model. The coefficient estimates in the SLX Tobit model for the empirical land development value model of BoDeTaBek give some evidence for the contribution of the neighborhood externalities on land value, leading to sprawl. In this case, among the two competing externalities, the social externalities create more significant effect on the development value.

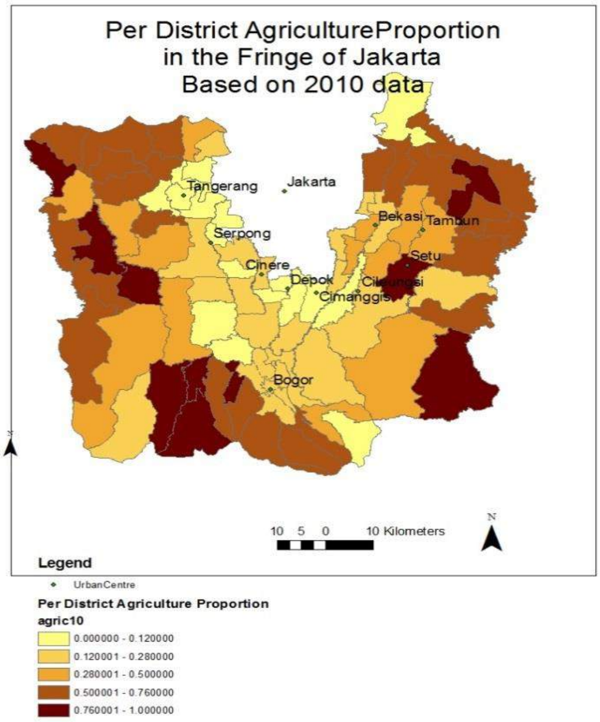

Figure 2: Per District Agriculture Proportion in the Fringe of Jakarta, 2010 Data

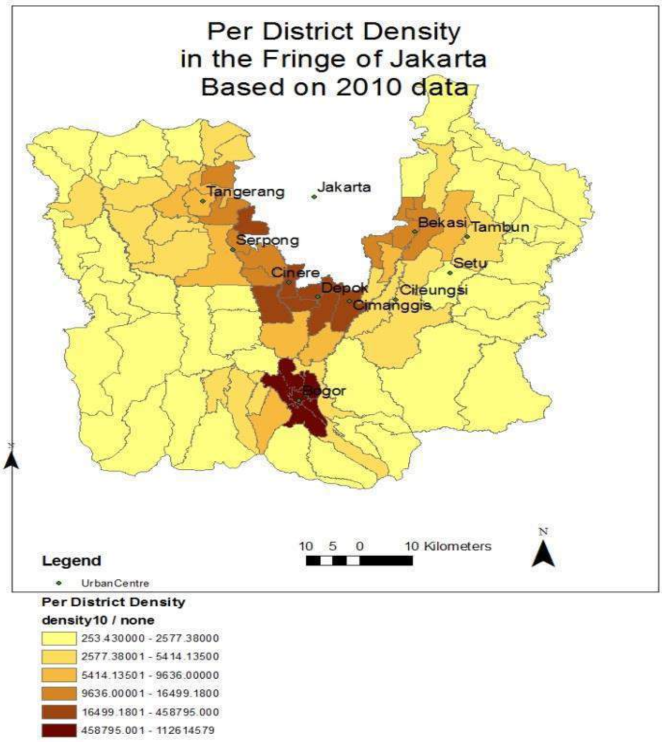

Figure 3: Per District Density in the Fringe of Jakarta, 2010 Data

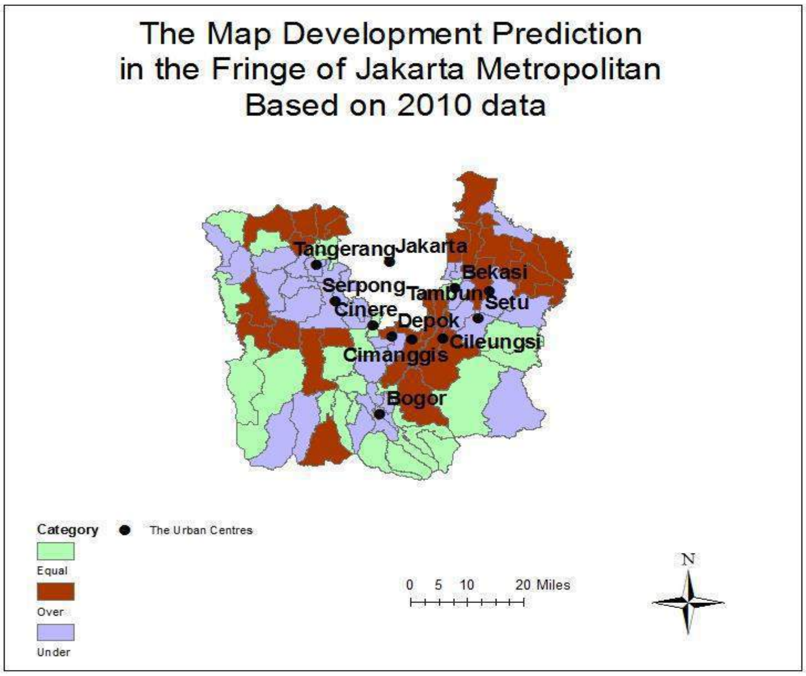

Figure 4: The Map of Development Prediction in the Fringe of Jakarta, 2010 Data

The knowledge regarding the local characteristic of the social externalities should be accommodated in the future development planning and policy. By accommodating this characteristic, the development pattern can be arranged more compactly, such that the new development can be concentrated on the nearby urban centre, and leave the as much as possible the conservation area in its current use. Moreover, any implemented policy in one district must be in line with the implemented policy in the neighboring districts.

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Proposal and Discussions of Simple PCS for PV Power Generation as Veranda Solar

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Abstract
The renewable energy including photovoltaic power generations have been accepted and spread widely. Various innovative power conditioning systems have been also studied. In domestic utilization, the actual application of such solar panels is almost installed on top of the roof of the detached house. However, some residents living in the apartment house are having a fairly strong desire to contribute for energy saving due to natural energy generation. The generating power in such case is fairly reduced, so the system construction should be balanced with the reduced power. Thus, it is necessary to improve the construction for simple one. In this paper, in order to give a reply, simple and concise photovoltaic power generating systems are examined. Considering fairly reduced generation power and narrow space of installation in the apartment houses, the system constructions should be simple and concise. In this paper, the circuit which gratified their wishes are presented and discussed. These solar panels can be easily connected like usual home appliances having attached plug for connection. For reversed power flows and increasing harmonics, their protecting circuits are installed in the input power line. Simple system circuit and construction will be presented and discussed. In addition, a battery storage system is also presented for more reliable power supply.

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1. Introduction

Preserving the developments of economy, science and technology with conquering the problems against environmental conservation is an important assignment for humanity of the world. The usage of the renewable energies is expected to be able to mitigate such problem, [1],[2] which is an important means. Among them, photovoltaic power generation have various advantages such as usage of inexhaustible and unpolluted sunlight, which is advantageous for maintenances, easily construction from small power to large one, and can be installed in various location including city center. In such a way, this power generation system is a promising one with bright future.

As a utilization form, utility interactive power generation system has been accepted and widely spread [3], [4]. In such power generation system, it is necessary to install the chopper, where the lower voltage of solar cell should be boosted to suitable voltage and inverter where the dc power of boosted voltage should be converted to ac power in the power system.

The power conditioners-PCS including inverter have been presented in various systems so far [5], [6]. However, it is necessary to reduce the cost even more. It is said that the system is approaching to an ideal ones with respect to efficiency and the like[7], but that cost would prevent wide spread if there is no public financial support.

In such discussions, there are many subjects to be solved to utilize the PV power in utility interactive power generation. Even more, various safeguard equipment required according to regulations make the cost increase. Thus, it is required to obtain even more low cost PCS and the like [8]. In an extremely lower capacity PCS as discussed in this paper, a way of handling would be different compared to conventional ones. In such case of reduced generating power, quantities of reversed power to the power system would be small, where another mitigated regulation or deregulation would be approved. Thus, in such photovoltaic power generation systems, there are so many subjects to be resolved.

Under such circumstances accepted by electrical utility industry as recognitions and assessments for renewable energy, spread of application is strongly sustained by financial supports of public organizations, and a lot of consumers are hoping to install such PV power generation system. For ordinary homes, installation of solar panel is restricted to house having roofs. However, a lot of residents living in the apartment house also wish to install the PV panel under considering resource conservation and public financial support.. In the present situation, however, there is no scheme to perform these requirements. In this paper some simple PV generation systems and the components for such residents are presented and discussed.

2. Pursuit for Simpler Power Conditioner

2.1 Elimination of specific lower order harmonics

In this chapter, in order to pursue simple wave for power conditioner, harmonic elimination methods for lower order harmonics with small power is presented and examined. Fig.1 shows conventional single bridge circuit used in these situations. Because of simple way, a particular waveform calculated in advance is given at terminals A and B to eliminate specific lower order harmonics like by feed forward control which are fifth and seventh order harmonics in this case. The pole voltages relative to neutral point O is shown in Fig.2(a) and (b) as V_A and V_B, respectively. In general, in utility- interactive operation, the sinusoidal current is a goal to inject to the utility with minimum harmonics. In order to achieve such purpose, by means of feedback control following the sinusoidal waveform of grid voltage, high frequency switching method is accepted. In this method, however, it is necessary to provide current detectors for making sinusoidal wave or hysteresis control circuit, so the total cost is increased and reliance would be somewhat lowered because of increased number of parts and sophisticated circuits and the like. Thus, it is more effective to improve the control schemes toward simple one. The objective of this chapter is to present a concise control scheme like feed forward control having simpler scheme, where single waveform having simple pattern resolved in advance is injected in the network.

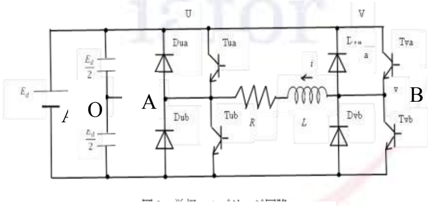


Fig.1. Full bridge

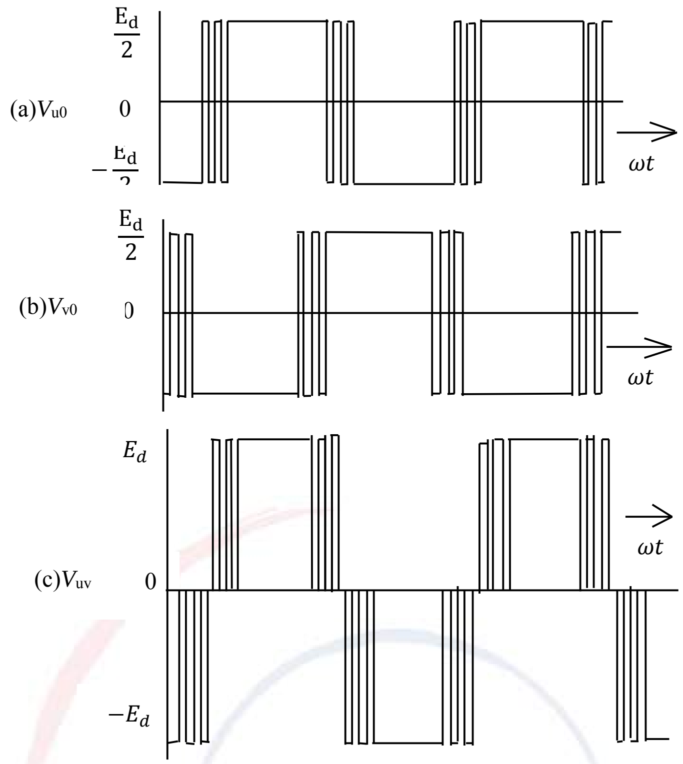


Fig.2. Waveforms; pole voltages (a) and (b); line voltage (c)

The waveforms of just mentioned in Fig.2(a) and (b) are derived with such intentions of obtaining a simpler waveform where fifth and seventh order harmonics, are eliminated. In order to eliminate such harmonics at the same time, following procedure is executed, so the solution can be obtained. Firstly, α_1 and α_2 are varied for fifth order harmonic to obtain the zero harmonic line. For the other harmonic, seventh order, analogous zero voltage line can be obtained. As described later, the solution of simultaneous zero voltage values for fifth and seventh order harmonics could be obtained.

Fig.2(c) shows the line voltage waveform injected into the network. In such a way, the values of α_1 and α_2 for fifth and seventh orders are resolved as pole voltage, where α_1 is the first switching angle from original point and α_2 is the second switching angle. After that, the line voltage can be calculated by equation $V_{AB} = V_A - V_B$ where triplen harmonics can be eliminated by giving phase difference of 120°. That operation principle is well known in symmetrical three phase circuit theory. Also in this single phase for utility-interact, this theory can be applied favorably. From such reasons, the fifth, seventh and triplen harmonics can be entirely eliminated.

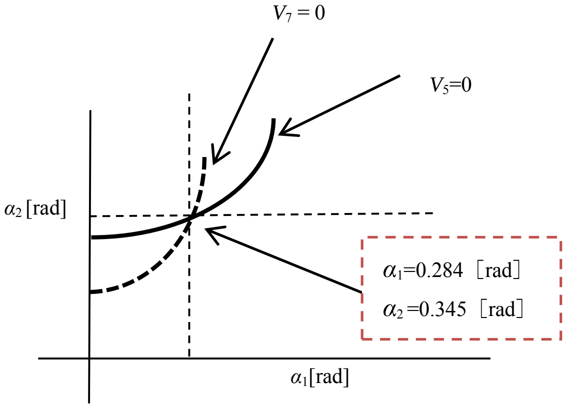


Fig.3. Solution diagram for fifth and seventh harmonics

As just described explanation, actual solution can be obtained as follows; Fig.3 shows an auxiliary figure to resolve the α_1 and α_2 where that is fifth and seventh order harmonics are zero simultaneously at the intersection point. The waveform in Fig.2(a) is expanded in Fourier series. The sub-expansions can be obtained as in (1) for $V_5 = 0$ and in (2) for $V_7 = 0$. In these equations, α_1 and α_2 are made varied to resolve for fifth harmonic. In the same way, α_{21} and α_{22} are varied for seventh harmonic, so that two zero line curves are obtained. The intersection point of two curves becomes $V_5 = V_7 = 0$ that is the solution of switching angles.

$$\alpha_2 = \frac{1}{5}\mathrm{Cos}^{-1}\left(\mathrm{Cos}\,5\alpha_1 - \frac{1}{2}\right) \quad \cdots(9) \qquad (1)$$

$$\alpha_{22} = \frac{1}{7}\mathrm{Cos}^{-1}\left(\mathrm{Cos}\,7\alpha_{21} - \frac{1}{2}\right) \quad \cdots(10) \qquad (2)$$

Fig.2(a) and (b) could be obtained in such manner that is $V_5 = V_7 = 0$ where $\alpha_1 = 0.284$ and $\alpha_2 = 0.385$. Fig.4 shows harmonic spectrum for the waveforms in Fig.2. As can be seen, Fig.4(a) is for pole voltage which contains triplen harmonics that is third and its multiple orders. Fig.4(b) is the harmonic spectrum of waveform in Fig.2(c) which can be obtained from phase difference by 120° between V_A and V_B as $V_{AB} = V_A - V_B$, where triplen harmonics are eliminated. In such manner, fifth and seventh plus triplen harmonics can be entirely eliminated.

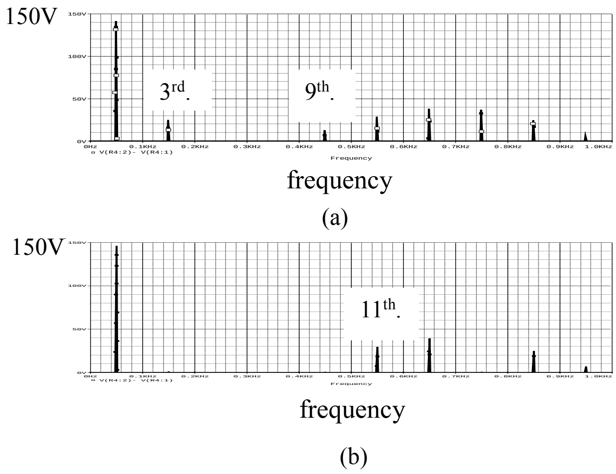


Fig.4. Harmonic spectrums: pole voltage V_A (a),line voltage V_{AB} (b).

2.2 Optimum PWM pattern of further improvement for harmonic characteristic

In the above section, the harmonic elimination method is up to seventh order plus triplen harmonics, for example, $V_3 = V_5 = V_7 = V_9 = 0$, etc. The existing lower order is eleventh harmonic, which could be suppressed by filter inductor and the like. If this installed inductor is increased, it might be concerned about its large size and subsequent cost.

In this chapter, another solution to reduce that harmonic will be examined. In just mentioned chapter, the number of switching is twice for α_1 and α_2. Another method of more increasing the number of switching could be realized. In the fundamental policy of our study, however, system should be constructed in concise and that control should be simple such as with minimum number of switching. And yet, harmonic characteristic should be satisfactory. Firstly, the evaluation or performance index is introduced by means of weighting function method for harmonic characteristic. Thus,

$$V_h^2 = (V_5/5)^2 + (V_7/7)^2 + (V_{11}/11)^2 \qquad (3)$$

In this equation, the minimum value is solved by varying α_1 and α_2. V_h is the effective value of harmonics for evaluation, where each term is divided by its order like $V_5/5$. By means of calculating the effective value using the weighting factor, the minimum value can be obtained as the optimum value. Fig.5 is a figure to obtain the optimum value from minimum effective value in (3). Firstly, α_1 and α_2 are varied to obtain the minimum value. In such a way, that minimum point is plotted according to varying α_1, so the curve can be obtained as shown in the figure.

The minimum of the effective value of the objective lower order harmonics represented in Fig.5 is $V_h = 0.016$ as shown by a circle, where $\alpha_1 = 0.196$ rad and $\alpha_2 = 0.286$ rad. In the previously mentioned results of $V_5 = V_7 = 0$, where $\alpha_1 = 0.196$ rad and $\alpha_2 = 0.286$ rad, the minimum value is shown by $V_h = 0.058$ which is increased almost by three times. As can be seen, the proposed method is significantly dominant compared to the usual specific harmonic elimination.

Fig.6(a) shows the output voltage waveform at eliminating the fifth, seventh and triplen harmonics, that is $V_3 = V_5 = V_7 = V_9 = 0$, etc. Fig.6(b) shows the harmonic spectrum of that waveform. As can be seen that the specific lower order harmonics are

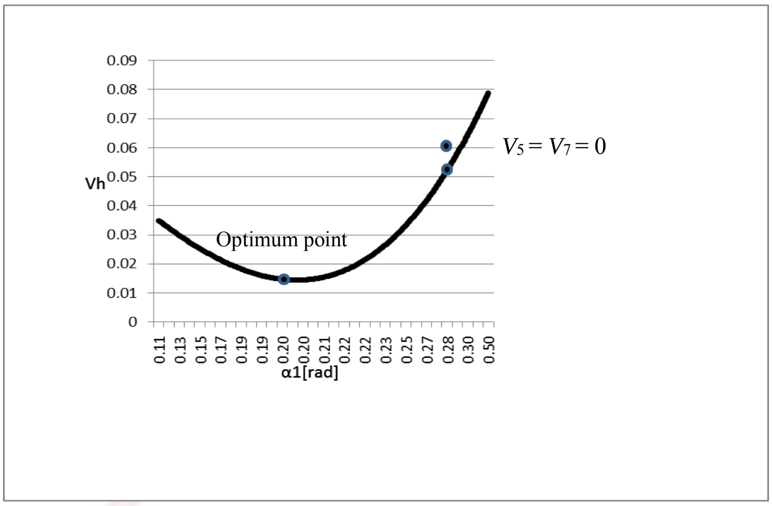
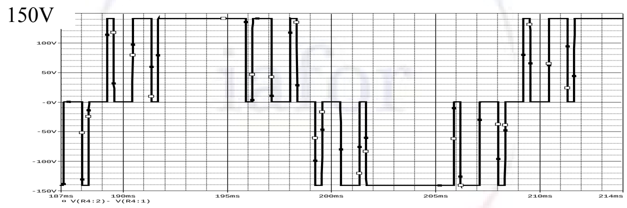
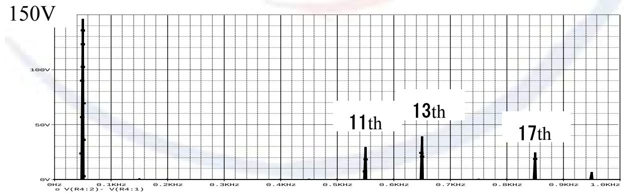


Fig.5. Resolving optimum value by varying α_1 and α_2.

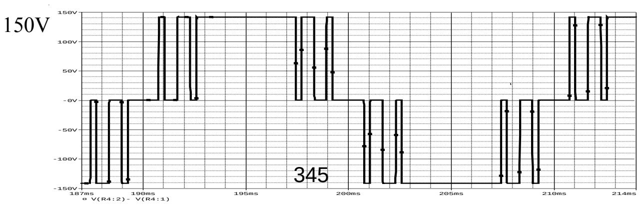


(a)



(b)

Fig.6. 5th, 7th and triplen elimination method.



(a)

150V

completely eliminated and do not appear. The lowest order is eleventh whose value is about 20.1% relative to fundamental one. Fig.7(a) is the minimization method of the lower order harmonics. The waveform pattern is analogous to just mentioned method. In the appearance of harmonic spectrum in Fig.7(b), however, as can be seen that the orders of up to eleventh are satisfactorily suppressed, though they do not made zero. The significant lowest order is 13^{th} whose value is fairly large of 7.6%. Comparing both figures, the harmonic minimization method can be considerably superior.

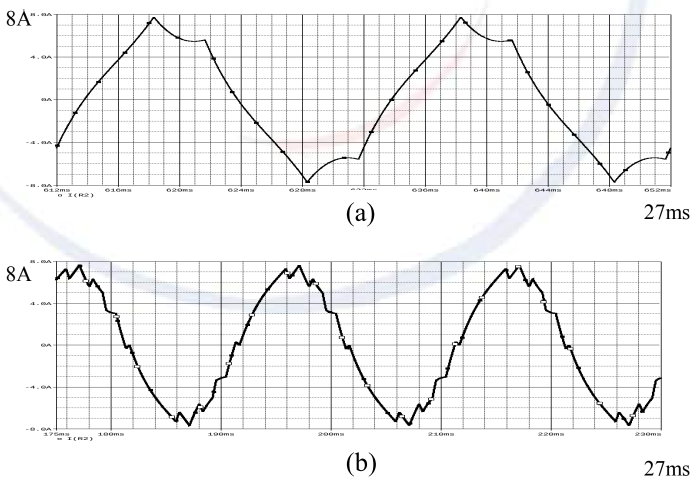


Fig.8. Current waveforms;120^{o} rectangular (a), harmonic minimization (b).

Fig.8 shows current waveforms of 120^{o} rectangular wave method (a) and harmonic minimization method (b). In the upper figure, the current ripple is fairly increased, in which the harmonics standard in JIS could not be cleared.

Table 1 represents comparison between specific fifth and seventh harmonic elimination method and minimizing method of specific lower order harmonics. For fifth and seventh elimination method, that is $V_5 = V_7 = 0$, the lowest order harmonic becomes fairly large, $V_{11} = 0.201$. To the contrary, in the method of specific lower order harmonics, though fifth and seventh order harmonics are a little generated, such values are fairly reduced and relative value of V_{11} is 0.008. The total effect value of harmonic can be much suppressed from 0.065 to 0.050 that is satisfactory result. From these results, it can be confirmed that the minimizing method for specific harmonics is effective solution.

Table 1. Comparison of output harmonics, relative to V_1

	α_1	α_2	V_h	V_5	V_7	V_{11}
Elim.of 5th ,7th	0.284	0.345	0.065	0	0	0.201
Minim.5th,7th11th	0.196	0.287	0. 050	0.030	0.034	0.008

4. Actual Circuit Configuration of Indoors Wiring

Fig.9 shows an example of indoors wiring from PV panel to utility network. As PV panel installed in veranda, there are various types such as from board type panels (BTP) to flexible PV panels (FSP) which can be rolled up like a curtain. In BTP, PCS in a thin box

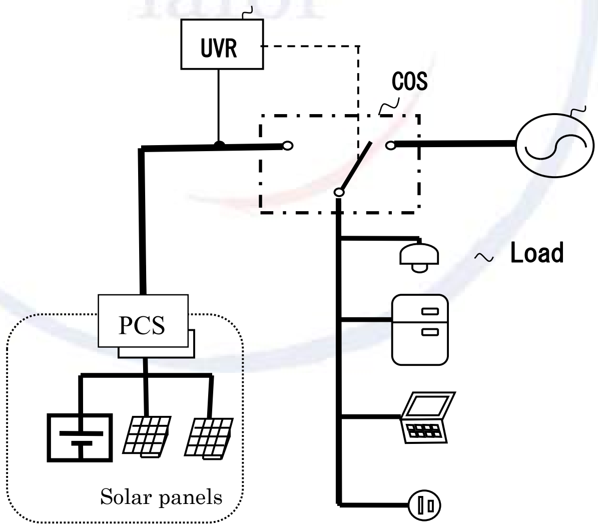


Fig.9. Actual circuit configuration of indoors wiring.

is attached to reverse side of board.These are selected in accordance to installed location. For usual roof installation type, a group of diodes protecting the reverse current, handling switches to each line and circuit breaker of lines with double polar and dual element are installed in the connection box. In this case, handling switch is operated by manual, while circuit breaker is made turned off by over current. In thin type PCS, manual switches and line circuit breakers are installed in PCS. In FSP, PCS could be attached to outer side of cylindrical box [9],[10].

Firstly, a certain exclusive line is provided where corresponding specific loads are connected. Consequently, the loads are connected to the PV panel. It is necessary to avoid the large power load to this line. This line is used for specific important load with reduced power at interruption. For emergency power supply at interruption which is positively used at night, it is necessary to install the battery as optional power supply. Because of minimum capacity of exclusive line at interruption, battery capacity can be also reduced. Recently, domestic battery storage systems are proposed and available. It might be considered to connect them this exclusive line. It is necessary to supply from the power system to charge, but it would be prospective subject. Thus, the line from PV panel uses the existing one. In order to utilize as the emergency power supply at disaster, it is important to select sufficiently and connect them as the important apparatuses at interruption.For example, the important apparatuses at disaster such as light equipment, PC for collecting information, charger for cellular phone and refrigerator to protect foods are connected to this line. For the conventional refrigerator, however, the large rush current flows at turned-on, so this PV power could not correspond such power. Thus, the inverter type refrigerator can be used which suppresses such rush current and mitigates. Consequently, the inverter type would be recommended.

When the generating PV power is reduced and then the power supplying is stopped, the under voltage relay (UVR) detects this and the change-over switch (COS) switches from PV side to the network side immediately. As the power is supplied again to the specific loads with a short time delay, the supplying performance cannot be deteriorated except a minimum instantaneous interruption.

After a negligible short interruption, the specific loads can be supplied satisfactorily.When the PV power is increased, UVR functions and the COS switches to PV side. Thus, the specific loads can be supplied regardless of the night and day. In this example, the islanding operation is examined and discussed. As power capacity, however, connected load is restricted to relatively reduced loads. However, the installation work is very simple which brings lower cost. Under such situations, the authors expect and wish to spread such solar application.

5. Innovative Battery System with Reliable Construction

Secondary batteries as energy storage devices have been examined and reported so far. However, as the voltage limit of devices is low, it is necessary to connect them in series and to use them in the vicinity of their voltage limit. In addition, over discharge should be avoided. In order to use efficiently, these devices must be used in well balanced manner. In general, it is necessary of periodic maintenance. In domestic applications, it is difficult to keep regular maintenance. In this veranda solar, innovative battery storage system is presented and discussed.

Fig.10 shows the proposed circuit for the balanced charging of secondary battery, sometimes called “equalizer”, which is constructed by Cockcroft-Walton circui (CW circuit). C_1* to C_5* on the left hand side indicate, for example, electrolytic capacitors, which have relatively uniform values and can be obtained at low cost construction. e is the ac power supply. The purpose is not to supply the output power to these, but to supply relatively reduced compensated power in order to balance the battery voltage on the right hand side. In this battery management system, there are many versions having different operating principle of CW circuit. By an operation of e, batteries can be held effectively in voltage equalization [11],[12].

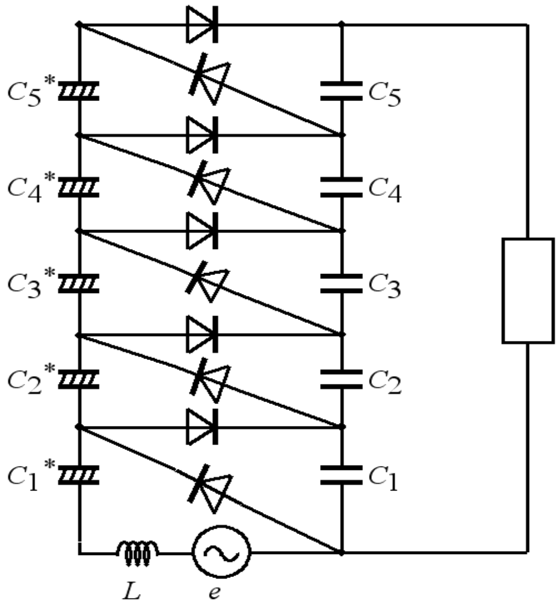
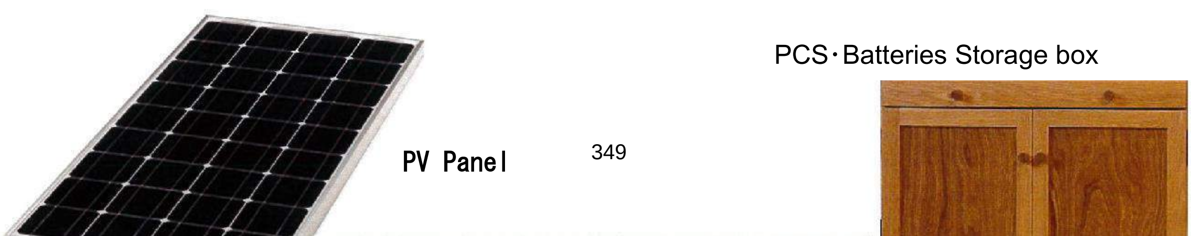


Fig.10. Basic equalizer with CW circuit.

5. Actual Model for Products

In the various wiring methods under discussion, above mentioned circuit construction would be the most prospective one which is presented in Fig.10. The distinctive features is mentioned as follows.The PV generated power is converted to ac 100V and the system can be set and used as home appliances. The generated power is also stored in the batteries. For a case of non-generating period at night and the like, by means of this batteries the connected appliances can be made work at all times . Even though the stored energy of batteries is entirely discharged, the connected load line is automatically switched to the ac power line and kept the load supplied. The system can be installed as home appliances by means of easy wiring, and can generate and store the power without delay. The required power can be obtained from the electrical outlet which is attached to the front of the storage box which is made as furniture-style.



6. Conclusions

It is a truth that many residents living in apartment house not only have interesting, but also desire to install the PV panel. An adequate power conditioner to be installed is discussed as an actual circuit. In such small generating power, reducing the power conditioners cost is more important compared to PV panel cost. The reason is; PV panel cost is reducing in proportion to reducing the number of panels, while power conditioner cost is not reducing in proportion to the generating power, because the number of power conditioner is single in general.

In such settlement at a narrow space like verandas, amounts of generating power is restricted, so lower cost is required even more. In such scheme, if the PV panel is handled as like home apparatuses having attachment plug, the settlement cost can be much reduced. If the unified specification is introduced and the mass production is promoted, even lower cost apparatus is supplied in the market. In such situation, the proposed simple power conditioner can bring with much more low cost favorably.

Acknowledgment

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Solar PVs to Charge EVs in Auckland –Potential for a Community Based Approach

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Abstract

Auckland enjoys 2050 hours of sunshine annually, comparable to Melbourne (2100) and Istanbul (2026). Auckland Council is committed to a sustainable pathway in mobility and energy consumption, aiming at 40-50% of electric vehicle (EV) fleet and solar photovoltaic (PV) installations powering an equivalent of over 176 500 homes by 2040, among other sustainability targets. The general challenge of combining solar PV with EV investments for most Aucklanders is the mismatched timing of solar output (day time) and vehicle availability for home charging (night time). Technically this could be overcome by smart meters for PV installations at residential homes and charging points at commercial buildings, where the vehicle could be charged and differences between EV load and PV output accounted for.

To evaluate the potential for EVs charged by PVs in Auckland we have assessed the solar potential in a residential area in Auckland and compared that to typical EV battery sizes. We present the idea of a community based organisation for charging EVs with solar power, where the solar panels are installed at residential homes and the charging takes place at a parking location in the commercial centre of Auckland. With a community based approach - whether based on people working for the same company, people working in the same commercial building, or simply people using the same car park - some investment and transaction costs, as well as risk, can be shared, battery storage costs avoided and the learned know-how transmitted onwards to transform Auckland towards its sustainability targets.

Keywords: solar PV, electric vehicles, Auckland

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Introduction

New Zealand has a long history of a highly renewable electricity sector, mainly due to large-scale hydro projects during the second half of the 20th century, and more recent growth in geothermal and wind energy. Current energy strategy focuses on economic growth and there are no economic incentives for renewable energy or low-carbon technologies in general. Yet, the government has a target to reach 90% renewable share of electricity from the current 70-75% share by 2025. The domestic renewable energy resources exist, and it has been shown that already consented projects would be sufficient to reach that target. However, demand has flattened and even decreased in the last five years, which has halted these projects. Transformation to electric mobility would imply three main opportunities for New Zealand: (1) an increase in domestic electricity demand, taking New Zealand closer to the 90% renewables target, (2) a decrease in dependence on imported crude oil, and (3) a direct reduction in greenhouse gases.

Auckland Council's Low Carbon Auckland report (2014) sets the 2040 sustainability targets for energy and transport in Auckland region. These targets include an equivalent of 176 565 homes power by solar PVs on buildings and 30-40% of the vehicle fleet to be electric, among many others. With these targets in mind, as many commute from residential areas to commercial areas, and park their vehicle at work for the day, solar power could be used to charge the electric vehicles (EV) at work during regular working hours.

To evaluate the feasibility for EVs charged by PVs in Auckland we have assessed the solar potential in a residential area in Auckland and compared that to typical EV battery sizes. We present the idea of a community based organisation for charging EVs with solar power, where the solar panels are installed at residential homes and the charging takes place at a parking location in the commercial centre of Auckland. We expect this approach would bring cost savings to the PV owners, as they would not need to install a battery system at home. In addition, the learned know-how could induce further EV and PV initiatives and contribute to transforming Auckland towards its sustainability targets.

Energy in New Zealand – Opportunity for electric mobility

New Zealand has a long history of producing a large share of its electricity from renewable resources, mainly due to large scale hydro developments in the second half of the 20th century. The renewables share of electricity was 75.1% in 2013. Due to this high share of renewable electricity, New Zealand is third in the world for percent renewables in total primary energy supply with 37% in 2012 (MBIE, 2013). This consists of 19% geothermal, 10% hydro and 8% other renewables (figure 1).

On the demand side, transport and the industrial sector consume the bulk of final energy, 37.6% and 34.7%, respectively. Although the electricity sector is largely renewable, the transport sector is dominated by oil consumption. New Zealand currently imports over twice the quantity of crude oil that it exports. At the same time the country has significant renewable energy resources available. This presents an opportunity for electrification of the transport sector, which implies both energy security in terms of reduced dependency on imported fuel and greenhouse gas abatement. In July2015 there were 660 electric vehicles registered in New Zealand (DriveElectric, 2015).

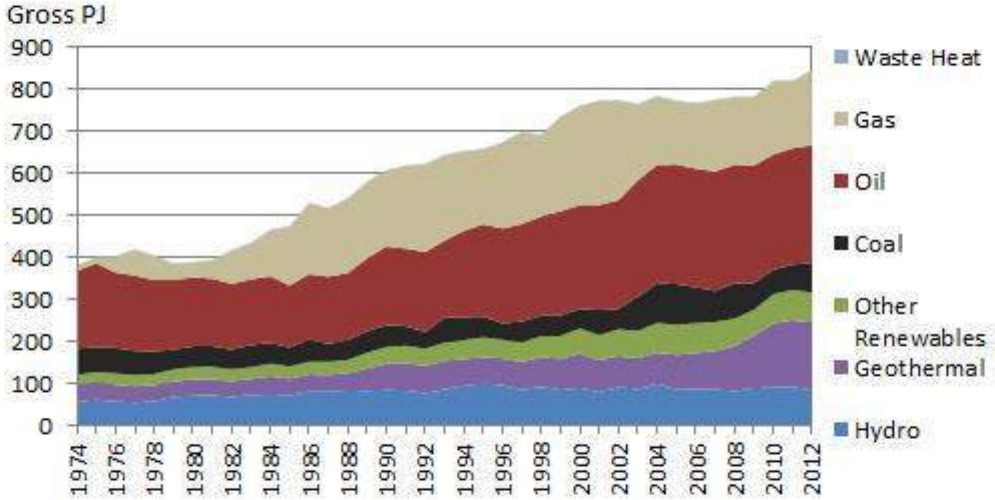

Figure 1: New Zealand's primary energy supply by source since 1974 (MBIE, 2013).

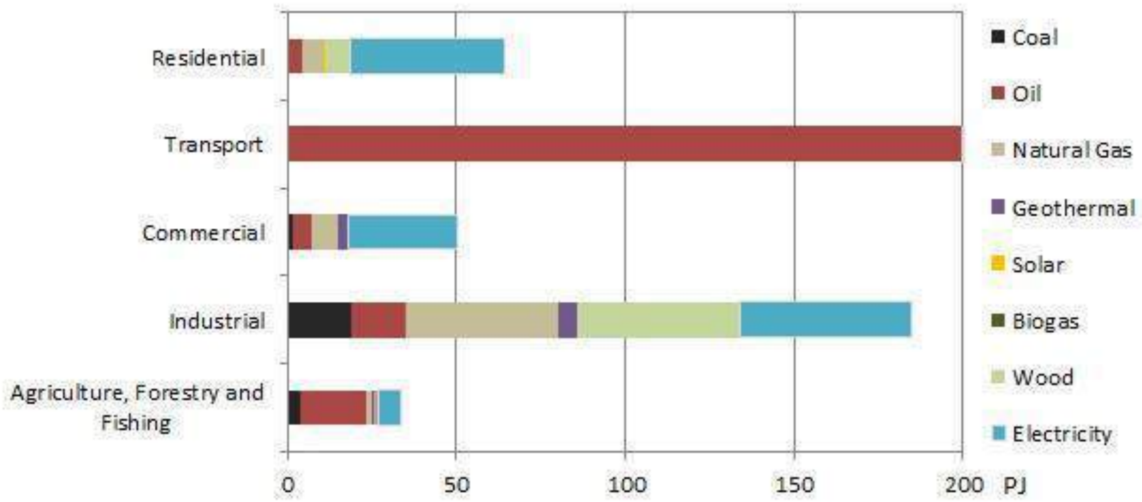

Figure 2: Primary energy consumption in New Zealand by energy source in 2012 (MBIE, 2013).

Electricity demand has flattened in the past decade and slightly dropped in the last couple of years due to decreased production at various industrial consumers (figure 3). Although wind and geothermal energy are the likely new future developments, major new investment (not already committed) is unlikely to occur until 2020.

New Zealand has an open, competitive electricity market (generation and retail separated by the wholesale market), while transmission and distribution are regulated natural monopolies.

Although the country has set an ambitious renewable energy target for the electricity sector – 90% renewable energy by 2025 – there are no quantitative targets for primary energy or the transport sector. Some of the main challenges for reaching this target, or any development towards a low carbon economy, include lack of policy support and geographic constraints. There is no national policy aimed to support this target. Renewable energy suppliers receive no feed-in tariffs or other direct incentives for low carbon technologies. However, already consented renewable energy projects add up to sufficient renewable energy supply to reach the 90% target, but currently these projects are not being built due to flattened demand. Also, as an island country, New Zealand has no opportunity to import or export power, meaning the variability of hydro, wind and solar power needs to be balanced nationally, posing an additional technical challenge.

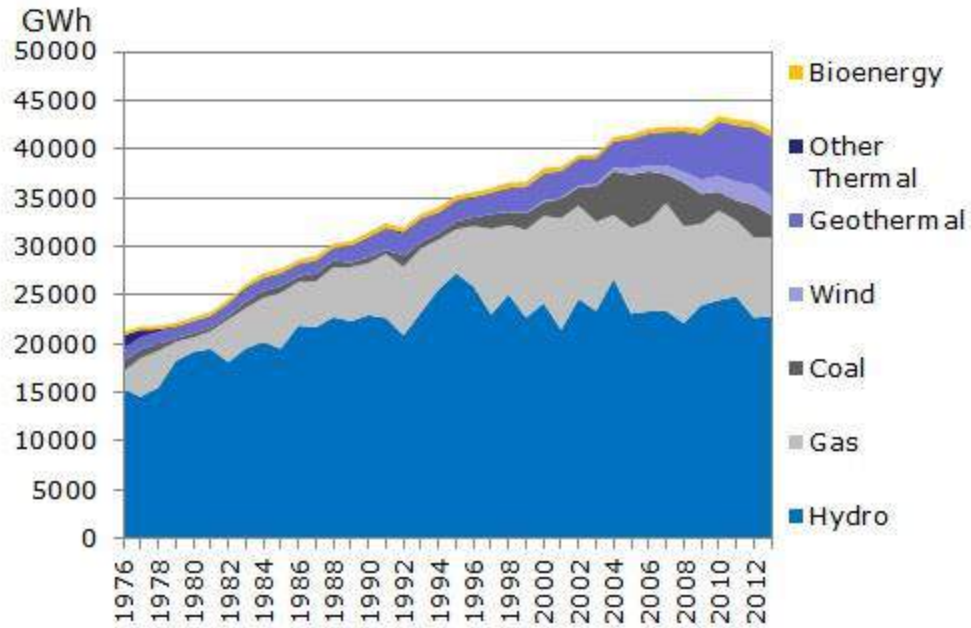

Figure 3: New Zealand's electricity supply by source from 1976 to 2013 (MBIE, 2013).

New Zealand's greenhouse gas (GHG) emissions were roughly 80 MtCO2-eq in 2013 (Ministry for the Environment, 2015). Energy accounts for 39% of the total GHG emissions, corresponding to 31.7 MtCO2-eq, second to agriculture (48%). Within energy, the transport sector shows the highest increase since 1990, from roughly 9 MtCO2-eq to 14 MtCO2-eq in 2013. New Zealand has one of the highest rates of car ownership in OECD countries and a relatively old vehicle fleet. This presents the opportunity for modernising the fleet where electric vehicles could play a significant role.

Solar potential in Auckland

A study by Byrd et al. (2013) on roof-top solar potential in Auckland showed that the low dense suburbia is the most efficient collector of solar energy in Auckland. They showed that enough excess electricity can be generated to power daily transport needs of suburbia and also contribute to peak daytime electrical loads in the city centre. A detached dwelling would consume less than half of its total demand during day-time, while a 3.5kW PV installation would be sufficient to supply the total demand. They concluded that a dispersed city is more efficient when distributed generation of electricity by PV is the main energy source and EVs are the means of transport.

The main problem with this concept is that during the day-time the supply system – the PV – sits on the rooftop of a residential home producing power, while the storage system – the EV – would typically be parked in the central business district (CBD), where most jobs are located.

Approach

To assess the suitability of using private electric vehicles to store excess solar energy from residential rooftops, we simulated scenarios of solar PV output with the following options:

- PV system size: 1 kW, 2 kW, 3 kW, 4 kW, 5 kW
- PV panel tilt: 15, 20, 25, 30, 35, 40, 45 degrees

We then compare the daily solar power output to residential electricity demand to estimate the daily excess solar power over a year in every scenario. By comparing these results to typical EV battery sizes, considering that the battery capacity is unlikely to be fully available for storing the solar power, we can evaluate the trade-offs of different configurations regarding system size, tilt and battery capacity.

Data and assumptions

To quantify the potential for rooftop PV systems on residential homes to charge EVs we make the following assumptions:

- PV panel: 8.33 m2/kW rated capacity,
- Total system efficiency from solar irradiation landing on panel to grid: 9%,
- North-facing panels,
- Location: Henderson, Auckland, approximately 20km from CBD, which corresponds to the average 40km of daily commute of Aucklanders.

Solar data from the National Institute of Water and Atmospheric Research (NIWA) solar tool SolarView (NIWA, 2015) was used to characterise the solar resource in Henderson. The tool gives a year of hourly data of solar irradiation per square meter, given a specified panel tilt. To show the impact of tilt on solar PV output, angles from 15 degrees to 45 degrees at 5 degree intervals, were used. To find the tilt that gave the maximum total annual output, the optimal tilt was narrowed down to 1 degree accuracy, which with SolarView was found to be 20 degrees. Using a different tool (e.g. PVWatts Calculator by NREL) can give a higher “optimal” tilt, and we believe the difference can come from the source of solar irradiation data, where theoretically calculated irradiation data taking into account latitude and mean atmospheric conditions would not take the occurrence or timing of clouds into account, whereas SolarView uses data measured at ground level data that will reflect any existing cloud patterns as well.

To characterise the electricity demand of a residential household we use metered hourly electricity demand data (EA, 2013) from a node in the residential area of Henderson, Auckland, and scale the values to represent the approximate average annual household demand in New Zealand, 8000 kWh. The data spans the years 2007 to 2012, giving six full years of hourly data.

EV battery storage capacity and charging options

High cost and low energy density of EV batteries have been the main challenge in developing EVs for commercialisation (CAENZ, 2010). Lithium-ion batteries have been the common battery type, with an energy density of about 100 Wh/kg. The battery system of an EV currently weighs roughly 150-250 kg, giving a typical capacity of 15-25 kWh. At the higher end, the Tesla Roadster has a battery weight of 450 kg and with a stated energy density of 118 Wh/kg, a battery capacity of 53 kWh. Table 1 give the currently available EV models in New Zealand, and their corresponding battery capacities (we acknowledge that the list is soon outdated with new models entering the market):

Table 1: Available electric vehicles in New Zealand, and their battery capacity.

	kWh
Audi A3 e-tron	26.5
BMW i3	22
Holden Volt	16
Mitsubishi i-MiEV	16
Nissan Leaf	24

This gives a rough idea of storage capacity for excess solar power. However, one must recognise that in most cases only a portion of the battery capacity would be available for this. At a minimum, the owner is likely to have enough power to return home after work, without charging during the day. Hence the actual capacity available for solar storage would depend on commuting distance and behavioural patterns, among others.

Table 2 gives the most common charging categories and general infrastructure requirements. We base our scenarios on the second and third options (4 kW and 13 kW, respectively), considering they are the likely options for our application. The first option could be unsafe and the last would be too expensive considering our aim to save on total costs (RMI, 2015).

Table 2: Charging mode options

	Can be used with typical existing household wiring and infrastructure	Requires dedicated charging equipment to be installed
• Slow charging [2-3kW] • Standard household socket • Standard lead	√	
• Slow charging [4-5kW] • Standard household socket • Lead equipped with protective device	√	
• Slow or fast charging [13kW] • Dedicated EV charging installation • Equipped with a protection function		√
• Fast charging [78kW] • External charger		√

Results

Solar PV output

Figure 4 shows the solar output with the above assumptions for each month for the various tilt angles. For each month, the daily mean output during non-zero hours was used, giving the range depicted by the boxplot: the thick horizontal line gives the mean, the rectangle and the whiskers represent the 0.25 and 0.75, and 0.10 and 0.90 quantiles, respectively. The annual output given on the top of each subplot show that the 20 degree tilt gives the highest annual output and the 40 degree tilt gives the lowest (45 degrees gives an even lower annual output, but is not shown in this figure). However, the impact of the tilt on monthly output is quite clear: the low tilts maximise output during summer months whereas the higher tilt captures more solar irradiation during winter months when the sun is closer to the horizon at noon, but captures less solar irradiation during summer. The higher tilt thus gives a more even annual pattern of solar output, although at the expense of total output.

Figure 5 gives the hourly output of a PV system in Henderson for three different tilts (15, 25 and 45 degrees) and the months of January (summer) and July (winter).Comparing the tilts it can be seen that in summer the higher tilt gives a clearly lower output over the day, whereas in winter a higher output can be expected.

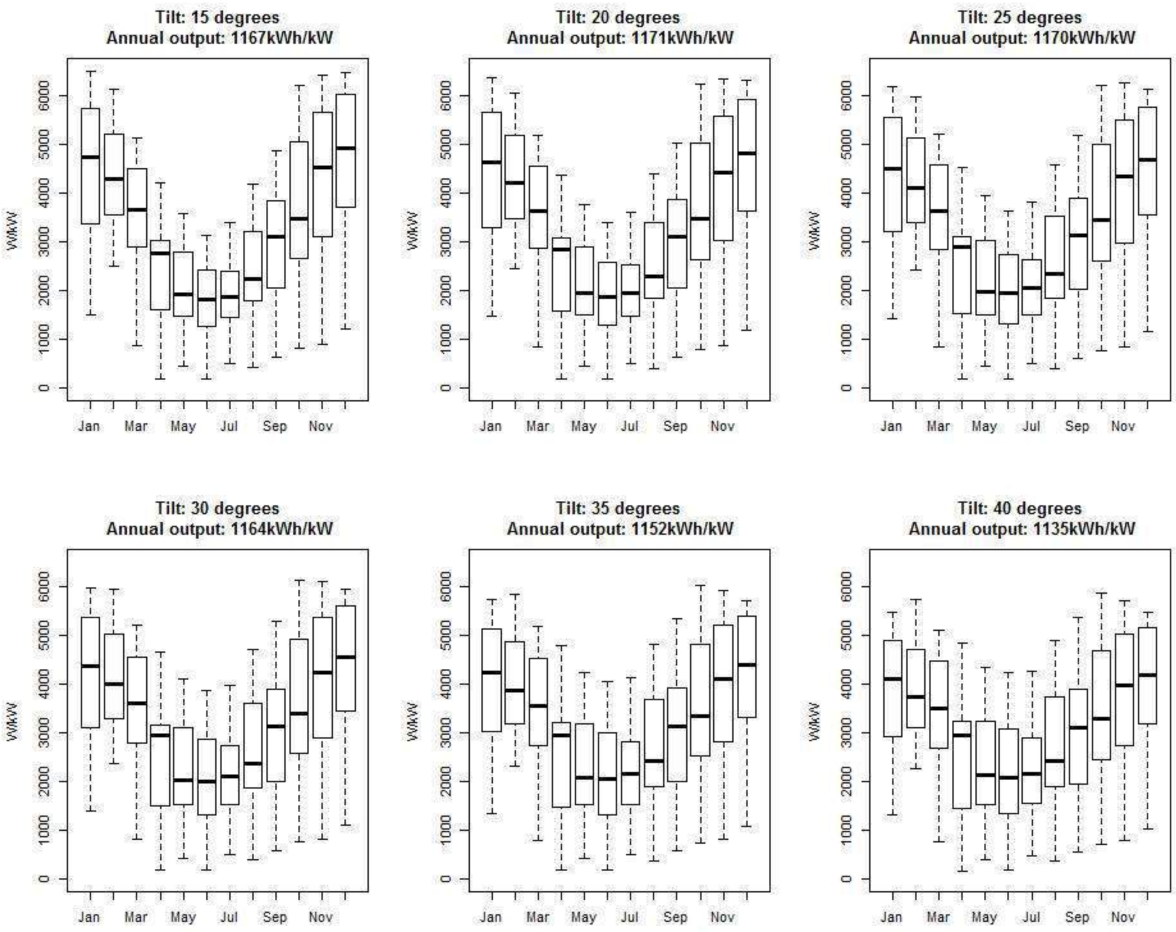

Figure 4: A year of hourly solar PV output data plotted at six different panel tilts. The mean daily output was calculated over non-zero output hours, represented in the boxplot for each month.

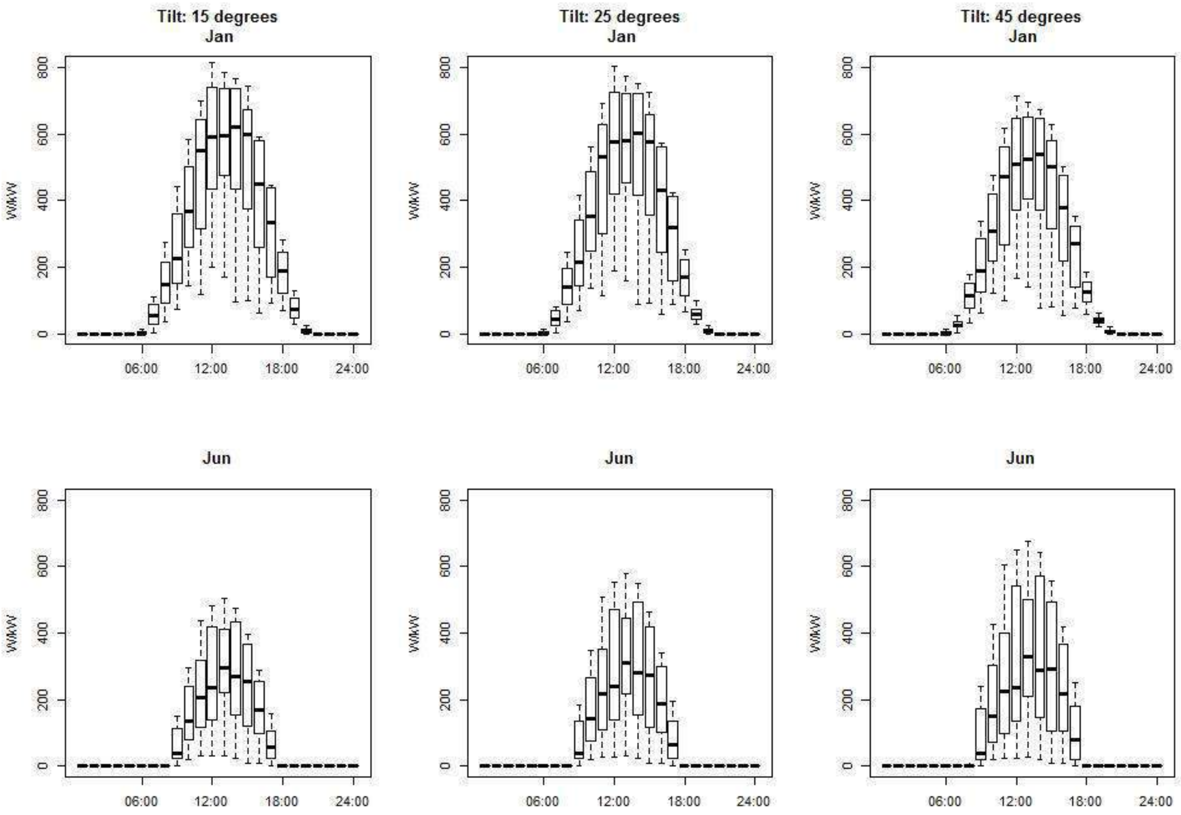

Figure 5: Hourly output of a PV system in Henderson, plotted for three different tilts (columns) and for January (top row) and July (bottom row).

Residential electricity demand

Figure 6 gives the average monthly household electricity demand over six years. Demand is significantly higher during winter months due to heating. Inter-annual variability is relatively small. Compared to the seasonal pattern of the solar PV system, the peaks are approximately 6 months out of phase as solar PV output peaks in summer whereas electricity demand leaks in winter. This could advocate for a higher tilt angle, to capture more solar irradiation during the winter months.
Figure 7 gives the daily electricity demand pattern for a summer day (hourly data for January) and a winter day (hourly data for June). The demand in summer is relatively flat during the day and decreases for the night. In winter, demand is higher and there are clear demand peaks in the morning and in the evening. Although solar power can be available for the increased day-time consumption, it will not be directly available for the evening peak in winter or the lower demand at night.

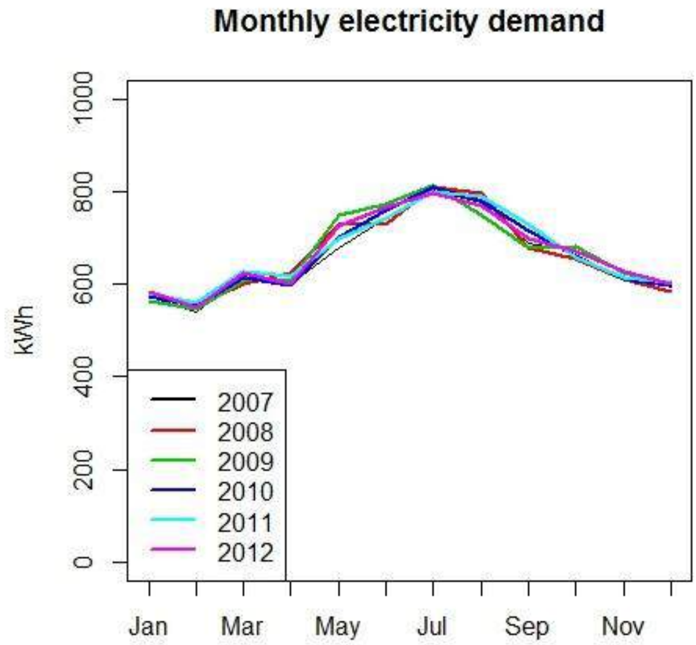

Figure 6: Average monthly household electricity demand over six years.

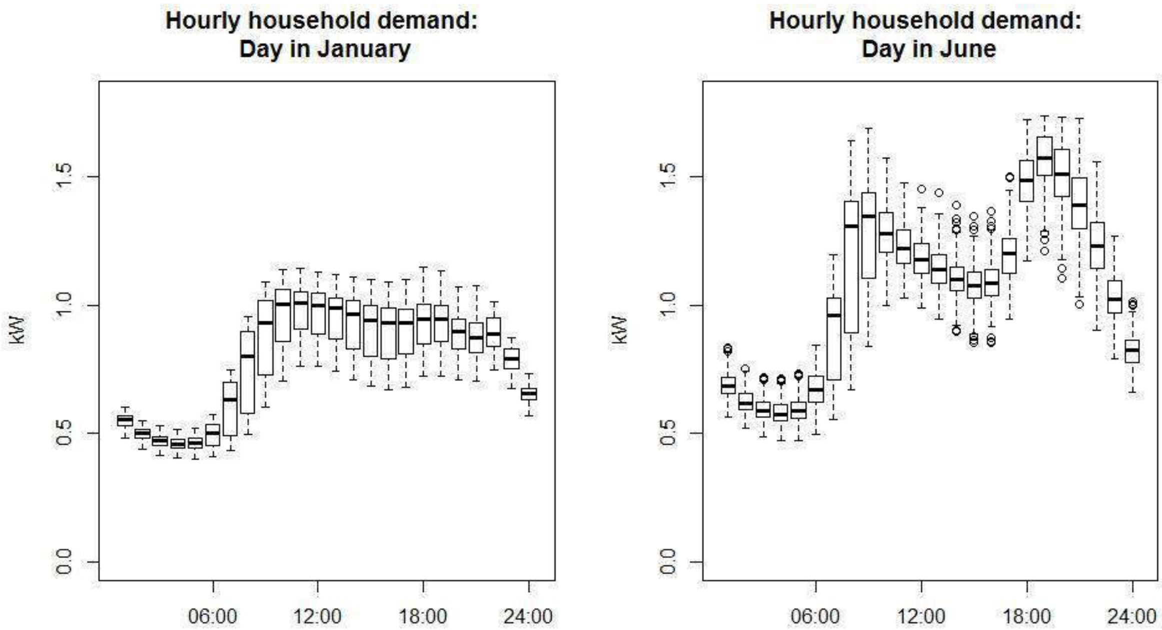

Figure 7: Daily electricity demand patterns for a household for a day in January versus a day in June.

To quantify the daily storage requirements from a given size PV system, the hourly demand was subtracted from the hourly output of the PV system. Figures 8 and 9 give the results for a 2 kW and 5 kW system, respectively. Results are shown for tilt angles of 15, 25 and 45 degrees (columns) and for January (top row) and June (bottom row). Figure 8 shows that for a 2 kW system the excess solar power output is less than 1 kW in summer and it is rare to get any excess power in winter. As figure 9 shows, the 5 kW system will provide excess solar power even in winter, although less so with a smaller tilt. In summer the excess power reaches approximately 2 kW on average during the peak. As can be expected, the difference is always negative during the night and power from the grid will be required during those hours.

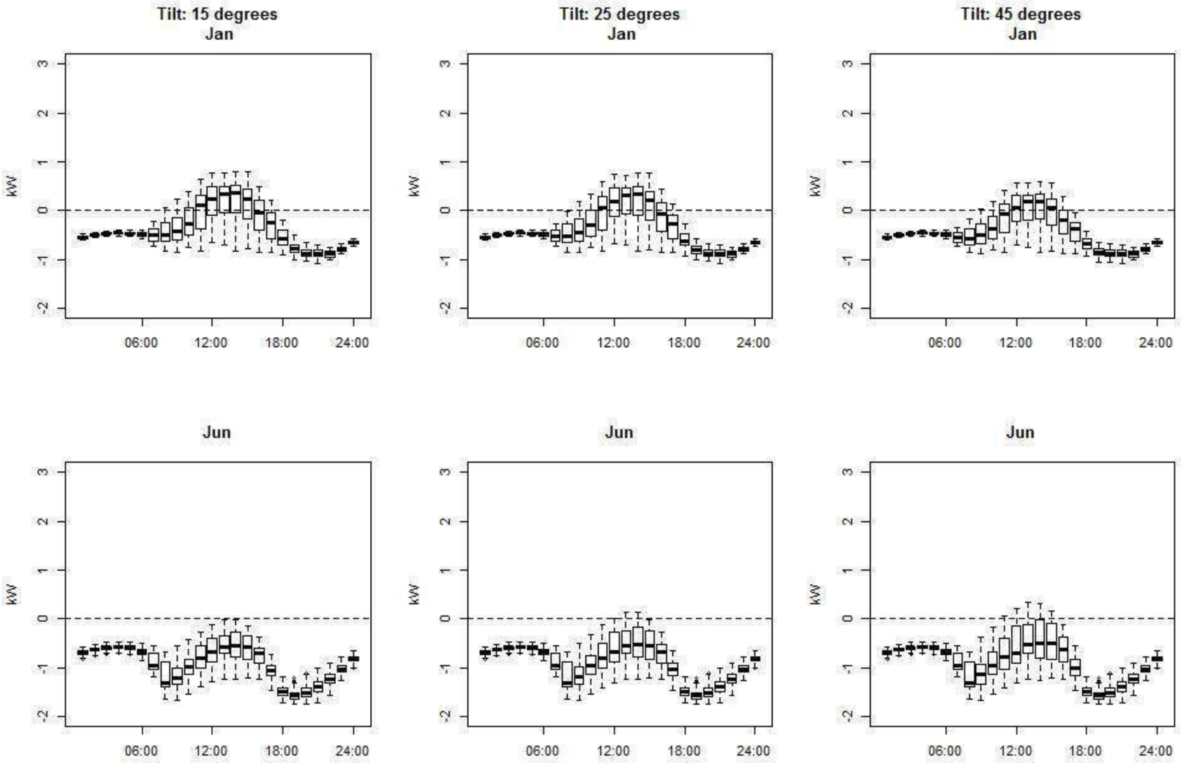

Figure 8: PV energy storage requirements for a 2 kW PV system.

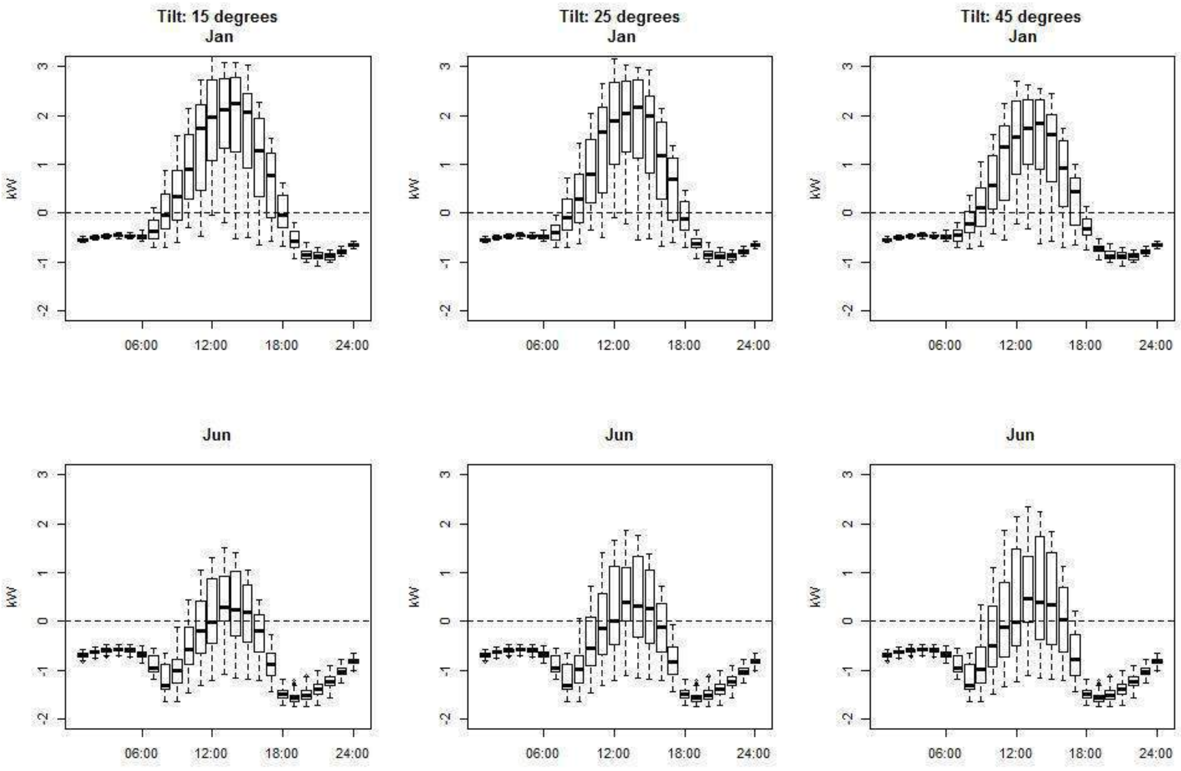

Figure 9: PV energy storage requirements for a 5 kW PV system.

Table 3 gives the full results for total annual storage needs (excess solar power) and required power from the grid for the different tilts and system sizes. Interestingly, the tilt angle that gives the maximum annual output (20 degrees), gives the lowest grid power requirements only for 1 kW and 2 kW system sizes. For bigger PV system sizes, the 15 degree tilt gives the lowest requirements for power from the grid. This implies that the low 15 degree tilt might be a better match with the demand pattern than higher tilt angles, and thus the optimal angle for a residential PV system, for larger systems. For a small system where all solar power is directly consumed, maximising total annual output would be the optimal solution.

Table 4 gives selected results for the mean daily storage need on average and for the months with highest (January) and lowest (June) PV outputs. The difference between the mean and maximum values is very important when assessing whether the EV battery system is sufficient to be used as storage for excess solar power. These results highlight the trade-off between maximising total solar output (20 degree tilt) and seeking a balance between summer and winter output (45 degree tilt); a slightly smaller output of the latter in summer is balanced by a slightly higher output in winter. Also the maximum values are smaller in with the 45 degree tilt.

Table 3: Annual storage needs vs. grid needs (in parenthesis).

[kWh]	Tilt 15	Tilt 20	Tilt 25	Tilt 30	Tilt 35	Tilt 40	Tilt 45
1 kW	0.2 *(6835)*	0.2 *(6831)*	0.1 *(6832)*	0.0 *(6838)*	0.0 *(6850)*	0.0 *(6867)*	0.0 *(6889)*
2 kW	201 *(5868)*	203 *(5862)*	201 *(5863)*	195 *(5869)*	185 *(5883)*	171 *(5903)*	153 *(5929)*
3 kW	820 *(5320)*	833 *(5321)*	836 *(5328)*	829 *(5340)*	810 *(5356)*	780 *(5377)*	740 *(5403)*
4 kW	1655 *(4988)*	1677 *(4994)*	1683 *(5004)*	1671 *(5019)*	1643 *(5037)*	1596 *(5058)*	1533 *(5083)*
5 kW	2601 *(4768)*	2630 *(4776)*	2637 *(4788)*	2620 *(4804)*	2580 *(4823)*	2517 *(4844)*	2431 *(4867)*

Table 4: Average daily storage needs and maximum daily storage needs.

	3 kW		4 kW		5 kW	
[kWh]	Tilt 20	Tilt 45	Tilt 20	Tilt 45	Tilt 20	Tilt 45
Annual average (max)	2.3 *(10.4)*	2.0 *(7.7)*	4.6 *(16.6)*	4.2 *(13.0)*	7.2 *(22.7)*	6.7 *(18.4)*
January average (max)	4.7 *(10.4)*	3.2 *(7.5)*	8.4 *(16.6)*	6.2 *(12.3)*	12.4 *(22.7)*	9.5 *(17.3)*
June average (max)	0.3 *(2.2)*	0.9 *(4.6)*	1.2 *(5.2)*	2.2 *(8.6)*	2.3 *(8.3)*	3.7 *(12.9)*

Charging time of excess solar power to EV

Figures 10 and 11 show the charging time of excess solar power to an EV with fast and slow charging as a function of panel tilt and system size, respectively. Figure 10 shows that in general charging time decreases with tilt, as excess power declines, except in winter when the higher tilts capture more solar irradiation. Also, maximum annual output coincides with the maximum output of January for most tilt angles. However, for 35 degrees or higher, the maximum output is not in January. For a 4 kW system, the highest charging time by slow charging reaches approximately 4 hours, which is still a reasonable time for charging the EV while at work. For a fast charger the highest charging time is roughly 1 hour 10 minutes. The average charging time in January is approximately 2 hours for low tilts using a slow charger, and less than 40 minutes with a fast charger.

Figure 11 shows a steep incline of charging time with system size. The maximum charging time with a slow charger is over 5 hours for a 5 kW system. However, the average charging time is significantly lower, at approximately 1 hour 40 minutes, and approximately 4 hours in summer. With a higher tilt angle, charging times are lowered, as seen in the top right sub-plot. Finally, as expected, charging times are significantly reduced with fast charging, as the bottom row sub-plots reveal.

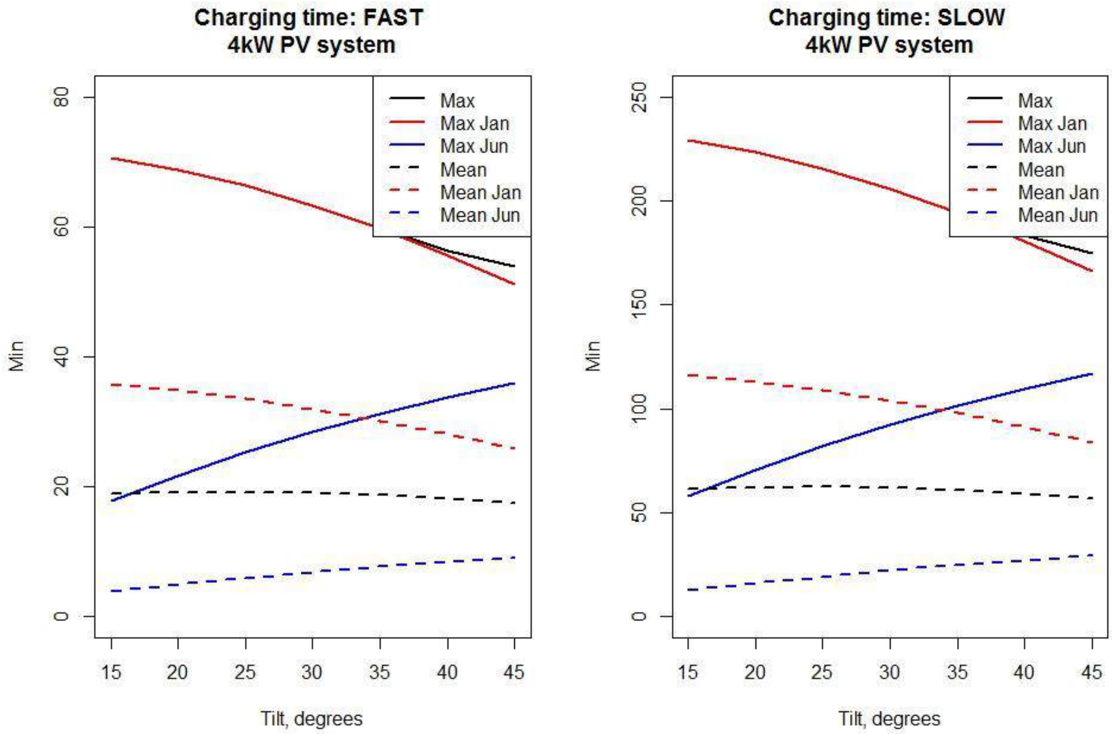

Figure 10: Charging time of excess solar power as a function of panel tilt.

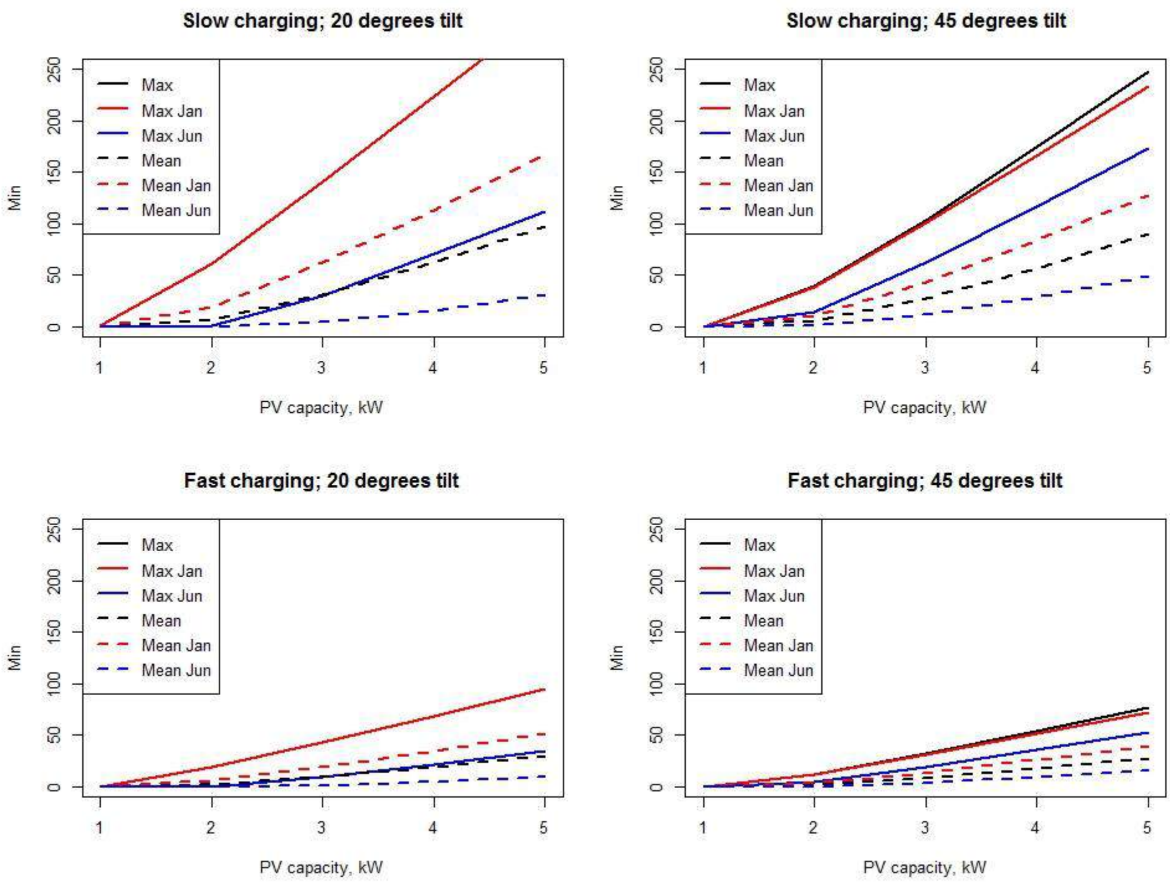

Figure 11: Charging time of excess solar power as a function of PV system size.

Discussion: A community based approach

The results show that in terms of PV system scale and typical EV battery sizes, it is feasible to use the EV battery to store excess solar power during the day. It is currently not possible mainly due to two obstacles: the lack of charging infrastructure at parking facilities in the CBD and the lack of a pricing mechanism to account charged power to generated solar output and take in to account any differences.
In this paper we explore whether a community based approach could be used to overcome those barriers.

What is it?

- EV owners co-finance a charging station at their parking location, and eliminate need for a battery system at home
- Pricing mechanism agreed with retailer or lines company
- Smart meters at PV systems and EV charging allow for transfer of “solar credits” and accounting for deviations
- Slow charging is an inexpensive, technically feasible option, with multiple outlets possible

Who is it for?

- “First-movers” with both solar PV and an EV
- Parking in same location most days

Challenges

- Cost of billing: the relatively small transactions may make the overall cost of the pricing mechanism unviable economically, especially with small numbers of clients
- The community needs to be flexible and open for newcomers, which may require a more complex definition of the agreement, than an informal arrangement between a few EV owners and the parking facility manager.

Opportunities

- Roll-out of EV charging points
- Experience gain through learning with small numbers
- Eventually a network of chargers, possibility to charge at different locations, that could expand from a small community to a nation-wide association
- Independent of national policy

Conclusions

In this paper we have assessed the rationale of using electric vehicles to store excess solar power in Auckland. Electric mobility provides a significant option for New Zealand to reduce GHG emissions, as the electricity mix is already highly renewable and likely to become more so, and move from imported oil to domestic renewable energy resources.

In the absence of national policy incentives, the deployment of EVs relies on local level proactivity, at the level of municipalities, the private sector and individual initiatives or "first movers". With the cost of solar power decreasing, Auckland has seen a steady growth of solar installations. We have showed that the scale of daily excess solar power could generally be stored in the battery of currently available EVs during working hours, even with a slow charger.

Community based approaches can lower initial costs and promote both the installation of solar power systems and the uptake of EVs in its initial steps of deployment in New Zealand. This would provide valuable knowledge gain in the community and help Auckland transform towards a low-carbon society.

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Comparison Analysis Between Rice and Cassava for Bioethanol Production in Japan Considering Land use Efficiency

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Abstract
The demand of rice in Japan is almost completely covered (99 %), however in the past years the total rice consumption had slightly decreased. In conjunction of an increment in the average age of famers as well as urban expansions, the arable land abandonment has also increased. In that sense, experts and researchers are considering alternatives to recover such lands. Consequently, studies on the possibility of producing bioethanol from rice in the abandoned arable lands in Japan have been presented. Nevertheless, rice production requires high water utilization furthermore, automated irrigation-systems are used for obtaining higher yields, indicating electricity and fuel consumption. On the contrary, crops as cassava root can be planted in poor soils with low to none electricity utilization. Utsunomiya city was selected as case study considering its food and fuel demand as well as the agricultural abandoned land available in Tochigi prefecture. The land use efficiency was analysed through a linear model. A range of feasible outcomes, as well as the net energy balance of two scenarios were studied. The design proposed is an on-farm bioethanol generation in order to reduce transportation costs; furthermore, self-sufficiency of electricity and heat through the use of CHP was included.

Keywords: Land use, bioethanol, on-farm, linear programing

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Introduction

Considering the competition for land that has hitherto existed among food and biofuels it was modelled a self-sufficient farm, on energy and food, which is able to supply both without affecting one another. The concept of such farm was inspired by two concepts, multifunctional farms and integrated food-energy system (IFES) which are explained later in this work.

The land efficiency of farms was analysed as an alternative of the usual approach of cost minimization, aiming to an improvement of land use for later considering the policies necessary to do so. Land use limitation issues affect every country without exception; the intensification of urbanization as well as protected areas in conjunction with elderly farmers retiring have generated an increment of agricultural land abandoned. Therefore, the use of abandoned land is proposed to generate both food and fuel. The methodology presented allows decision makers to observe diverse optimal solutions according to their preferred goal: food or fuel.

The potential of current abandoned land for producing food and biofuel was analysed under two scenarios taken from optimal solutions. Scenario 1 considers fuel production as primal goal, while Scenario 2 includes food production as well.

The subject of study was Tochigi prefecture's abandoned land for supplying food and fuel demand of Utsunomiya city. Nonetheless with the goal of extrapolating to the southern part of Japan. A combination of cassava and rice was chosen to the extent of maintaining the self-sufficient ratio of rice (99 %) while including a high-energy crop.

Nomenclature and abbreviations

A	Area [ha]
CC_f	Calorific content of fuel [MJ/L]
E	Electricity [MJ]
Fl	Fuel [MJ]
f	Food [kg]
f_d	Food demand per capita [kg]
H	Heat [MJ]
i	Type of crop (ex: rice, cassava)
k	Percentage of population to supply fuel to [%]
m	Percentage of population to supply food to [%]
n	Population
R	Residue [kg]
Yc	Yield of crop [kg/ha]
Yf	Yield of fuel [L/kg]

Multifunctional farms

Multifunctional as the word indicates, represent several activities within one place or by one artefact. A multifunctional farm is then thought to produce more than food as conventionally presented. Nowadays by-products are as well obtained to generate for example bioenergy; furthermore beautiful sceneries from paddy fields are representing tourist destinations. T. Dobbs and J. Pretty (2004) indicate that "The idea that agriculture provides these other types of goods and services is not new, of course, and, in itself, is not controversial. The controversies surround how this concept is translated into policies" (Dobbs, 2004). The multifunctional farms addressed in this work describe the potential use of agricultural residues to produce electricity, heat and bio-fuel on-farm; furthermore evaluate energy outcomes and land efficiency considering policy change of *more fuel* or *more food*, in percentage of demand.

A farm where food and energy is produced within its boundaries has been described by the Food and Agriculture Organization (FAO) as Integrated food-energy systems (IFES). FAO proposes two types: "Type 1 combines the production of food and biomass for energy generation on the same land, through multiple-cropping systems, or systems mixing annual and perennial crop species and combined with livestock and/ or fish production (ecosystem approach). Type 2 seeks to maximize synergies between food crops, livestock, fish production and sources of renewable energy, using agro-industrial technology such as gasification or anaerobic digestion" (FAO, 2013).
The previous concepts determine foundation and motivation of this work.

Abandoned land

The present work takes into consideration what is defined by the Ministry of Agriculture and Fishery of Japan (MAFF) as abandoned cultivated land. In 2010 it was reported a total of 396,000 ha abandoned (See Fig. 1), 1.8 times as for 1990 (MAFF, 2014). The increment observed has been driven by several factors, however the most critical is the retirement of elderly farmers; nowadays approximately 60 % of farmer population in Japan is over 65 years old.

Another reason of abandonment has been the decrease in rice and tea demand; however the self-sufficiency ratio of the former one increased from 97 % to 99 % because of higher yields achieved. In this way of thinking, some researchers have been considering other alternatives of utilizing such lands for energy production. “Utilization of such abandoned cultivated lands as well as marginal lands could bring opportunities for rural development. For that purpose, choices should be made carefully regarding locations and which feedstocks to cultivate. Also, the potential impacts of biofuel crop cultivation on existing ecological systems and possible indirect GHG emissions due to land use change should be considered” (Matsumoto et.al., 2009).

According to Matsumoto, N. et.al. (2009), the first collaborative project plan approved in December 2008 to produce ethanol was from rice, furthermore on unutilized rice fields, beside other previous projects organized by MAFF for larger scale. Nevertheless, current import is greater than production and is done exclusively from Brazil. Table 1 presents the fuel ethanol imports in Japan in the last nine years.

Table 1. Market penetration of ethanol in Japan

Market penetration	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fuel ethanol [kL]	30	90	200	15,000	27,811	52,146	56,067	79,114	91,700

Kanto and Tozan area were considered, more specifically Tochigi prefecture because it has the greater agricultural land abandoned as observed in Fig.1. Furthermore, it was applied a conservative land use factor of 70% as used in city planning when taking into account future generations and its development.

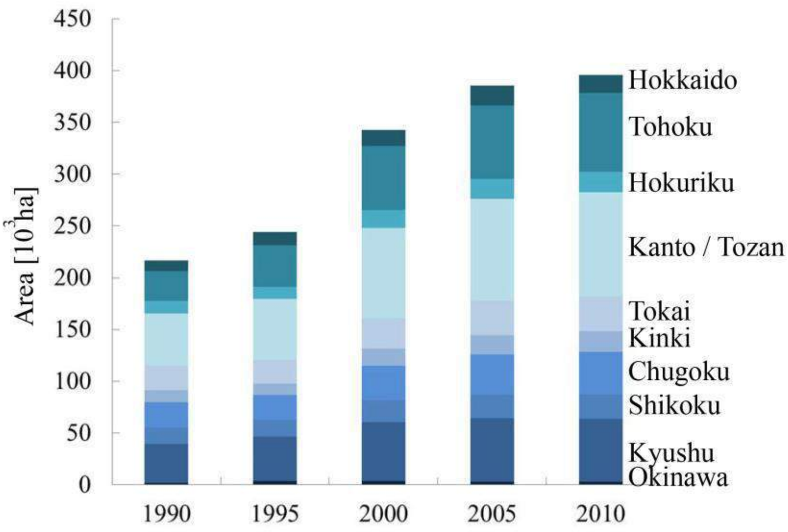

Figure 1. Agriculture abandoned area in Japan

Crops analysed

A difference among edible and non-edible fraction of the plant was considered to be able to distinguish the actual dilemma of food versus fuel, since it is the edible fraction which encounter such issue. Furthermore, the model developed in this research describes the use of edible fraction for food or fuel as main factor in the objective function; then non-edible fraction is treated as resource to generate either electricity and heat (CHP) or biofuel.

The use of human food as resource for ethanol production has created extensive debates, considering that there are about 827 million undernourished people in the world according to the FAO (2012). Nevertheless Japan does not face such issue directly, using a staple food as it is rice for such purpose it may create a risk; furthermore if considering factors as the great east earthquake that affected the country in 2011.

In this way of thinking, the utilization of cassava is proposed as an alternative, comparing the efficiency of using one or both for bioethanol production. It has been observed that rice uses great amount of water, it may not have high bioethanol yield as other crops like sugarcane or cassava as well as it could affect its market price. The use of Cassava instead, may not improve directly the food self-sufficiency ratio however will not reduce it since is not a staple food in Japan. Furthermore, there is an opportunity of using locally produced cassava chips as feed to increase livestock production as an alternative of importing corn as currently.
A brief description of the crops analysed is as follows; furthermore energy content and yield data used are in Table 2.

Rice

Is a cereal grain widely used as staple food in many countries, however is stronger in Asia where an area of 1.4×10^6 km^2 is harvested. In Japan, rice represents a staple food and nearly the only agricultural product that is exported. The self-sufficient ratio of rice in Japan reaches 99 % (MAFF).

Rice has grown interest as starchy resource for bio-ethanol production, mostly because of the concern about its bulky agricultural residue and possible uses as biomass. The edible part of the plant is the grain while the husk and straw are the residues as shown in Fig. 2. Furthermore, as observed in Table 2, residue is produced almost as grain. Rice is worldwide grown and there are many species, *Oryza sativa* is majorly found in Asia and *Oryza glaberrima* in Africa.

There are other many species and several researches intend to increase its yield for bio-fuel production. Nonetheless, the interest is usually on the residues because if it is left on the field causes erosion, therefore is a “free” resource. Furthermore, the global bioethanol potential from residues is estimated to be 205 GL (Kim, S. 2004).

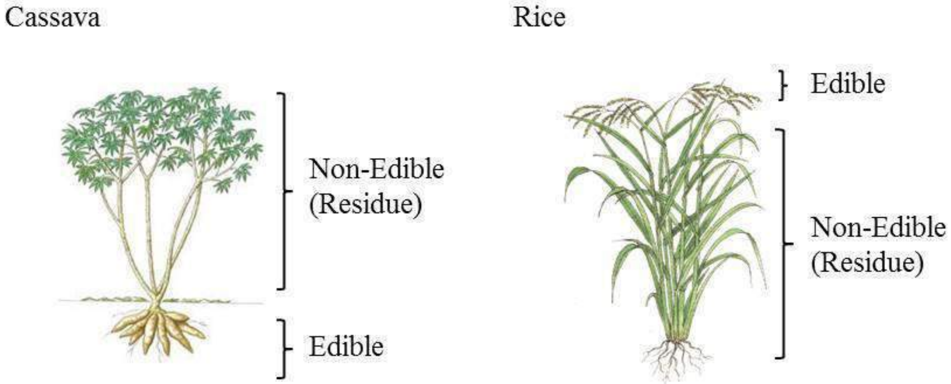

Figure 2. Edible and non-edible fractions of rice and cassava (Source: FAO)

Table 2. Energy content and yield of rice and cassava

Crop	**Edible/ Non-Edible fraction**	**LHV [MJ/kg]**	**Yield [kg/ha]**	**Ethanol Yield [L/kg]**
Cassava	Stem, rhizome	18.42	3,854	0.14
	Root	15.90	14,527	0.41
Rice	Husk, straw	14.27	5,126	0.28
	Grain	15.20	6,210	0.48

Cassava

Manihot esculenta Crantz by its scientific name is the third most important source of calories in the tropics after rice and maize (FAO). "Cassava is a woody perennial shrub, which grows from 1 m to 5 m in height. It is believed to have been cultivated, mainly for its starchy roots, for 9,000 years, making it one of agriculture's oldest crops" (Howeler, R. et.al. 2013). History suggests it was originated in South America and later during colonization times, it was extended to Africa and Asia, being the former one where is widely used as staple food. Currently Thailand is the major exporter of cassava followed by Vietnam.

Even though cassava has been established greatly in tropical regions, nowadays it can be found under lower temperatures as well, because it can grow in low quality soils or marginal lands. It is observed in Fig. 3 an extension to the north of the Tropic of Cancer, particularly in China, of cassava uses. In China the interest for biofuel production with cassava has increased notably. C. Janson et.al. (2009) say that "recently, cassava-derived bioethanol production has been increasing due to its economic benefits compared to other bioethanol-producing crops in the country". As well in United States, where there is no published nationwide production of cassava, a study in Alabama suggested that "with warmer maximum and minimum temperatures and a frost-free period of over 220 days was sufficient to produce significant root biomass" (Ziska, L. H. et.al., 2009). Therefore we considered cassava as an alternative to make use of abandoned and marginal lands in Japan in near future, without affecting food security.

The stem, leaf and rhizome are considered in this work as residues as observed in Fig.2. However, some regions in Africa consume the leaves in spite of it toxicity if is not treated well.

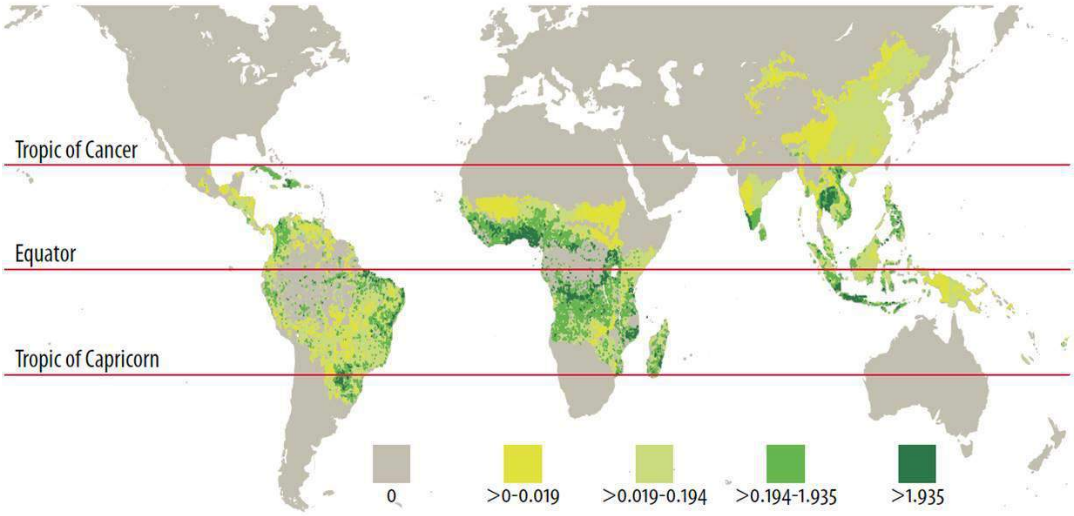

Figure 3. Cassava plantation worldwide [ha/km^2] (Howeler, R. et.al. 2013)

Background

The current research analyses the use of rice and cassava for ethanol and food production together and not exclusively as have been observed in several previous researches. Furthermore, it analysed the Net Energy Balance (NEB) considering *Labour* because it was noticed that it has been excluded. However, labour is a variable that must be taken into account because first it represents of about 30 % of agricultural cost and secondly because there are notably differences of its intensity among crops.
In this work NEB values and energy production of a design where cassava and rice are used were compared to a one-crop system; one case of only cassava and another one of only rice. In Table 3 a summary of variables considered and compared with previous researches is presented.

Case study

As said before Tochigi prefecture was selected, furthermore the city of Utsunomiya. The target population is about 511,739 inhabitants with fuel consumption per capita of 14,047 MJ and annual electricity consumption per capita of 7,848 kWh. Currently, Tochigi has 43 thousand hectares of agricultural land abandoned. The objective of this work is to analyse the potential of such land to supply fuel and food demand of Utsunomiya.

Table 3: Comparison of previous studies

		This research	K. Saga et. al.	Nguyen
Agriculture production	Rice	✓	✓	
	Cassava	✓		✓
Final product	Food	✓		
	Fuel	✓	✓	✓
	Electricity	✓	✓	
	Heat	✓	✓	✓
Indirect energy	Seeding	✓	✓	✓
	Fertilizer, Manure, Pesticides	✓	✓	✓
	Irrigation	✓	✓	✓
	Machinery, Vehicles	✓	✓	✓
	Labor	✓		
	Others	✓	✓	✓

Methodology

Figure 4 represents the schematic design of the farm proposed. As observed, edible fraction of crops is used for food and fuel, while its residues could be used for biofuel and cogeneration of electricity and heat. Electricity and biofuel are used in the agriculture process as direct energy inputs, while indirect inputs come from outside farms limits. Heat is used for biofuel production on-farm.

Typically in agriculture, the selection of crops is denoted by a minimization of cost or maximization of profit approach. However, the land variable is not directly studied. Therefore, a minimization of land used approach was analysed where the objective function considers land for food and for fuel (E.q. 1).

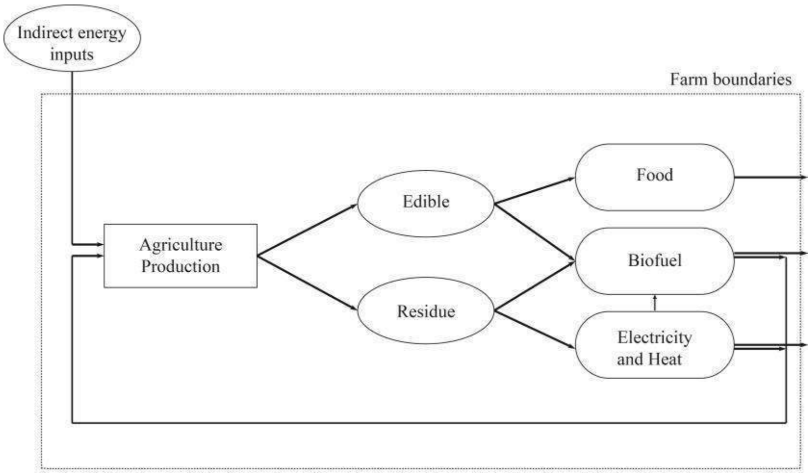

Figure 4: Conceptual system design

$$\min A_{total} = min\left(\sum_i A_{food_i} + \sum_i A_{fuel_i}\right) \quad (1)$$

where the area for food (A_{food_i}) can be expressed in terms of food produced (f_{out_i}) and crop yield (Y_c) (E.q. 2). Analogously the area for fuel (A_{fuel_i}) is based on fuel produced (Fl_{out_i}) and fuel yield (Y_f) (E.q. 3).

$$A_{food_i} = \frac{f_{out_i}}{Y_{c_i}} \quad (2)$$

$$A_{fuel_i} = \frac{Fl_{out_i}}{Y_{c_i} CC_{f_i} Y_{f_i}} \quad (3)$$

Residues (R) are planned to be used for electricity, heat and fuel generation (E.q.4). A fraction a is for biofuel and a fraction b is for cogeneration. Therefore $a+b=1$.

$$\mathrm{R}_{Total} = a\sum_i \left(R_{food_i} + R_{fuel_i}\right) + b\sum_i \left(R_{food_i} + R_{fuel_i}\right) \quad (4)$$

The constraints implemented are as follows:

1. Total electricity produced (*E_{out}*) has to be equal or greater than electricity needed on-farm (*E_{in}*) (see E.q. 5)

$$E_{out} \geq \sum_i E_{in_i} \tag{5}$$

2. Total heat production (*H_{out}*) has to be greater or equal than heat for biofuel production (*H_{in}*) (E.q.6).

$$H_{out} \geq \sum_i H_{in_i} \tag{6}$$

3. Food produced (*f_{out}*) has to supply food demand per capita (*f_d*) to a percentage m of the target population n. (E.q.7)

$$f_{out_i} \geq m.n.f_{d_i} \tag{7}$$

4. Fuel produced (*F_{out}*) has to supply on-farm fuel use (*Fl_{in}*) as well as a fuel demand per capita (*Fl_d*) to a percentage k of the target population n.

$$Fl_{out} \geq \sum_i Fl_{in_i} + k.\ n.Fl_d \tag{8}$$

An iteration of m and k is analysed with the objective of understanding the limitations and potential of the land available as well as optimal solutions. Such iteration is evaluated from zero to 100 % in intervals of 1 %.

After obtaining the feasible region, two "extreme" scenarios are analysed and compared:

- Scenario 1, *Only-fuel Scenario*: Describe a policy where producing fuel is the goal. In other words it could be seen as an energy secure scenario.
- Scenario 2, *Food&Fuel Scenario*: Is the maximum efficient use for land targeting both food and fuel.

From each Scenario the following can be obtained: the values of m and k for which it is are feasible, the optimal share of rice and cassava, and the net energy balance (NEB). Such balance is calculated by subtracting energy output from energy input.
The data used in the model are in Table 4 and Table 5.

Table 4. Data used in the model

Crop	**Rice**	**Cassava**
Food demand per capita [kg]	43.30	0.10
Crop yield [kg/ha]	5,110.00	14,527.20
Labour [h/ha]	24.00	952.86
Electricity [kWh/ha]	120.00	14.93
Fuel [MJ/ha]	3,118.00	3,528.57
Residue	**Straw**	**Stem and Rhizome**
Residue Yield [kg/ha]	4,218.82	3,854.07
Calorific content residue [MJ/kg]	14.27	18.42
Calorific content full crop [MJ/kg]	15.20	15.90
Bioethanol production		
Ethanol conversion rate residue [L/kg]	0.28	0.14
Ethanol conversion rate crop [L/kg]	0.48	0.41
Electricity input [kWh/L]	0.39	0.34
Heat input [MJ/L]	10.65	6.36
Calorific content output [MJ/L]	22.00	21.12

Source: Pimentel&Pimentel (2008), Nguyen T.(2008)

Results

In Fig. 3 the feasible region obtained from the model by iteration of *m* and *k* values can be appreciated. A gradient of colours was used to indicate the land needed to achieve different fuel and food production respect to demand. As well, Scenarios selected are detailed. From here it can be noticed that Scenario of Food and Fuel use land more efficiently because with nearly the same area it could produce 100 % of food demand and 42 % of fuel demand in contrast of Only-Fuel Scenario that reach 38 % of fuel.

Table 5. Data used for NEB

	Energy input [MJ/ha]	Rice	Cassava
Direct	Electricity	1,308.00	162.74
	Fuel	3,118.00	3,528.57
Indirect	Seeding/Sticks	558.64	1,126.00
	Fertilizer	7,896.25	3,591.00
	Manure	-	23,684.00
	Herbicide and insecticide	5,183.91	-
	Others	804.42	-
	Irrigation	2,129.01	-
	Agricultural service	5,337.28	-
	Facility	2,628.43	-
	Labour (h/ha)	3,432.00	21,216.00
	Vehicles	1,517.35	-
	Machinery (kg/ha)	11,975.92	391.00
	Production management	43.75	-

Source: MAFF (2010), Pimentel&Pimentel (2008)

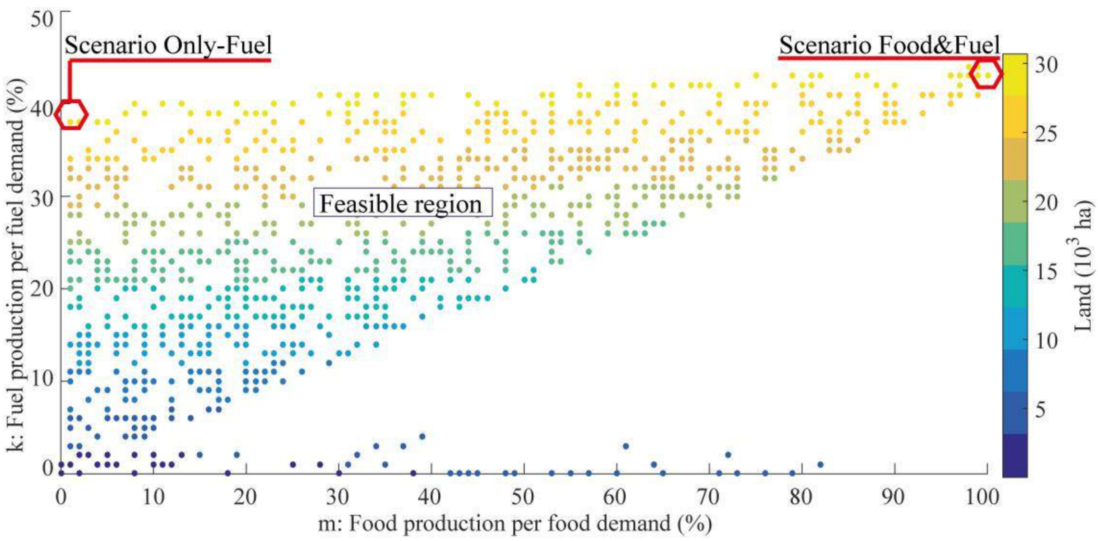

Figure 3: Feasible region obtained from iteration of *m* and *k* values from where two scenarios were chosen.

The optimal combination of crops for each scenario is shown in Fig. 4, from where it can be observed that for Scenario of Only-Fuel, cassava is preferred over rice. Furthermore, the combination of 41 % of the land for rice and 59 % for cassava in Food&Fuel Scenario allows slightly less land use than in the previous one.

When observing results heretofore it can be noticed that for cassava-rice configuration in our case study, it does not exist apparent *food versus fuel* dilemma, instead it indicates that the target population selected can be self-sufficient on rice and at least 41 % on fuel.

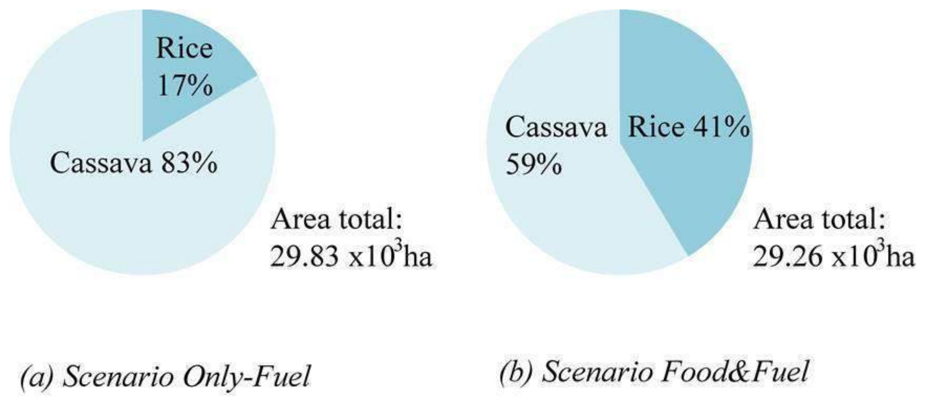

Figure 4: Land used by different crops in the two scenarios selected

As described in the methodology section NEB was analysed for the two scenarios described. In this study direct energy input are electricity, heat and biofuel, all produced on-farm. Electricity and fuel are used for irrigation and transportation as agricultural inputs, and electricity and heat are used for biofuel production. Indirect energy was indicated in previous section. Even though Food&Fuel Scenario revealed to have higher land efficiency based on the amount of food and fuel produced, it can be observed in Fig. 5 that its actual energy balance is lower than for Only-Fuel scenario. Nonetheless, both Scenarios 1 and 2 have positive balance of about 71.99 GJ/ha and 80.99 GJ/ha respectively. It is thought that the differences between them relies on that the energy output in food is not considered in Scenario 2.

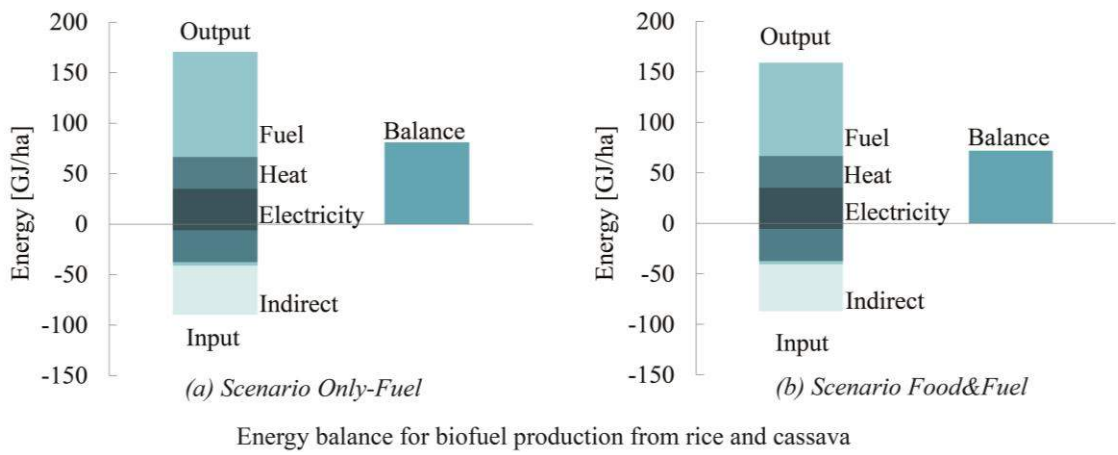

Figure 5: Energy balance for biofuel production from rice and cassava for the two scenarios selected

In Fig. 6 the energy flows are represented by Sankey diagrams for easier understanding of results. Both scenarios are compared with previous research of only-rice and only-cassava cases. It can be observed that the optimal share obtained in this research achieves higher ethanol production per hectare (approximately 10-13 GJ/ha higher), from which Scenario 2 provides the highest potential; moreover generates its own heat and electricity on-farm.

As well it can be noticed that residues are used for electricity and heat production however not for biofuel, despite of being proposed as alternative in the model. Another aspect observed is that heat generation matches own consumption, meanwhile a surplus of electricity can be obtained.

Discussion

Producing fuel does not imply a food security dilemma considering land use, however is the choice of crops what determines such issue. Due to the non-direct consumption of cassava as food it was obtained that in combination with rice the case study presented achieves food security and about 41 % of fuel demand. Nonetheless, cassava does have a market in Japan in the form of starch or already processed as tapioca balls due to the import of Thai food. Currently China and Japan are the biggest importers of cassava starch due to paper industry (80 % of total production). A further study of market price should be analysed; as well it could be considered the use of cassava chips for feeding purposes in comparison with the current use of corn, which is also an imported good.

The NEB obtained for both scenarios is 80 GJ/ha and is approximately 40 GJ/ha lower than the best balance scenario presented by Saga et.al 2008. Nonetheless the indirect energy input from labour was included; which is intensive, especially for cassava. Despite lower balance, the bioethanol yield per hectare is higher.

If current design is applied from middle to southern area of Japan the bio-ethanol potential could reach up to 19 PJ, or 906,107 kL which is equivalent to 130 % of imported bio-ethanol in 2010.

Conclusion

One of the advantages of using the methodology described is that decision makers are not influenced by only one solution, instead can observe the big picture moving forward more efficient systems.

It was observed that providing about 40% of fuel demand of Utsunomiya City leaves land to supply from 1% to 100% of rice demand depending on the optimal share of crops or the objective of decision makers, either only fuel or food and fuel.

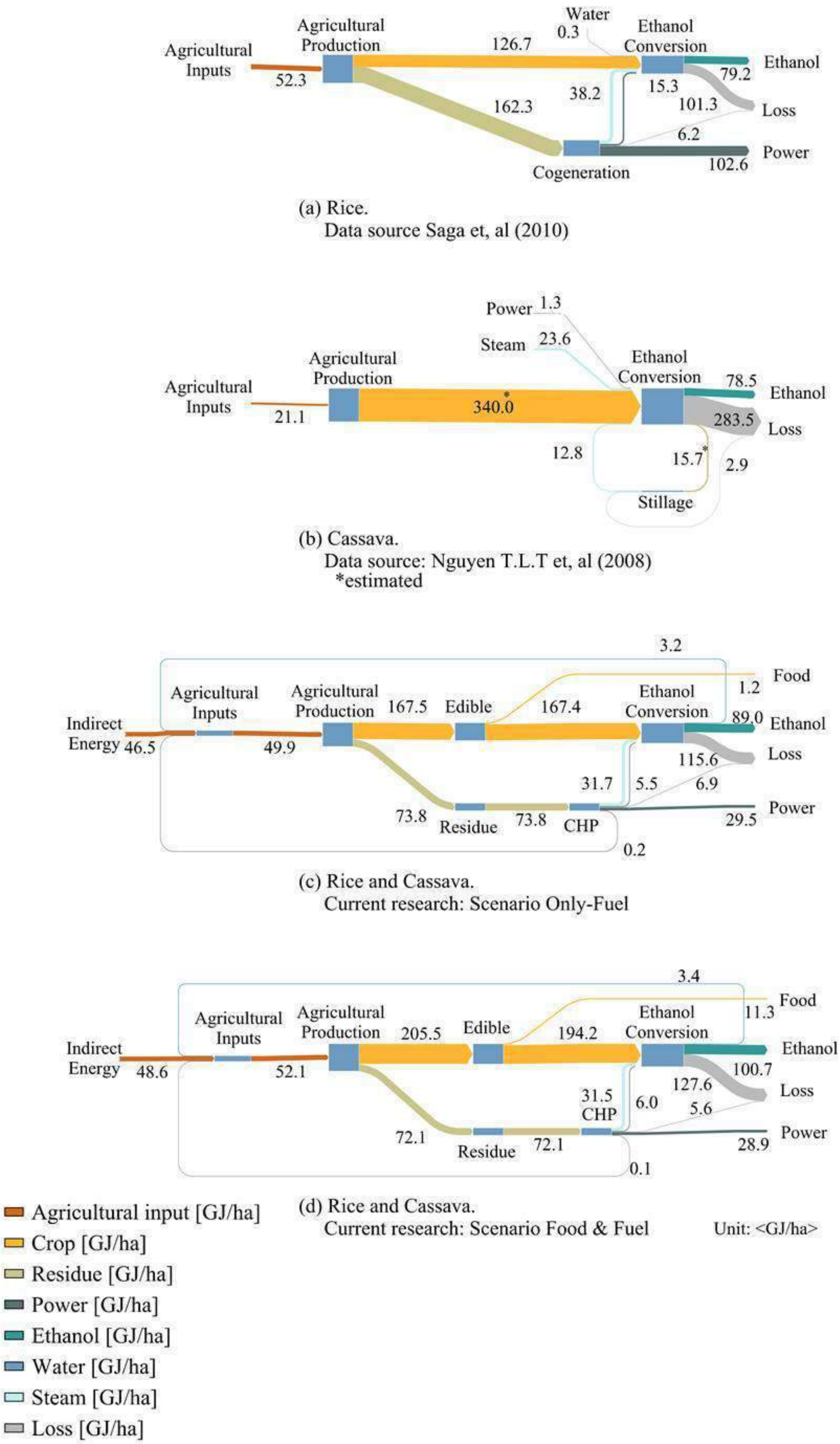

Figure 6: Energy flow of the two scenarios selected and previous researches

Producing both food and fuel at its maximum possible by land available, using Scenario 2, ensue higher ethanol production approximately 11.7 GJ/ha compared with only-fuel scenario. Moreover, food demand of rice for the case study is completely accomplished locally.

It is recommended a soil study for cassava plantations. However, it is known cassava grows in poor soils and marginal land; furthermore there are studies that indicate crop rotation as a mechanism to improve soil quality.

Results indicate that producing bio-ethanol not necessarily affects food production, instead could be done in conjunction if a proper choice of crops is done. Japan land is known for not being as productive as in other countries; however crops like cassava which does not collide with food security and can be planted in marginal land, provides a high opportunity for biofuel production, therefore increasing energy security.

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Coastal Urbanization Impacts on Biodiversity the Case of Marinas in Singapore

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Abstract
Most of Singapore's coastline has been modified by coastal development with variable influences on marine biodiversity. Marinas are typically designed as a semi-enclosed environment with a complex mix of structures that provide ecological niches throughout the water body. Water flow is inevitably reduced with a possible decline of water quality. This investigation was conducted to determine how marinas affect marine biodiversity. The three marinas studied - Marina at Keppel Bay (MKB), One Degree 15 Marina (ODF), Raffles Marina (RM) - all supported rich biodiversity. The combined 71 faunal taxa (two Classes, 10 Orders and 59 Families) from the soft bottom of all three marinas surveyed using the Ekman grab, were dominated by polychaetes (71.4%) and arthropods (16.7%; mainly crustaceans). The total fish species surveyed using customised traps was 49 from 31 Families, ranging from the very common and abundant fan-bellied filefish (*Monacanthus chinensis*) and eeltail catfish (*Plotosus* spp.), to the less commonly seen fishes such as the starry triggerfish (*Abalistes stellatus*) and estuarine stonefish (*Synanceja horrida*). Reef-associated fish species were more abundant at MKB and ODF, while estuarine species dominated at RM. Epibiotic diversity was evident on the artificial structures in all marinas. The submerged sides of berthing pontoons supported up to 107 taxa, dominated by ascidians, macroalgae and sponges. Corals also recruited naturally with 10 and 22 scleractinian genera established on pontoons at MKB and on seawalls at ODF, respectively. In general, fish and soft bottom macrobenthic abundance and diversity were comparable or higher within the marina compared to the adjacent open water. The findings indicate that modified coastal environments such as marinas can support diverse biological communities.

Keywords: coastal, biodiversity, urbanization, marinas, Singapore

Introduction

Extensive coastal development in Singapore since the 1960s has resulted in the modification of many natural shores to cater to various sectoral demands such as port operations and marine recreation, causing interference with natural physical processes and impacts on the original biodiversity (Chou, 2006). The popular demand for seafront living and marine recreation has also resulted in the transformation of natural shores to human-modified ones such as marinas and coves. Marinas – of which Singapore currently has seven – are built to provide sheltered conditions for the berthing of pleasure craft (Chou et al., 2010). These semi-enclosed environments can compound environmental problems due to the resultant alterations in hydrodynamics and reduction in water quality, and lead to the decline of marine life.

However, the newly created environment with its structural complexity can support and sustain new or modified biological communities. For example, coastal infrastructure such as seawalls have been observed to serve as habitat for various species (Martin et al., 2005; Clynick, 2006), while organisms growing on the surfaces of other structures can serve as food for larger animals (Rilov & Benayahu, 1998). Marinas comprise a complex mix of artificial structures such as berthing pontoons, pilings and seawalls, and thus have the potential to function as new habitats for marine organisms. To investigate how marinas in Singapore affect marine biodiversity, surveys were conducted between 2012 and 2015, focusing on the epibiotic, pelagic and macrobenthic communities in Raffles Marina (RM), One Degree 15 Marina (ODF) and Marina at Keppel Bay (MKB). The open waters up to 150m beyond these marinas were also surveyed.

Macrobenthic diversity

The reduced hydrodynamic energy within the marinas result in the accumulation of a thick layer of sediment on the seabed. Macrobenthic organisms inhabiting the soft bottom sediment within the three marinas, as well as the adjacent open waters of RM (i.e., the Straits of Johor) and MKB (i.e., the Straits of Singapore), were surveyed using an Ekman grab. The area outside ODF was not surveyed as the substrate comprised mainly coarse gravel and cobble. The sediment samples were sieved to extract the animals, which were then brought back to the lab for identification under the microscope.

A total of 71 faunal taxa (two Classes, 10 Orders and 59 Families) were recorded within the marinas. Annelids (71.4%) and arthropods (16.7%; mainly crustaceans) comprised the majority of the macrobenthos, followed by molluscs (6.3%), echinoderms (4.0%), and other animals such as fishes, cnidarians, and platyhelminthes (1.7%). There was a higher abundance of macrobenthic organisms within RM and MKB compared to the adjacent open waters. While faunal diversity was higher within MKB (Shannon Wiener index, $H' = 2.41 \pm 0.30$) than the open waters ($H' = 2.00 \pm 0.64$), that within RM ($H' = 1.93 \pm 0.52$) was lower compared to the surrounding waters ($H' = 2.31 \pm 0.29$).

The dominance of opportunistic polychaetes (i.e. those that thrive in polluted environment) from the families Cirratulidae (Rygg, 1985; Reish & Gerlinger, 1997; Ganesh et al., 2014) and Spionidae (Levin et al., 1996; Chandler et al., 1997; Inglis &

Kross, 2000; Neira et al., 2013) and low Shannon Wiener Index in RM were indicative of depressed environmental quality within the marina, but this was likely a consequence of the much reduced flushing in the Johor Straits. The enclosed nature of RM compounded the situation. This was in contrast to MKB and ODF, where the abundance of opportunistic polychates was not as high (RM: 29.58%; MKB: 9.65%; ODF: 6.40%). The presence of openings at both ends of MKB encouraged water exchange between the marina and the fast currents of the Straits of Singapore, thus helping to maintain acceptable water quality.

Epibiotic diversity

The presence of various structures in marinas such as pilings, berthing pontoons and seawalls served as suitable substrate for the recruitment and colonization of sessile epibiotic communities. Pontoons – as floating structures that demarcate berths for vessels in the marinas – are unique as parts of them are permanently submerged close to the water surface. Yet, information on their potential as habitat for epibiotic organisms in Singapore's urbanized coasts is minimal (Lam & Todd, 2013). The epibiotic assemblages on the sides of the berthing pontoons in all three marinas were photographed *in situ* and the images analyzed using the software CPCe (Kohler & Gill, 2006) for the percentage area occupied by each taxa. In spite of the limited area available for colonization, a total of 107 taxa were recorded on the submerged sides of these pontoons. The epibiotic communities on the pontoons were dominated by macroalgae (43.53%), sponges (8.17%) and ascidians (6.03%). A diverse range of other animals were also recorded, including bivalves, alcyonarians, hexacorallians, hydrozoans, bryozoans, annelids, gastropods, arthropods, and echinoderms. MKB and RM, with up to 50cm of their concrete-coated pontoons submerged, harbored higher richness, 87 and 90 respectively. Only 66 taxa were recorded on ODF pontoons, likely due to their small submerged area (10-15cm). Interestingly, reef-building corals from 10 scleractinian genera (seven families) were recorded on the pontoons at MKB. Corals of the genus *Pocillopora* were the most common. The presence of a constant light source, altered hydrodynamic conditions, and larvae that recruit near the water surface resulted in the creation of a habitat rarely found in nature (Connell, 2000; Holloway & Connell, 2002; Perkol-Finkel et al., 2006, 2008), and it was clear that the shallow floating pontoons in the three marinas facilitated the filter-feeding and photosynthetic processes of the epibiotic communities.

Seawalls are another major component in Singapore's marinas, and consist of large granite rocks piled together to form the periphery of each marina. These are substrates which in recent years have been documented to support the natural colonization of hard corals in Singapore's marinas (Chou et al., 2010; Tan et al., 2012). Additional surveys of scleractinians colonizing the seawalls in ODF showed 22 scleractinian genera (out of Singapore's total of 56; Huang et al., 2009) from 12 families with colonies of the genus *Turbinaria* dominating. There was an increase in diversity and evenness compared to the scleractinian communities surveyed in 2007 within the same marina, when the dominant genus was *Pectinia* (Chou et al., 2010). The current study also recorded corals larger than 50cm diameter, which were not observed in the previous survey. The results indicated that seawalls in marinas have the potential to sustain scleractinian biota in spite of impending global threats, such as the mass bleaching due to sea warming in 2010 which severely impacted large tracts of Singapore's coral reefs (Tun et al., 2011).

Pelagic diversity

Although marinas in subtropical areas are known to function as habitats for diverse fish assemblages (e.g. Clynick et al., 2007), surprisingly little is known about those in tropical marinas. Custom-made fish traps were deployed on the seabed in a catch-and-release program to document the fish communities inhabiting all three marinas. To investigate if the presence of marinas affects nearshore fish communities, the open waters adjacent to RM were also surveyed. No sampling was carried out outside ODF and MKB due to navigational safety reasons.

Forty-nine fish species from 31 families were recorded from within all three marinas. MKB and ODF, both situated in the vicinity of coral reefs, harbored reef-associated fish species (e.g. *Chelmon rostratus*, *Parachaetodon ocellatus*), with the former having the highest diversity of all three marinas. RM was sited in an estuarine strait, and thus supported mainly estuarine species (e.g. *Arius oetik*, *Etroplus siratensis*). Fish diversity measured using the Shannon Wiener index was the least within RM, but catch abundance here was the highest among the three marinas.

Diversity (H') and richness (S) were comparable between fish communities within RM (H' = 1.63; S = 26) and the adjacent open waters (H' = 1.80; S = 24), but abundance within the marina was twice that of the latter. These results differ slightly from other studies which reported that fish communities within heavily modified environments were highly dissimilar to the original or adjacent natural habitats (Wen et al., 2010; Clynick, 2006; Guidetti, 2004). More importantly, the current findings highlight the ability of a tropical marina to aggregate or attract diverse fish communities from the relatively featureless open water vicinity.

Conclusion

The results from this study indicate that rather than being entirely harmful to marine biodiversity, marinas can host altered but reasonable levels of biodiversity. Apart from being sheltered havens for vessels, they also create novel habitats and serve as refugia for marine life. To optimize this role of promoting coastal biodiversity, the proper management of marinas must be complemented with sound scientific inputs and regular monitoring. In Singapore where the coastline has been rapidly urbanized, marinas have functional roles in biodiversity maintenance.

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Environmental Challenges and Economic Growth in Developing Countries: Indonesian Perspective

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Abstract
Economic growth has become an objective of developing countries, including Indonesia. The sustainability of economic growth in developing countries depends on the sustainability of natural resources. Hence, it is very important to apply sustainable development principles to boost economic growth in developing Countries. The concept of sustainable economy should be integrated in the economic growth, because all economic activities may affect the environment in general and natural resources particularly. However, the conflicting factors in economic growth and protection of the natural resources can be resolved by harmonizing the interest of economic growth and protection of the environment. In order to achieve both of the objectives need appropriate planning, strategies and programmes. Each state has its own planning, strategies and progammes. Indonesia as one of the developing countries should design its own planning, strategies and programmes how to deal with negative impacts of economic growth. The paper questions the Indonesian government how to cope with the environmental challenges in enhancing economic growth. The paper focuses on the short, middle and long term planning of the Indonesian government including the strategies. The emphasis, therefore, is on the programmes how to cope up with the environmental challenges and economic growth in Indonesia in order to improve the welfare of the citizens mandated in the Indonesian Constitution. The methodology employed in addressing these issues is library-based research and the normative approach.

Keywords: Environmental challenges, economic growth, sustainable development, and natural resources.

1. Introduction

Indonesia is the world's largest archipelagic state encompassing over 17,000 islands and home to over 237 million inhabitants2, which makes it the fourth most populated country in the world. The population has more than doubled since 1970 and is estimated to grow to 262 million people by 2020. Nearly 60% of Indonesia's terrestrial area is forested. The landscape is also mountainous and volcanic with over 500 volcanoes out of which 129 are still active. Indonesia’s macro-economic development during the past 30 years is to a large extent based on its natural resources. However, these resources have been exploited unsustainably and communities living in the vicinity of formerly resource rich areas are experiencing increasing levels of poverty.[1]

Economic growth in Indonesia becomes one of the parameters to indicate the success of development. It contributes to the fruit of development that can be enjoyed also by the poor people through trickle down effect. However, it should bear in mind that economic growth in Indonesia is affected by the economic and social welfare objective stipulated in the Indonesian Contsitution in Article 33 (4) which mentions that “ The organization of the national economy shall be conducted on the basis of economic democracy upholding the principles of togetherness, efficiency with justice, continuity, environmental perspective, self-sufficiency, and keeping a balance in the progress and unity of the national economy”.[2] It means that the economic growth in Indonesia shall be based on those principles. Hence, it is inportant to integrate sustainable development principle in the process of economic growth in Indonesia.

In the early 1970s several factors, such as awareness of expanding environmental degradation, depletion of natural resources, poverty and social discruption,led states to realize the harmful impact of human activities especially economic activities on the environment. Because of that the sustainable development principles surfaced n the international community and international environmental law. The 1972 Stockholm Declaration marked the beginning of new conception of development. Development was no longer regarded in term of gross national product but as a policy aimed at better living condition for all.[3] The sustainable develoment principle was introduced by the World Commission on Environment and Development in 1987 which defined sustainable development principle, as “ development that meets the needs of the present without compromising future generations to meed their own needs”. Thus, sustainable development principle is aimed at establishing norm for environmental protection and conservation that were ecology-oriented rather than utilization oriented.

[1] School of Busines Economics and Law, university of Gottenburg, Departement of Economic, “ Indonesia Environent and Climate ChangePolicy Brief, 2008”, Retrieved from http://sidaenvironmenthelpdesk.se/wordpress3/wp-content/uploads/2013/04/Environmental-policy-brief-Indonesia-2008.pdf. 25 April 2015.

[2] Article 33(4) the 1945 Constitution of Republic Indonesia.

[3] Christina Voigt, *Sustainable Development as Principle of International Law,* 2009, Leiden-Boston, Martinus Nijhoff Publishers, at 13-14.

It is now widely belief that the planet faces diverse and growing range of environmental challenges which can only be addressed through international cooperation[4] by integrating environmental concern in the national policy of a state. In the context of economic growth in Indonesia, economic activities initiate environmental problems in Indonesia, such as air pollution, water pollution and also environmental degradation. The Indonesian economy is based on its natural resources, however, the natural capital is consumed rapidly in an unsustainable way, causing human poverty as well as losses to the national economy. Consequently, Indonesia must balance the need of making productive use of its natural resources with maintaining and managing its natural capital. Indonesia is highly dependent on its natural resources, which have been, and still are, the basis for Indoneisa's economic growth. [5]

Hence, it is very important to integrate sustainable development in the economic growth in Indonesia. The sustainable development principle has been adopted in the Act No. 32 /2009 concerning the Protection of the Environment. Realizing the bad impact of economic growth in Indonesia to the environment, and especially to the sustainability of the natural resources in Indonesia, the Indonesian government establishes National development planning which is regulated by law and coordinated by the National Development Planning Agency by integrating environmental protection in the long time Development Plan which concists of four stages. Within the current long-time planning framework (2005-2025), four five-year plans have been, put in place. These are so-called medium-term development plans. The first stage was started in 2005 and end in 2009, while the second stage was started in 2010 and end in 2014.[6] Indonesian government has adopted green economy concept in its economic growth and it was materialized in the Medium Term Development Plan and Annual Developmen Plan.[7]

It is submitted that the article analysis how the government of Indonesia copes up with the environmental chalenges in enhancing the economic growth in Indonesia. Firstly, it discuss how the Long Term Development Plan which is carried out step by step throuh the Medium and Short Term Develoment Plan. Secondly, it discusses the environmental challenges in order to enhance economic growth in Indonesia, especially only the second stage of the Medium-term Development Plan (2010-2014) because of the limitation of the article. Finally, it is followed by opportunities to harmonize between protection of the environment and enhancing economic growth in Indonesia.

2. Statement of Problem

Based on the background which is mentioned previously, the questioned is closely examined how does the Indonesian government adresses the environmental

[4] Philippe Sands, Principles of International Environmental Law I Framework, Standards and Implementation, 1995, Manchester University Press, Manchester and New York, at 9.

[5] Federal Department of Economic Affairs, Swiss Economic Cooperation and Development " Indonesia Country Strategy 2013-2016". Retrieved www.seco-cooperation.admin.ch/.../index.html? , 24 April 2015.

[6] Ibid.

[7] Act No 17/ 2007 Regarding the Long Term Development Plan

challenges in enhancing economic growth especially in the second stage of the Medium –Term Development Plan in 2010-2014?

3. Objective of the Research

The objective of the research is to analyze how the government of Indonesia in adressing the environmental challenges to enhance economic growth especially in the second stage of the Medium-Term Development Plan in 2010-2014.

4. Research Method

It is qualitative research. The methodology employed in this article is library-based research. It uses normative approach. While the main reseach materials used in the research are primary and secondary sources. The primary sources concist of Kyoto Protocol, Indonesian Constitution, Act No. 32 /2009, regarding Environmental Protection and Management, Act 25/2004 on the National Development Planning System, Act No 17/2007 on National Long-Term Development Plan, Regulation of the President of Republic Indonesia, No. 5 /2010 regarding the National Medium Term- Development Plan 2010-1014. While the secondary sources consist of books, Journal, report and internet which are relevant to the subject matter.

5. Results/Findings

Based on the research that has been conducted regarding the environmental chalenges and economic growth in Indonesia in the second stage of Medium Term Development Plan in the Year of 2010 -2014, there are some results that can be presented based on the analysis that has been determined in the objective of the research.

5.1 Environmental Challenges and Economic Growth in Indonesia

The implementation of development in the period of 2010-2014 has produced encouraging results, but it still leaves works ahead. There are many environmental problems which are faced by the Indonesian government as the impacts of economic growth. Indeed, there are many regulations in Indonesia to regulate environmental Protection, such as Act No 32/ 2009 regarding the Protection and Management of Environment. However, the law enforcement is still weak and the government policy regarding the environmental protection has not carried out properly. The global population will continue to increase, all the natural recources will become increasingly more scarce and valuable, thus it is necessary to be managed in sustainable manner.[8]

The Indonesian government has already determined the vision and mission of Long Term Development Pland and the Medium Term Development Plan. The vision of Medium and Term Development Plan is to materialize prosperity, democratic and justice , while the mission is to continue development in order to achieve prosperity in Indonesia, strengthen democratic pillars and srengthen justice in every aspect of development.[9] Based on the vision and mission, the government of Indonesia

[8] Appendices Regulation of the President of the Republic of Indonesia No. 5/2010 Regarding the National Term Development Plan 2010, at 1.
[9] Ibid.

determines the strategy and target that were achived in 2010-2014. Based on vision and mission of Medium Term Development Plan, the economic growth in Indonesia is based on "green economic".[10] However, in the year of 2010-2014 there are many environmental chalenges that are faced by the Indonesian government how to materialize green economic growth in Indonesia.

It cannot be ignored that economic growth is a triggiring factor of environmental degradation if it ignores protection of the environment. According to Carol. J.Miller, the tension that exists between the contending goals of environmental protection and economic growth accelerates from the following three sources: (i) different valuations of environmental priorities between states; (ii) the extraterritorial nature of measures designed to remedy them; and (iii) the perceived incompatibility of free-trade goals and trade measures directed at the environment.[11] In the context of economic growth and protection of environment in Indonesia, it can be submited that Indonesia government actually has already put environmental protection as one of the elements that to be integrated in the economic growth.

5.1.1 Environmental Challenges in Indonesia in the National Medium Term Development Plan (2010-2014)

Economic growth that has been achieved by the Indonesian government is reflected in the National Medium-Term Development Plan (hereinafter RPJMN 2010-2014). Based on the result of RPJM demonstrated that economic growth in Indonesia increased significantly. Indonesia as one of the most biologically rich countries in the world with abundant natural resources. Because of the escalating economic and social pressure post economic crisis in the late 1990s caused the government to intensify natural resource extraction for short-term economic gains. Though the rate has declined in recent years, Indonesia still experiences one of the highest rates of tropical forest loss worldwide. The carbon intensive economic growth continues today with increases in energy demands without concurrent increases in production or system capacity. The impacts of over exploitation of the natural resources are disproportionately felt by the poor whose livelihoods are directly tied to the quality and productivity of natural resources, are often located in high-risk disaster areas and cannot afford mitigation strategies to cope with degradation.

Rapid growth of Indonesia's industrial sector to support economic and trade activities has serious worldwide environmental implications. Increased exploitation of natural resources including high consumption of water and accelerated forest conversion, increased generation of energy and deterioration of other resources, as well as increased levels of pollution, are examples of environmental problems happening worldwide.The international community is

[10] Bambang PS Brojonegoro, "Accelerating Green Economy Transition Through Greening the RPJMN", Retrived http://apgreenjobs.ilo.org/resources/accelerating-green-economy-transition-through-greening-the-rpjmn, 24 April 2015.

[11] Carol J. Miller and Jennifer L. Croston, "WTO Srutiny Environmental Objectives: Assessment of International Dolphin Conservation Program act ", (Fall, 1999), *American Business Law Journal*, Vol. 37, at 78.

making efforts to take concrete actions to protect the environment, mitigate the negative impacts of increased trade and promote the positive impacts.[12]

There are many environmetal chalenges in the process of economic growth in Indonesia, in the year of 2010-2014, some of them are: **First,**deforestation is thus a critical problemin Indonesia. The primary causes of deforestation include (i) illegallogging, (ii) conversion for agriculture, (iii) forest fires, and (iv) mining. Large-scale landconversion was the biggest single cause of the 1997/1998 forest fires that destroyed nearly 5 million ha of forest. Much of the land conversion has been related to increases in palm oil plantations. **Second**, loss of coastal resources. Indonesia is home to the most extensive and biologically diverse mangrove forests (42 species) and sea grass beds (13 species) in theregion, 18% of the world's coral reef, and 60% of the world's coral species. Coastal resources are being endangered because of inland activities that have increased the discharge of sediments onto the reefs; pollution from agricultural and industrial activities; damaging harvesting practices; and conversion of mangrove forests into fish/shrimp ponds, housing, and industrial use. **Third,** Urban waste management**.** Water quality degradation from industrial sources and urban settlements continues to be a problem. Solid waste from households and commercial operations suffers from poor collection and disposal solutions. Urban air pollution is an issue in major metropolitan cities, especially Jakarta. **Fourth**, Environment and natural resource institutions and capacity**.** Since 2000, Indonesia has devolved many environment and natural resource management authorities to 495 districts and municipalities and 33 provinces, each with their own institutions. This devolution of authority has left ministries at the national level with largely a role in developing national policies; preparing technical guidelines and standards (norms, standards, procedures, and criteria); and supervising implementation at the local level..[13]

5.1.2 Economic Growth in Indonesai in the National Medium Term Development Plan

Indonesian people are steadfast to strategically step forward in the 2010-2014 period to jointly overcome the problems and face challenges in order to utilize all of the existing potentials and opportunities. All these are endeavored by the people of Indonesia for attaining their ideal goals, namely (i) to realize public welfare through economic development that is based on its competitive advantage, its natural resources, its human resources and national culture, which is fully supported by the mastery of science and technology, (ii) to realize a society, nation and state that is democratic, civilized, dignified, and upholds the responsibility of freedom and basic human rights, and (iii) to realize development that is just and equitable, that is carried out actively by all, and which results can be benefit by all the Indonesian people.[14]

[12] UNEP, "Sustainable Use of Natural Resources in the Context of Trade Liberalization and Export Growth in Indonesia : A Study on the Use of Economic Instruments in the Pulp and Paper Industry". Retrievedhttp://www.unep.ch/etb/publications/indonesia.pdf, 21 April, 2015.

[13]The Appendices Regulation of the President of the Republic of Indonesia No. 5/2010 Regarding the National Term Development Plan 2010, op.cit, 18-19.

[14] The Appendices Regulation of the President of the Republic of Indonesia No. 5/2010 Regarding the National Term Development Plan 2010,*op,cit,* at 4.

Furthermore, according to Bambang as chairman of Fiscal Policy, Ministry of Finance indonesia, economic growth reached 7% in 2014.[15]

However, green economic growth will not occur automatically. A number of challenges must be overcomed in order to realize the sustainable development to reach the objective of sustainable develoment. Indonesia's current economic structure is primarily focused on agriculture and industries which extract and harvest natural resources. There are only limited industries which focus on products with added value. In addition to this, there is a development gap between western and eastern parts of Indonesia. Another challenge for a huge archipelago such as Indonesia is the provision of infrastructure to support economic activities. Infrastructure itself has a very broad spectrum. Connectivity between regions should be developed to accelerate and expand economic development. [16]

According to the second stage of Medium Term Development Plan (2010-2014), the challenges faced by national development were not easy. In the midst of global competition, there are a number of challenges that have to be faced in the efforts to realize an Indonesian society that is prosperous, such as : **First**, the desired economic growth should involve the largest possible number of Indonesia's population (inclusive growth). This is for accelerating the reduction of the population living below the poverty line and for strengthening the capacity of households to be resilient in facing shocks. The reduction of poverty cannot fully rely on economic growth, but also requires various effective intervention measures. Inclusive growth requires appropriate government intervention measures that affirmatively benefit marginalized groups. This is in order to ensure that all community groups have adequate capacity and equal access to emerging economic opportunities. **Second**, in order to reduce inter-regional gaps, it is necessary that economic growth is spread-out in all regions of Indonesia, especially in regions that still have relatively high poverty rates. Growth in all regions must take into account the linkages of local participants and resources, so that more community members can become involved and benefit from the yields of economic growth and from the added value-in these regions. **Third**, in order to reduce the gap among business participants, it is necessary that economic growth provides the widest possible job opportunities and that it is evenly spread within the development sectors to create large work opportunities. It is expected that through investment, economic growth could create a large number of employment opportunities. It is also to be expected that micro, small, and medium scale enterprises can grow and develop for further productivity and stronger competitiveness. The expected higher economic growth can be realized if workers are equipped with the skills, competence, and the ability to work and be prepared to face global competition in the labor market. **Fourth,** economic growth must not damage the natural environment. Environmental damage will lead to unsustainable economic growth. Ineffective management of natural resources will result in the rapid depletion of resources and could easily lead to the recurrence of a food and energy crisis, as occurred in 2007-2008. Degradation of the natural environment will result in the increase in the cost of living and a reduction of the quality of life. Environmental

[15] Bambang Bojonegoro, "Accelerating Green Economy Transition Through Greening The RPJMN", Retrieved from http://apgreenjobs.ilo.org/resources/accelerating-green-economy-transition-through-greening-the-rpjmn

[16] Ibid.

aspects become more widely associated with climate change issues which are strongly linked with degradation of the natural environment and with not environmentally friendly activities. Climate change threats do not only relate to the potential occurrence of unpredictable calamities, like natural disasters, but also threaten the productivity of natural resources. If this happens, then the food crises could recur again.[17]

5.2 Opportunities to Solve the Environmental Challenges and to Enhance Economic Growth in Indonesia in the Year of 2010-2014

The 2010-2014 National Medium-Term Development Plan (RPJMN 2010-2014) is the second phase of implementation of the 2005-2025 National Long-Term Development Plan (RPJPN 2005-2025) promulgated through Law 17/2007. The RPJMN 2010-2014 forms the basis for ministries and government agencies in formulating their respective Strategic Plans (Renstra-KL).[18] Regional governments must also take into account the RPJMN 2010-2014 when formulating or adjusting their respective regional development plans to reach national development targets. For the implementation of the 2005-2025 National Long-Term Development Plan, the RPJMN is to be further elaborated into the Annual Government Work Plan (RKP) that will then become the basis for formulating the Draft Government Budget (RAPBN). Therefore, the RPJMN 2010-2014 is the guideline that central and regional governments, society, and the business community should follow in order to achieve the goals of the nation contained in the Preamble of the 1945 Constitution of the Republic of Indonesia.

5.2.1 Opportunities to Solve Environmental Challenges in Indonesia

Indonesia has an abundance of natural resources, its strategic geographical situation, its ideal demographic structure, its diverse and strong cultural resources, and its human resources contribute to an infinite potential and creativity. Indonesia has succeeded in transforming crises and challenges into opportunities. Regarding energy, Indonesia has various sources, including crude oil, natural gas, coal, and an abundance of renewable energy sources, such as geothermal and hydro power. Based on the environmental challenges that presented previously, there are some opportunities that can be done by Indonesian government to achieve the objective of sustainable development, as followed :

First, there are many changing of the government policy regarding the protection of environment in Indonesia. Each Ministry has its own vision and mission to materialize into programme and activities based on the vision and mission in the Long Term Development Plan and the Medium Term Development Plan. Thus all the programme and activities shall be implemented in accordance with the objective of the development.

Second, the opportunity to maintain protection of the environment are carried out by various institution in Indondesia that has been mandated in the Long Term Development Plan. For Example, there are many programmes that have been made by

[17] The Appendices Regulation of the President of the Republic of Indonesia No. 5/2010 Regarding the National Term Development Plan 2010 *op.cit,* at 18-19

[18] Id. at 1.

the Ministry of Environment how to achive sustainable development. The Ministry of environment use economic instruments how to encourage companies to participate in the protection of environment, such as Indonesia's Program for Pollution Control, Evaluation, and Rating (PROPER) is a national-level public environmental reporting initiative.[19]

Third, all the objectives to protect the environment and sustainable use of natural resources carried out by numerous Ministry in Indonesia, such as the ministry of Industry, Ministry of Economic Affairs, ESDM, Ministry of Planning and Development (BAPENAS) has already designed the green growth programme[20] that has to be coordinated by each Ministry and they also have their priority programme to materialise green growth.

Fourth, the opportunities to materialize green growth to achieve sustainable development, the Indonesian government adopted many regulations to regulate this matter, in order to provide clear legal basis to enforce the law. This also conforms with one of the values and principles of the United Nations Millennium Declaration, namely rrespect for nature.[21]

Fifth, Indonesia also contributes to mitigate and to adapt the climate change as one of the opportunity to obtain financial support to mitigate and to adapt the climate change, since Indonesia as the Member of the Kyoto Protocol. Indonesia is endowed with rich biodiversity and natural resources, which to a large extent has constituted the basis for the past decades of macro-economic growth. However, these natural resources have not been managed in a sustainable or equitable manner, which has led to over-exploitation and depletion.[22] As the Party of Kyoto Protocol Indonesian government has the right to use the mechanism which are provided by the protocol such as Clean Development Mechanism.[23] .

5.2.2 Opportunities of Economic Growth in Indonesia

In order for Indonesia to accelerate its economic development, Indonesia will need to embrace a new way of thinking, a new way of working, and a new way of conducting business. Regulations at the central and regional level need to be streamlined to ease

[19] Parameeta Kanungo and Magüi Moreno," Indonesia's Program for Pollution Control, Evaluation, and Rating (Proper), Retrieved from http://siteresources.worldbank.org/INTEMPOWERMENT/Resources/14825_Indonesia_Proper-web.pdf, 27 April 2015.

[20]Secretary Ministry of Planning and Development and Global Green Growth Institute, "Green Growth Program 2013-2014". Retrieved from http://www.greengrowthknowledge.org/sites/default/files/4D_Bappenas.pdf, 24 April 2015.

[21] Article 6 of the United Nations Millennium Declaration.

[22]. Departement of Economic, University of Gothenburg, " Indonesia Environmental and Climate Change Policy Brief". Retrieved from http://sidaenvironmenthelpdesk.se/wordpress3/wp-content/uploads/2013/04/Environmental-policy-brief-Indonesia-2008.pdf, 24 April 2015.

[23] Article 12 (2) of the Kyoto Protocol stipulates that the purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

doing business.Based on the economic achievement that has been demonstated previously, there are some opportunities that can be obtained to enhance green growth in Indonesia, such as :

First, The implementation of the new way of thinking in the economic development, needs collaborative efforts among government, local governments, state owned enterprices, private enterprises and the people. The government has very limited funds to finance development through its State Budget (APBN).

Second, in order to enhance green economic growth, all economic activitoes have to integrated with the environmental protection and the need of the private sector participation. Thus, to foster the economic growth in Indonesia, it will depend on the private sector participation which includes state-owned enterprises, and private domestic and foreign investors. Government policy must be streamlined to allow a bigger participation from private sector.[24]

Third, all the regulation which are still overlape have to be amended to protect the interest all stakeholders who involved in the economic activities. Regulations must be clear, and without possibilities for mis-interpretation, in order to encourage trust and maximum participation from investors to build much needed industries and infrastructure. Furthermore all existing regulatory frameworks must be evaluated, and strategic steps must be taken to revise and change regulations.

Fourth, Indonesia has alredy determined the Masterplan for Acceleration and Expansion of Indonesia Economic Development (MP3EI) as a directive for Indonesia's economic development up to the year 2025, since Indonesia has an abundance of renewable (agricultural products) and un-renewable (mining and minerals) natural resources. It must be able to optimize the handling of its natural resources by increasing a processing industry that will provide high added value, while at the same time reducing exports of raw materials.

Fifth, Population and human resources, in 2010, Indonesia ranks the 4th most populous country in the world. Its huge population and the rapidlyincreasing buying power of its population is creating a significant market. Moreover, the population is also increasing in the quality of its human resources, thus providing a desirable competitive edge.

Sixth, Geographical location Indonesia is the world's largest archipelago, stretching from east to west with a length of 5,200 km and a width of 1,870 km. Indonesia has a direct access to the world's largest market since it is passed by one of the most active Sea Lane of Communication (SLOC), i.e. The Malaccan Strait. This route is the prime route for global container shippings.[25]

[24] Jessie Goff , " Future of Indonesia". Retrieved from http://pardee.du.edu/sites/default/files/The%20Future%20of%20Indonesia.pdf. 24 April 2015.

[25] Coordinating Ministry for Economic Affairs, "Master Plan Acceleration and Expansion of Indonesia Economic Development 2011-2025". Retrieved from http://www.kemlu.go.id/rome/Documents/MP3EI_PDF.pdf. 24 April 2015.

6. Conclusion

Economic Growth is always accompanied by environmental chalenges. In Indonesia context, the Indonesian economic growth enhances significantly during the second stage of the Medium Term Development Plan. The economic growth can be proven from the incresing of GDP for 7% in the end of 2014. Indonesia as the Party of the Kyoto Protocol has obligation to reduce emission. Consequently, the green growth concept has been integrated in the vision and mission of the long Term development Plan and it is elaborated in the Medium Term Development Plan Year 2010-2014. Indonesia still in the process of achieving the objective of the Long Term Development Plan and the Medium Term Development Plan. The Environmental chalenges that are faced by the Indonesian government are solved by various policies, strategies and programmes which are materialized in the Ministry level and also in the Provincial and Distric level. Furthermore, the Indonesian government also establishes Master Plan for Acceleration and Expansion of Indonesia Economic Development 2011-2025 which also includes the environmental protection in the Master Plan. Thus, it can be concluded that environmental challenges in Indonesia can be turned into opportunities to enhace economic growth.

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Carol J. Miller and Jennifer L. Croston, (Fall, 1999),"WTO Srutiny Environmental Objectives: Assessment of International Dolphin Conservation Program act ", *American Business Law Journal*, Vol. 37.

Christina Voigt, *Sustainable Development as Principle of International Law,* 2009, Leiden-Boston, Martinus Nijhoff Publishers.

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International Instruments

Kyoto Protocol
Stockholm Declaration
United Nations Millennium Declaration

National Regulations

The 1945 Constitution of Republic Indonesia.
Act 25/2004 on the National Development Planning System.
Act No 17/2007 on National Long-Term Development Plan.
Act No 17/ 2007 Regarding the Long Term Development Plan.
Act No. 32/2009 Regarding Environmental Protection and Management.
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Greenhouse Gas Emissions of Robusta Coffee Plantation in Thailand

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Abstract
Robusta coffee is one of main industrial crops in Thailand. Most of robusta coffee beans are used as raw materials for instant coffee products. The greenhouse gas (GHG) emissions of robusta coffee product from acquisition of coffee cherries are necessary data to assess the carbon footprint of robusta coffee products. This paper studied GHG emissions and identified the hotspots of robusta coffee plantation in Thailand. The 180 datasets were collected by questionnaires and field surveys in Chumphon province, the largest robusta coffee planting area in Thailand, in the year 2014. The functional unit of analysis was 1 kg of robusta fresh coffee cherry. The scope of the study included land preparation, cultivation and harvest. The amount of GHG emissions in a unit of kgCO_2e/kg of fresh coffee cherry was calculated by following the guidelines of carbon footprint of the product method provided from Thailand Greenhouse gas management organization (public organization) and emission factors were referred from national life cycle inventory and IPCC databases. The results showed that the GHG emissions from small (0.16-1.60 ha), medium (1.61-3.20 ha), and large planting area (more than 3.20 ha) were 1.19, 1.25 and 1.11 kgCO_2e/kg of fresh coffee cherry, respectively. The weighted average of GHG emissions was 1.20 kgCO_2e/kg of fresh coffee cherry. The largest GHG emissions was from fertilizers (96%), followed by herbicides (1%), organic fertilizer (2%) and fossil fuel consumed in agricultural machines (1%).

Keywords:Robusta coffee, coffee cherry, plantation, greenhouse gas emissions, Thailand

1.Introduction

In Thailand, the coffee industry has grown rapidly due to high demand markets. It was reported that the revenues from coffee products in Thailand was up to 2,500 million baht in 2008 with total productivity of 50,442 tonnes [1]. 95 % of coffee products are from robusta coffee, which is commonly grown in the south of Thailand, especially in Chumphon and Ranong Province. However, in the past few years, coffee products from Thailand lost their competitive export because coffee products from Vietnam and Indonesia have lower production cost and to be sold in lower price [2]. Accordingly, the Department of Agriculture has drafted a strategic plan focused on the development of the coffee industry during the year 2014-2017 [2]. The ultimate gold of this strategy is to increase the export values from coffee products by encouraging coffee farmers to improve coffee productivity and reducing production cost and environmental impacts through the whole production chains [2]. The first step to follow the strategic plans is identifying the hotspots of resource consumption and environmental impacts from coffee cultivation. This research aims to study the inventory of resources used and estimate greenhouse gas (GHGs) emissions from robusta coffee cultivation. The outcome of this study will be preliminary information supporting the development of coffee industry in Thailand.

2. Methods

2.1 Data collection

The primary data collection was conducted in Chumphon province, located in the south of Thailand which is the largest robusta coffee planting area in Thailand. The size of the sample of the population in the study was calculated by Taro Yamane's method as shown in Eq.1 [3]. The 180 datasets were obtained by questionnaires and field surveys. The questionnaires were designed for collecting all necessary data for assessment of GHG emissions. In this study, the area of robusta coffee cultivation was 518.08 ha, which can be divided into 3 sizes such as a small farm (0.16-1.60 ha), a medium farm (1.61-3.20 ha) and a large farm (more than 3.20 ha).

$$n = \frac{N}{1 + Ne^2}$$

n = sample size required.
N = population size
e = sampling error can be accepted.

(Eq.1)

The numbers of datasets divided by plantation area are presented in table 1.

Table 1 Number of datasets divided by plantation area

Small plantation area (0.16-1.60 ha)	Medium plantation area (0.16-1.60 ha)	Large plantation area (0.16-1.60 ha)
42 datasets	92 datasets	46 datasets

2.2. Calculation of carbon footprints

In this study, Life Cycle Assessment of the product (LCA) is used as a tool to calculate GHG emission from robusta coffee cultivation. The scope of this study is shown in Fig. 1. The process starts from land preparation, cultivation, maintenance and harvest. The inventory of raw materials, resources, energy, wastes during cultivation process was constructed, based on a functional unit of 1 kg fresh robusta coffee cherry as presented in Table 2. The activity data were then converted to GHG emissions by following the guidelines of carbon footprint of the product method provided from Thailand Greenhouse gas management organization (public organization) and emission factors were referred from national life cycle inventory [4] and IPCC databases [5].

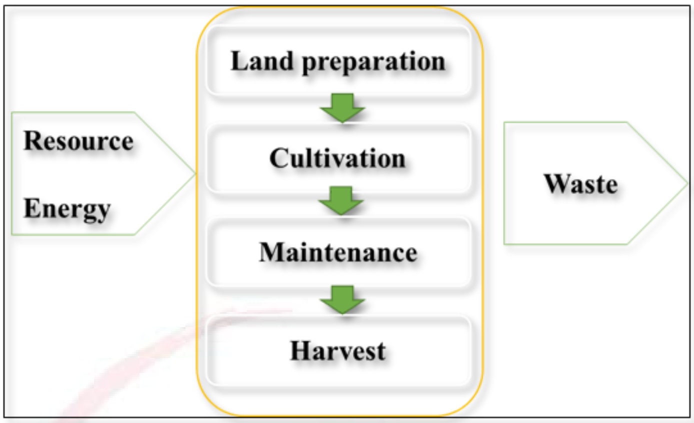

Figure 1 Scope of this study

Table 2 Inventory of data collection in this study

Process	Unit	Activity data	data collection
Land preparation	kg	No machinery, herbicides and fertilizers used.	questionnaires and field surveys
Cultivation	kg	▪ organic fertilizer	questionnaires and field surveys
Maintenance	kg L L kg	▪ chemical fertilizer ▪ gasoline ▪ diesel ▪ herbicide	questionnaires and field surveys
Harvest	kg	No machinery used.	questionnaires and field surveys

GHG emission was calculated by the guidelines of carbon footprint of the product method provided from Thailand Greenhouse gas management organization (Eq.2)

$$\text{GHG Emission (kg } CO_2) = \sum \left[\text{Activity data (unit)} \times \text{EF (kg } CO_2\text{/unit)} \right] \quad \text{(Eq.2)}$$

Emission factors used in this study was shown in Table 3.

Table 3 Emission factors used in this study

Activity data	Unit	Emission factors (kgCO_2eq/unit)	References
Organic fertilizer	kg	0.3320	[5]
Chemical fertilizers ▪ 15-15-15 ▪ 13-13-21 ▪ 16-0-0	 kg kg kg	 1.5083 3.6737 1.3470	 [6] [6] [6]
Gasoline	kg	0.7069	[6]
Diesel	kg	0.3282	[6]
Herbicide	L	10.2000	[5]

3. Results

3.1 GHG emissions from small plantation area (0.16-1.60 ha)
The average GHG emissions of robusta coffee cultivation in small coffee farms are shown in Fig 2. Total GHG emission was 1.19 kg of CO_2e per kg of coffee cherry. The largest GHG emission was mainly contributed by chemical fertilizers, 96 percent of all GHG emissions, followed by organic fertilizer, 3.13 percent of all GHG emissions.

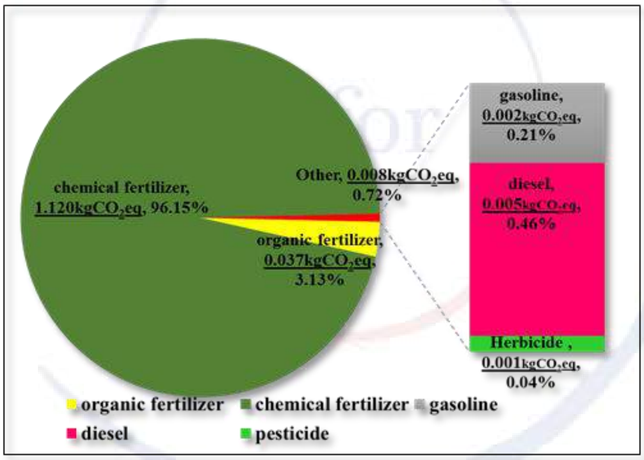

Figure 2. GHG emissions from small coffee farm

3.2 GHG emissions from medium plantation area (1.61-3.20 ha)
The average GHG emissions of robusta coffee cultivation in medium coffee farms are shown in Fig 3. Total GHG emission was 1.25 kg of CO_2e per kg of coffee cherry. Similar to GHG emission from small coffee farm, the largest share of GHG emission was from chemical fertilizers, 97 % of all GHG emissions, followed by organic fertilizer, 2.58 % of all GHG emissions.

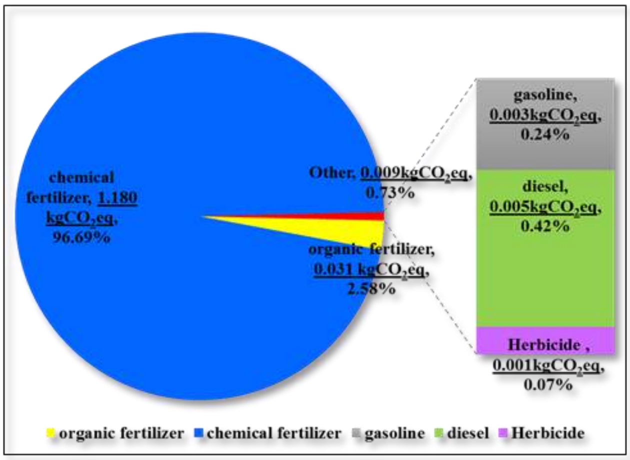

Figure 3. GHG emissions from medium coffee farm

3.3 GHG emissions from large plantation area (more than 3.20 ha)

The average GHG emissions of robusta coffee cultivation in large coffee farms are shown in Fig 4. Total GHG emission was 1.11 kg of CO_2e per kg of coffee cherry. Chemical fertilizer is also the main hotspots of GHG emission, accounted for 96%, followed by organic fertilizer, 3.16 percent of all GHG emissions.

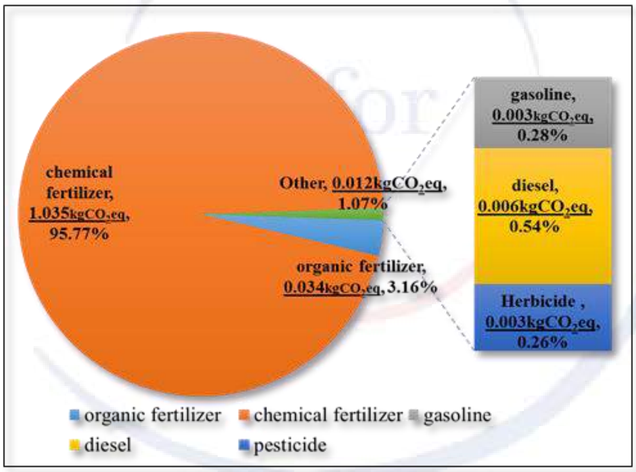

Figure 4. GHG emissions from large coffee farms

The average of GHG emission from robusta coffee cultivation based on number of samples is 1.20 kg of CO_2e per kg of coffee cherry. Among all sizes of coffee planting areas, the lowest GHG emission was from large coffee farms, followed by small and medium coffee farms, respectively. This might because the process of applying fertilizers in large farms has better economies of scale than small and medium farms. Similar to all planting area, chemical fertilizer is the major source of GHG emission from robusta coffee cultivation. This is because the chemical fertilizers that coffee farmers usually apply to soil are formula 15-15-15, 13-13-21 and 46-0-0, which has high content of nitrogen. Nitrogen in soil can be oxidized to nitrous oxide (N_2O), an important GHG with the Global warming potential (GWP) of 310 [7]. Accordingly, GHG reduction measure from robusta coffee cultivation should be paid attention on the optimal fertilizer application such as use low nitrogen chemical fertilizer and reduce chemical fertilizer uses by improving soil property.

4. Conclusion

The average of GHG emission from robusta coffee cultivation based on number of samples is 1.20 kg of CO_2e per kg of coffee cherry. The robusta coffee cultivation in medium farm emits the highest GHG emission while, that in large farm emits the lowest GHG emission. The hotspot of GHG emission is chemical fertilizer application. The optimal fertilizer application and soil management are recommended measures to reduce GHG emission from robusta coffee cultivation in Thailand.

5. Acknowledgement

The authors would like to thank the Division of Environmental Technology, School of Energy, Environment and Materials (SEEM), King Mongkut's University of Technology Thonburi, (KMUTT), National Research Council of Thailand (NRCT) for financial supports. The authors also would like to thank Chumphon Horticultural Research Centre for their kind collaboration.

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Game Analysis on Promotion Stakeholders of Low-Carbon Building

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Abstract
Recently, the climate change has become a globe issue influencing human survival and development and all countries have taken steps to reduce carbon emissions to address climate change. Low carbon building is one of the effective methods to deal with climate change. However the low carbon building market is developing slowly. Thus, it is necessary to analyze the factors influencing the market promotion. Promotion of low carbon building market concerns about stakeholders including the government, developers and consumers. Considering their interest, a game analysis is done between the developer and consumer under the background of policy support. And the price of low carbon building is calculated which meets the interest of both sides. Results show that consumer dominates the promotion of low carbon building because the developer's decision relies on prediction about whether a consumer prefers to buy a low carbon or an ordinary building. Besides, higher government grants lead to more profits for developers and a lower incremental price for consumers.

Key words：low carbon building; promotion; stakeholders; game analysis

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Introduction

Nowadays, climate change has imposed remarkable problems and significant risks worldwide. The climate change issue affects the basic elements of people's lives, such as water, health, and safety. The Kyoto Protocol 1995 sets a challenging target of reducing carbon emission by 60% by 2050 with real progress by 2020. While China has also set the goal to decrease carbon emission by 40%-45% by 2020[1]. According to the IPCC's report, building construction, operation and maintenance together account for 40 percent energy sources and lead to 36 percent of energy-related carbon emissions[2]. Thus, it is significant to promote the development of low carbon buildings, especially for its market promotion to control the overall carbon emission. Compared with green building, low carbon building emphasizes on reduction of carbon emission by using low carbon materials, renewable energy and operating efficiently[3].

Low carbon building, as one of the effective methods of dealing with climate change, develops relatively slow. Thus, it is necessary to analyze the promotion factors of low carbon building. This issue involves many aspects, some scholars discuss the defects of the current policy[4], some investigate the feasibility of low carbon building from the perspective of developers[2], some analyze the promoting and restricting factors for low carbon buildings from designers' point of view[5] and some put forward the importance of consumer in low carbon building market and analyze the internal and external factors influencing consumers [6] - [8].

However, these researches mainly consider one subject, which are not sufficient to analyze the comprehensive market. Promotion of low carbon building is a complicated target involving many stakeholders. Thus, it is essential to consider the relationship between different stakeholders.

Recently, the researches on multi-stakeholders have focused on government and developers[9] without considering the consumer. To make the market of low carbon building develop spontaneously instead of guided by the government, it must consider the benefits needed by stakeholders. At present, due to externalities, the low carbon building market promotion still needs the policy intervention. Thus, the paper establishes a game model considering the government, developer and consumer to explore the promotion of low carbon building.

1 Establish the game model

The life cycle of low carbon buildings involves numerous stakeholders, such as government, designer, constructor, material suppliers, developers, operators and consumers, etc. They will cause certain effect for the promotion of low carbon buildings. However, when confining the stakeholders to the ones who have direct and great influence on promotion, it should only take the government, developer and consumer into consideration.

1.1 The government

The government presents the interest of the public, thus will consider the environmental, economic and the social benefits. It cannot be considered as an entirely rational subject. Regarding the development of low carbon building, it has significant benefits. Thus, it assumes that the government supports the development of low carbon building and will provide an incentive policy environment.

1.2 The developer

The developer has two strategies: developing low carbon buildings or ordinary buildings. The influence of developers on low carbon buildings mainly effects by their development decisions. Only when the developers choose to develop low carbon building, can low carbon buildings be traded in the market. Because of the profit-driven, the developers will choose low carbon buildings only when the development of low carbon buildings will provide incremental benefits. Otherwise, they will develop ordinary buildings. The assumptions are as follows:

1) Developer is a completely rational economic party;
2) Developer will act after perceiving the strategies of the government;
3) Developer takes the risk that the consumers do not buy low carbon buildings

1.3 The consumer

The consumer is the subject who buy and use low carbon building. A large portion of the social and economic benefits of low carbon buildings emerge gradually in the operation process and the prerequisite is that customers are willing to buy low carbon buildings. Therefore, consumers also play an important role in low carbon building. The consumer has two strategies: buy low carbon buildings or buy ordinary buildings. The assumptions are as follows:

1) Consumer is a completely rational economic party;
2) Consumer can choose what kind of buildings to buy by them;
3) The incremental price of low carbon buildings charged by developers will affect consumers' decision.

2 Game analyses

Regarding the benefits of low carbon building and the current situation, it can be assumed that the government will support the market promotion and provide subsidy (N) to low carbon building developers. On the premise of government support, the complete information dynamic game model between developer and consumer is as shown in figure 1.

π_{C1} is the benefits for consumer buying low carbon building under the premise when developer builds low carbon buildings.

$\pi_{C1}=n\triangle S-P-\triangle P$ (1)

$\triangle S$——annual incremental economic benefit compared with ordinary buildings in operation period

n——design working life

P——the price for ordinary buildings

P——incremental price for low carbon buildings

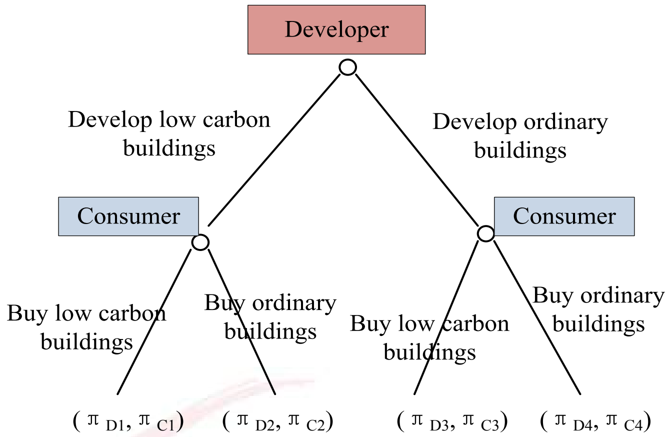

Fig.1 Game model between stakeholders of low carbon building

π_{C2} is the benefit for consumer buying ordinary building under the premise when developer builds low carbon buildings. Considering the large amount of ordinary buildings in the market, the cost the consumer pays to find ordinary ones can be simplified into 0. Thus:

π_{C2}= -P (2)

π_{C3} is the benefits for consumer buying low carbon building under the premise when developer builds ordinary ones. Because that there are a few low carbon buildings in the market, consumer has to pay to find low carbon building and the price is △F.

π_{C3}=n△S-P-△P-△F (3)

π_{C4} is the benefits for consumer buying ordinary building under the premise when developer builds ordinary ones.

π_{C4}= -P (4)

As to the developer, the benefits it can get when it builds low carbon building and consumer chooses to buy it is:

π_{D1}=P+△P+N-C-△C (5)

N——subsidies for low carbon building developers

C——construction cost for ordinary buildings

C——incremental construction cost for low carbon buildings

The benefit the developer can get when it builds low carbon building while the consumer chooses to buy ordinary ones is:

π_{D2}=N (6)

The benefit of the developer when it builds ordinary building while the consumer chooses to low carbon ones is:

π_{D3}=0 (7)

When the developer builds ordinary building and the consumer wants to buy it, the benefit of the developer is:

π_{D4}=P-C (8)

3 Model Solutions

3.1 Simplification

In the actual analysis, searching cost ($\triangle F$) of low carbon buildings is relatively smaller than other indicators ($\triangle S$, P, $\triangle P$). It also has relatively less impact on the game result. To simplify the calculation, $\triangle F$ can be ignored and then $\pi_{C1}=\pi_{C3}=n\triangle S-P-\triangle P$; Developers are profit-seeking, they can passed on the incremental constructing cost $\triangle C$ to consumers by incremental price ($\triangle P$). So the developer will decide to build low carbon building only when they can earn money, which means that $\pi_{D1} > \pi_{D3}=0$

3.2 Calculation

Using backward induction, the sub game refining Nash equilibrium solutions are as follows.

1)When $\pi_{C1} > \pi_{C2}, \pi_{C3} > \pi_{C4}$,which means that the benefit for consumer to buy low carbon building is greater than ordinary one, the refining Nash equilibrium is (develop low carbon building, {buy low carbon building, buy low carbon building}). The result is: $n\triangle S > \triangle P$; $P+\triangle P+N-C-\triangle C > 0$.

2)When $\pi_{C1} < \pi_{C2}, \pi_{C3} < \pi_{C4}$,which means that the benefit for consumer to buy low carbon building is less than ordinary one, if $\pi_{D2} > \pi_{D4}$,the refining Nash equilibrium is (develop low carbon building, {buy ordinary building, buy ordinary building}). The result is: $N > P-C$.

3)When $\pi_{C1} < \pi_{C2}, \pi_{C3} < \pi_{C4}$,if $\pi_{D2} < \pi_{D4}$,the refining Nash equilibrium is(develop ordinary building, {buy ordinary building, buy ordinary building}).The result is: $P-C > N$.

Conclusion and suggestions

Conclusion

1) Whether consumers choose low carbon buildings depends on incremental costs ($\triangle P$) and the expected value of low carbon buildings ($n\triangle S$).Only when $n\triangle S > \triangle P$, will they choose to buy low carbon buildings. Whether developers build low carbon buildings or ordinary ones depends on incremental benefit of low carbon building($\triangle P-\triangle C$), benefit of ordinary building ($P - C$) and the subsidies (N). Because that $P+\triangle P+N-C-\triangle C > 0$, when the developer predicts that the consumers will buy low carbon buildings, they will build low carbon one. While the consumers are predicted to buy ordinary buildings, only when $N > P-C$, will the developer build low carbon building. This means that the government will take the risk that the developer cannot sell out low carbon buildings, which is doubtless a huge burden.

Thus, the consumer dominates the low carbon building market which is in conformity with the market law. The choice of developer depends largely on the consumer. Developers will pass on the incremental building cost ($\triangle P$) to the consumer. When consumers expect the benefit of low carbon building in operation period can offset the incremental cost of buying ($\pi_{C1} > \pi_{C2}$), they will choose low carbon building and drive developers to build low carbon building.

2) In the equilibrium of (Develop low carbon building, {buy low carbon building, buy low carbon building}), the developer and customer both want the maximum benefit which are $\pi_{D1}=P+\Delta P+N-C-\Delta C$;$\pi_{C1}=n\Delta S-P-\Delta P$. However the developer wants the price to be higher while the consumer wants it to be lower. So when $\pi_{D1}=\pi_{C1,}$ the price gets to an agreement, which is $P+\Delta P= (n\Delta S\ N+C+\Delta C)/2$.

3) The government hopes that the equilibrium to be developed into (Develop low carbon building, {buy low carbon building, buy low carbon building}). It requires that $n\Delta S > \Delta P$; $\pi D1 > 0$,thus increasing N can promote the developer and decreasing ΔP can promote the customer

Suggestions

1) Educate the consumer
Low carbon building is dominated by consumers. However, as the difference of education and culture background, consumers have various understanding and expected benefit of low carbon buildings. Consumer’s decision largely depends on their expectations on low carbon building ($n\Delta S$). The government should enhance the publicity of low carbon buildings by network transmission, community lectures, advertising and other ways to show the consumer advantages of low carbon building and its benefits in operating period.

2) Economic incentive on consumer

Consumers' purchase decisions are determined by the incremental cost of the low carbon buildings △P. The government can share the incremental cost paid by consumers in purchase phase. The government can also provide certain economic rewards and other preferential policies to encourage consumers to buy low carbon buildings.

3) The extension of developers functions

The government can extend the functions of developers to operation stage. The developer is responsible for both the building and operating of low carbon buildings and the operation and be realized by proprietary or outsourcing. In this way, the developer only charge consumer the price of ordinary building (P) and the incremental cost (∆C)of low carbon building will be charged in operating period by energy saving. It can stimulate the developer and consumer to save energy in operating period and share the consumer's purchase cost to avoid the short-sighted behavior of consumers.

4) Policy incentives on developer

Recently, the market of low carbon has not been matured enough. So it still needs the government provide policy intervention, such as the reduction or exemption of tax, economic incentives or low carbon building label.

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From E-Waste to Green Energy: Waste as a Critical Material Source for Photovoltaic Technologies: A Case Study for Industrial Symbiosis

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Abstract
The world faces the limits of current 'linear' economic models due to resource security issues, growing population and increasing per-capita consumption. Transition is necessary to a new 'circular economy': a resource-efficient industrial economy which decouples growth from resource consumption. This model mirrors nature with materials moving in cycles and losses from the system minimized. Available resources remain economically productive throughout multiple product cycles. Reuse/recycling, eco-design of products, minimization of environmental impacts and renewable energy generation are prioritized. The concept of 'waste' is replaced with one of 'resource'. Enhanced resource efficiency delivers economic, environmental and social benefits. Process waste is eliminated through industrial symbiosis, becoming feedstock of other processes.

A major obstacle to transition is a lack of familiarity with the economic opportunities within circular economy. However, waste electrical and electronic equipment (WEEE), the planet's fastest growing waste stream, is a valuable source of materials including precious and 'critical' metals. Appropriate recycling technology can directly generate 'added value' precursor compounds for use in manufacturing, allowing additional value to be derived from WEEE over that possible through traditional recycling chains. The potential for recovery of platinum from waste thermocouples as chloroplatinic acid for use in dye-sensitized solar cells (DSCs) has been examined, and shown to potentially increase derivable value of platinum by a factor of five. This 'closed loop' strategy reduces environmental impacts of recycling and DSC fabrication, while generating revenue from wastes and reducing manufacturing costs for DSCs. This simultaneously solves a waste management issue and mitigates materials criticality issues.

Keywords: platinum, recycling, materials recovery, hexachloroplatinic acid, circular economy, industrial symbiosis, sustainable development, thermocouple, dye-sensitized solar cell (DSC).

Introduction

Sustainability has become a key issue in all aspects of society today. The quest for sustainable development i.e. "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al., 1987) has become one of humanity's primary concerns, and for good reason. Consider Figure 1 which plots the position of the world's nations in 2007 on the basis of two indicators: the human development index (HDI) and the ecological footprint per person. Each nation's position on the HDI axis is a measure of its citizens' standard of living, with the vertical blue line indicating the UNDP threshold for human development, above which citizens are considered to be 'living well'. The dashed horizontal lines represent the Earth's average biocapacity per person, which has decreased as global populations have risen. In order to achieve sustainability, countries must transition into the green region of the graph in which citizens will be living well, within the limits of our planet. In 2007 no country held this position.

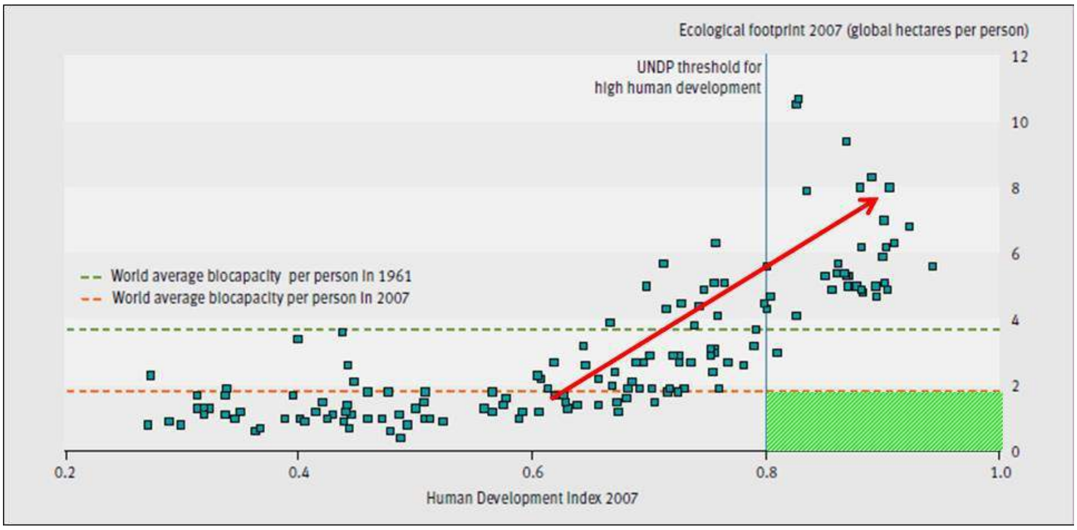

Figure 1: Human Development Index vs Ecological Footprint of the World's Nations in 2007. Taken from (UNEP, 2012). GEO_5 Global Environmental Outlook – Environment for the Future We Want.

As countries develop economically, they move according to the trend indicated by the red arrow. The standard of living of citizens rises along with their ecological footprint. This has resulted in all nations above the UNDP threshold surpassing the planet's ability to sustain their citizens. One of the major contributing factors to this trend is that, since the dawn of the industrial revolution, mankind has pursued an unsustainable 'linear' economic model in which economic growth is strongly coupled to the consumption of the Earth's finite resources. In this 'linear' model, resources are extracted from the earth and refined before being fabricated into components and products which are used by consumers for a limited time before being disposed of as waste. We are rapidly approaching the limits of this model, with every waste item being discarded requiring new primary resources to be extracted and converted into replacement products at considerable cost to the environment.

The accelerated consumption of natural resources, particularly those 'technology metals' which are used in electrical and electronic equipment (EEE) including consumer electronics and renewable energy technologies (e.g. Ta capacitors, In for LCD displays, Nd and Dy magnets) has led to widespread global concerns over resource security (Buchert, Schuler, & Bleher, 2008; Chancerel et al., 2013) and prompted a trend in resource criticality assessments in which raw materials are assessed in terms of their risk to supply and the economic significance of supply shortage (Harfield, Harris, & Sanders, 2014). Those materials that have high combined risk of shortage and associated economic impact are deemed to be 'critical'. Resource criticality is a key issue for the EU which imports 85 % of the raw materials it consumes, and the EU Raw Materials Initiative has been created to manage the response to resource criticality at the EU level. As part of this process an EU specific list of critical raw materials has been produced and is updated periodically (EC, 2010, 2014a).

Circular Economy

A new resource efficient economic system is required which decouples economic growth from natural resource use, thereby enabling less developed nations to develop and improve living standard for their citizens whilst maintaining sufficiently low ecological footprints, and enable developed nations to achieve economic growth whilst simultaneously maintaining standards of living and reducing the ecological footprints of their citizens. This would allow all nations to transition to a state in which all citizens are 'living well' within the planet's limits. One such model is that of circular economy which mirrors nature by keeping resources in use for as long as possible and cycling materials through recovery and regeneration of products/materials at the end of each service life (Ellen MacArthur Foundation, 2013). Examining the case for materials used in a PC (Figure 2) and processes through which resource productivity is maximized; primary resources are extracted and refined before fabrication into products (PCs) which would be designed for easy maintenance and upgrade by users in order to extend the useful life of the item for as long as possible. Also rather than selling PCs to users, it will be common to lease items to users for collection and take back at the end of the use phase of their life cycle. Following take-back, PCs could be redistributed to new users directly for reuse or when the condition of the item is such that direct reuse is not practical, they would be sent for refurbishment/remanufacturing before being sent back through service providers to users for another useful life. Eventually PCs will be damaged beyond the point of repair, or become too out of date to be upgraded to a useful state. At this point only, would they be sent for recycling. At this stage, any components of the PC which are suitable for reuse would be isolated and utilized in refurbishment, upgrade or manufacturing operations. Those components which no longer have utility value will be sent for recycling, unlocking valuable resources for use in manufacturing new products and components, and offsetting demand for virgin materials from primary resources. Leakage of materials from the system through energy from waste (EfW) processes or landfill is minimized. Other features of circular economy include the use of renewable energy, replacement of the concept of waste with that of resources, thinking in systems, and eco-design of products to facilitate effective reuse, repair, upgrade and recycling. By retaining materials within the center of the 'circle' their economic productivity is maximized and economic growth is decoupled from primary resource consumption.

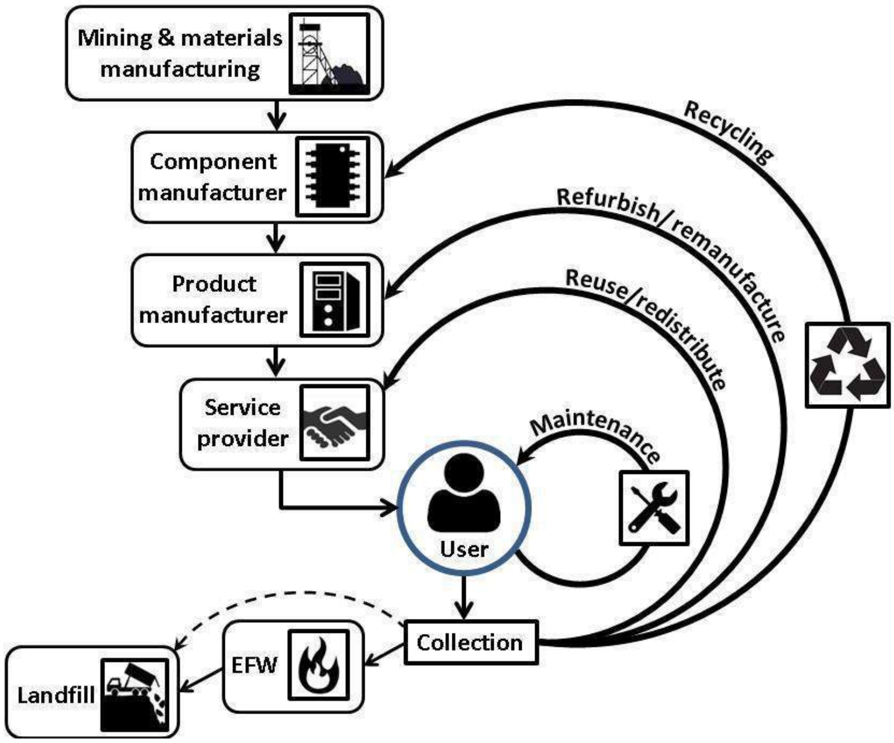

Figure 2: Material flows in a circular economy for personal computers. Adapted from (Ellen MacArthur Foundation, 2013).

This resource efficient system is synergistic with the three pillars of sustainability i.e. Environment, Economic and Social (Bunting, Huxtable, & Clement, 2006). Resulting reductions in landfill, rate of ore and fossil fuel extraction and emissions to the environment will give an increase in environmental quality (Bigum, Brogaard, & Christensen, 2012). Materials cost savings will positively affect revenues of organizations and additional economic opportunities will be created for those able to assist others to improve resource efficiency. It is thought that adoption of circular supply chains could generate over US$ 1 trillion for the global economy by 2025 (Ellen MacArthur Foundation, 2014). Such a system will also enhance quality of life for citizens by generating more value from less, and creating a better appreciation of the value of resources. The EU considers transition to circular economy as crucial to: its sustained economic growth, as a means of mitigating resource criticality issues, slowing the rate of climate change, and achieving a high standard of living for its citizens whilst remaining within the limit of the planet’s ability to sustain us.

Developing secondary supplies of raw materials is crucial for a functioning circular economy. Figure 3 highlights elements which have been reported as critical in recent assessments. Current recycling rates for these elements are generally poor, with many technology metals currently recovered at a rate of <1% from end-of-life materials. The reason for this is that many of these elements are utilized in trace amounts which are mixed thoroughly with other materials. This makes separation difficult and recovery is often uneconomic due to the small amounts of metals involved and the cost of separation. Additionally, metals are lost in recovery processes which preferentially target more valuable materials with which they are combined. Metals used in trace amounts with high economic value such as precious metals and the platinum group metals (PGMs) have improved rates of recycling driven by their economic value, yet recycling rates for such metals are at best ~60% (Reck & Graedel, 2012). Recovery of these metals results in significant environmental savings due to the high ecological impacts associated with their primary production (StEP, 2009). However, despite the high value of precious metals and PGMs, and high recycling rates from bullion and jewellery, recovery rates from other applications remain low.

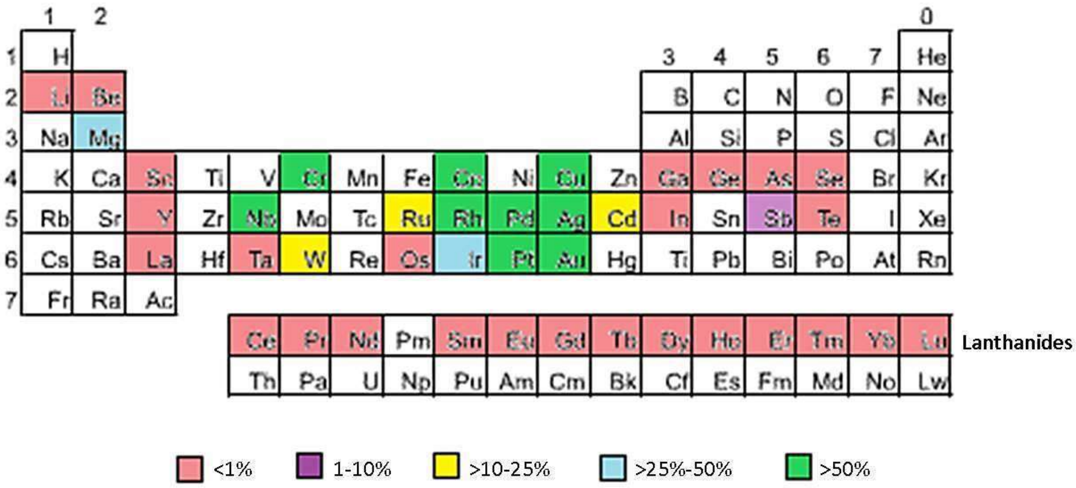

Figure 3: Metals highlighted as critical in recent assessments and their end-of-life recycling rates. Data from (EC, 2010, 2014a; Graedel et al., 2011; Harfield, Harris, & Sanders, 2014;).

WEEE

Waste electrical and electronic equipment (WEEE) or e-waste is the fastest growing waste stream on the planet (Ongondo, Williams, & Cherrett, 2011) with global production having reached ~50 million tonnes/year (UNU-ISP, 2014). WEEE is a complex heterogeneous mixture of materials containing up to 60 elements (UNEP, 2009), including critical materials (Buchert, Manhart, Bleher, & Pingel, 2012), precious metals and bulk metals such as copper, aluminium and ferrous metals. As such WEEE is a highly viable secondary resource of materials for the circular economy (Oguchi, Murakami, Sakanakura, Kida, & Kameya, 2011). Despite this, barriers to efficient recovery of even the most valuable metals exist. In addition to the aforementioned causes for low recovery rates of valuable metals, low collection rates, falling market values of metals and rising costs of recycling, inappropriate recycling practices and economic viability also inhibit effective recovery of critical materials.

Platinum

Consider platinum, one of most frequent elements cited as critical. This metal has a high economic value (> US$ 37/g LME 10th July 2015) which reflects its relative abundance in the Earth's crust, the expense and environmental impact of its production (13,954 t CO_2/t of metal i.e. 4100 times greater than copper). Global demand for platinum in 2014 was 291 tonnes (O'Connell et al., 2014). The majority of demand comes as a result of the exceptional catalytic activity of platinum (Figure 4).

68% of demand comes from the autocat industry. Electronics, glass and petroleum industries each account for approximately 1% of demand, with the medical and chemical industries accounting for 5% and 6% of total demand respectively. 10% of demand comes from the jewellery industry with the remaining 8% accounted for by other applications such as retail investment and dental uses (EC, 2014b).

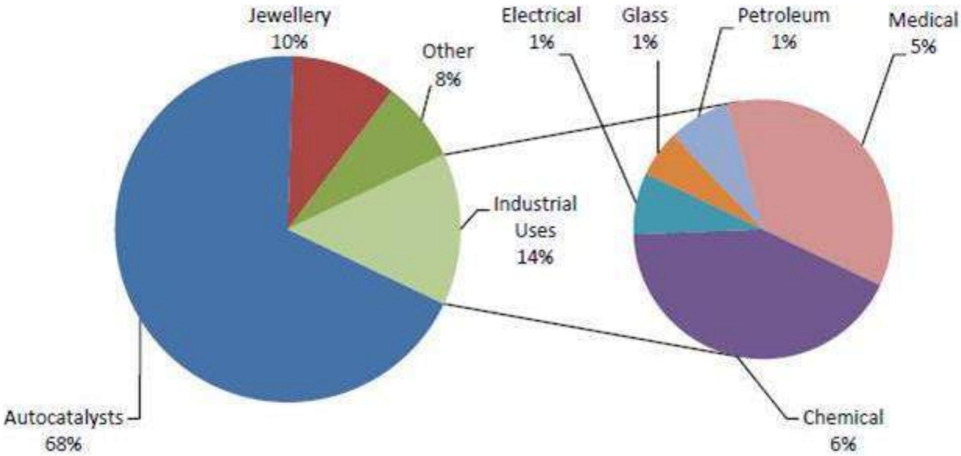

Figure 4: Global demand statistics for platinum by sector (EC, 2014b)

Recycling rates for platinum in traditional applications like bullion and jewellery are high (90-100%) as are recycling rates from high value chemical catalysts such as those used in chemical and petrochemical industries (≤90%). Such high recycling rates are due to the high value of these materials and careful control and monitoring during application. The recycling rate of platinum from autocats is somewhat lower at 50-55%, which reflects the collection rate of ~50%. In contrast the recycling rate of platinum from electronics is <5%, despite the high value of the metal. To understand this low rate, consider the applications of platinum in EEE and processes employed for recovery.

The recycling process for platinum from WEEE occurs in stages. First items are collected and sent for pre-processing where platinum bearing components are isolated from WEEE items, either manually or in automated processes. Those components are then sent for platinum recovery in hydrometallurgical or pyrometallurgical processes which produce platinum concentrate materials. Finally platinum concentrates are refined in hydrometallurgical processes into platinum. These processes are rarely carried out at a single site so environmental impact and economic costs are accumulated during transportation between sites (often in different countries) and processing at each stage.

The major application of platinum in EEE is within the platters of hard disk drives (HDDs). Pt is used only in trace amounts in platters, which constitute only a small proportion of the overall mass of a HDD, the majority of which is aluminum. Disassembly of the drives to recover the platters is uneconomic in Europe due to high operational overheads for recycling, and the low quantity of platinum available in each HDD. Instead it is common practice to shred hard drives, which disperses trace quantities of platinum (and other CRMs) throughout the bulk of the shredded material. This makes efficient recovery impossible with subsequent separation processes (Chancerel, Meskers, Hagelüken, & Rotter, 2009). This practice is encouraged by many organizations producing waste hard drives, as a means of ensuring data security. In such cases corporate data security agendas are in direct conflict with national resource security agendas.

Waste Thermocouples

A second application of platinum in EEE is in the filaments of platinum/platinum-rhodium thermocouples, invented by Henri LeChatellier in 1885, and used extensively today for bath temperature measurements in foundries. Thermocouples such as the Heraeus Electro-Nite Positherm Expendable (Figure 5) are designed for single use after which they are discarded as waste (Van Der Perre, 2000). Despite the presence of these platinum filaments, the value of the platinum present is insufficient to cover the cost of processing waste thermocouples via traditional means, which presents a major barrier to recycling. In order for platinum to be recovered, additional value must be derived from the items to finance recovery.

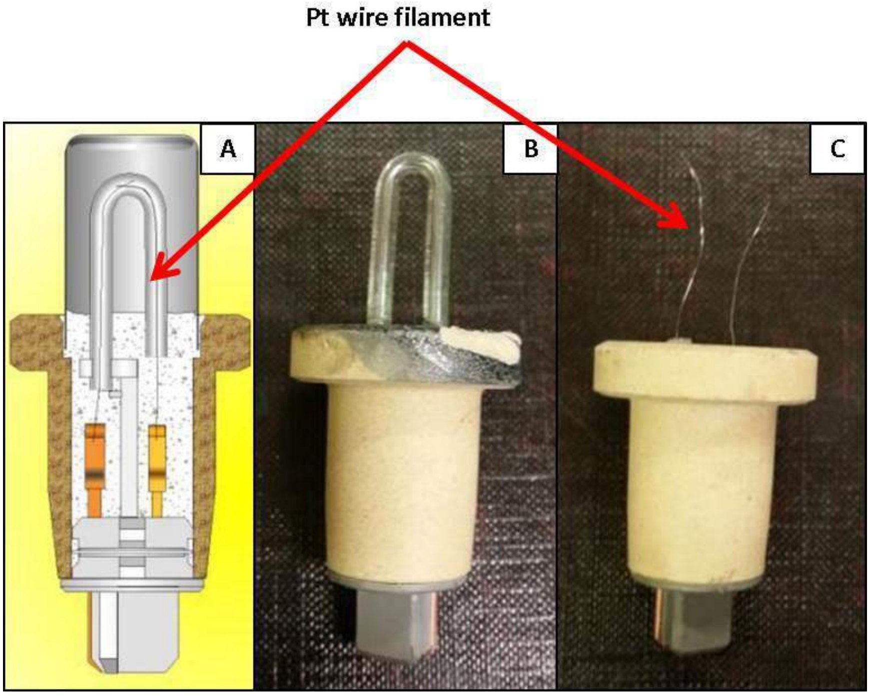

Figure 5: a. Thermocouple schematic, b. photograph of waste thermocouple, c. photograph of thermocouple with platinum filaments exposed.

Industrial Symbiosis

One strategy which would enable additional value to be generated from these thermocouples is industrial symbiosis. Industrial symbiosis is an association between two companies in which the waste of one becomes the raw material of another. This can reduce material costs and waste management costs, generate revenue from waste and by-products, divert waste from landfill, reduce environmental emissions, and create new economic opportunities within circular economy (WRAP, 2015). This is a promising strategy for enhancing recycling rates of critical materials from wastes,

particularly when recoverable value is insufficient to justify recovery through traditional recycling process chains.
Industrial symbiosis presents an opportunity to bypass traditional waste management chains, resulting in circular flows of materials within the economy with potential financial and environmental savings through avoidance of costs and emissions associated with recycling and transportation. If platinum in waste thermocouples could be processed into an added value raw material for another process, this may generate sufficient value from the material to justify its recovery.

Dye-sensitized Solar Cells (DSCs)

A relatively new application of platinum is in the creation of dye-sensitized solar cells (DSCs) (Hagfeldt, Boschloo, Sun, Kloo, & Pettersson, 2010), a thin film photovoltaic technology which has excellent potential within the context of circular economy. The structure of a DSC (Figure 6) is composed of a photo anode and counter electrode, with electrolyte in between.

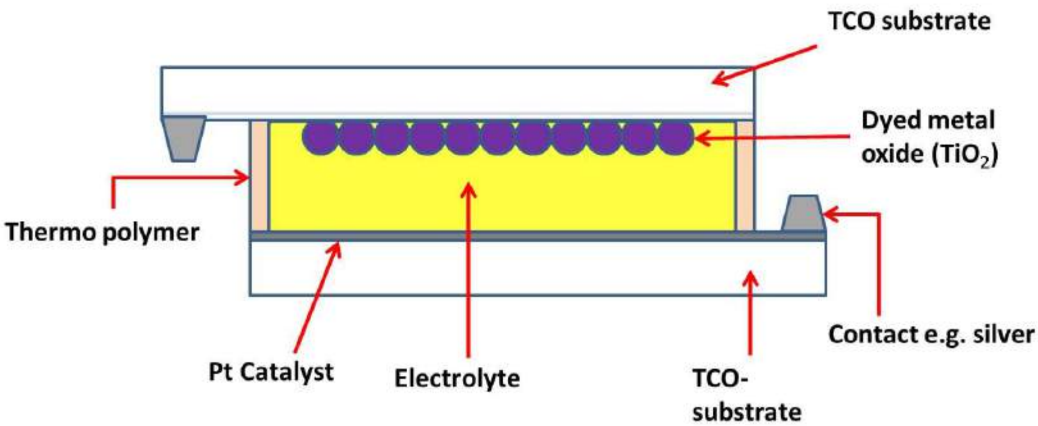

Figure 6: Structure of a dye-sensitized solar cell (DSC or Grätzel Cell)

The photo anode consists of a substrate coated in transparent conductive oxide (TCO), onto which a porous layer of semi-conductive titania is coated and dyed with a compound which absorbs strongly in the visible region of the spectrum. The counter electrode is constructed from a second TCO coated substrate onto which a catalytic layer of platinum is deposited by sputtering of platinum metal, or by coating a layer of hexachloroplatinic acid (H_2PtCl_6) solution onto the substrate which is thermally reduced *in situ* to platinum metal (Fang, Ma, Guan, Akiyama, & Abe, 2004; Fang, Ma, Guan, Akiyama, Kida, et al., 2004). The electrodes are then sealed together with a thermo-polymer to form a cell, which is filled with electrolyte and sealed before assembly into modules. The role of platinum in catalyzing the electron transfer reaction from the counter electrode to the electrolyte is crucial to the function of the cell(Hauch & Georg, 2001).

Potential strategy for Industrial symbiosis

If an organization utilizing hexachloroplatinic acid to produce DSCs with the capability to directly generate this from platinum in waste thermocouples were to partner with a foundry or metal works creating waste thermocouples, sufficient value could be derived from the platinum to justify its recovery. The additional value from such a strategy would be greater in regions where costs associated with traditional platinum recycling routes are high, and where partner organizations are within close proximity.

The optimum thickness of the platinum layer in a DSC is 100 nm (Fang, Ma, Guan, Akiyama, & Abe, 2004) so 1 m^2 of DSCs requires 2.15 g of platinum. Waste Positherm thermocouples obtained from a small foundry in South Wales were found to contain 14 mg of platinum each. At present, in the absence of an economically viable recycling process these are sent to landfill at a rate of 43,344 per year, incurring landfill tax and waste management costs. This quantity of thermocouples contains 61 g of platinum, enough to produce 28 m^2 of DSCs. If isolated from the thermocouples, the filaments are easily digested in aqua regia and platinum precipitated as hexachloroplatinic acid hydrate ($H_2PtCl_6.xH_2O$). Hexachloroplatinic acid hydrate is available from Sigma-Aldrich in the UK at a cost of US$ 59-70 /g depending on the quantity purchased, with a Pt content of 38%. At this price, the platinum in the thermocouples could replace US$ 9,400-11,226 worth of purchased chloroplatinic acid each year and the value of the platinum is increased by 4.2 to 5.0 times in comparison to the market value of this metal. This additional value may be sufficient to drive the recovery of platinum from these thermocouples for utilization in DSC manufacturing. We are currently exploring the viability of this approach in the South Wales region of the UK.

Adoption of this strategy would reduce landfill tax and waste management costs for foundries and metal works producing waste thermocouples. This may also result in materials cost savings for DSC manufacturers and reduce the cost per kWh for electricity generated by DSCs which is important to ensure this PV technology remains competitive in the marketplace. The lifecycle impact of DSCs using recovered platinum will be reduced in comparison to those produced from virgin platinum as will energy payback time (EPBT), cumulative energy demand (CED) for DSCs and greenhouse gas emissions for electricity generation (CO_2 equivalents i.e. kg/kWh) This strategy may also allow conversion of a costly waste stream into a source of revenue. If appropriate partners could be found, this strategy for improving recovery rates of platinum from waste thermocouples is very promising.

Utilization of the chloroplatinic acid for DSC manufacturing is only one application of chloroplatinic acid, and an industrial symbiosis partnership with any organization utilizing chloroplatinic acid in manufacturing is possible. In addition, alternative added value products could be generated from the platinum such as ammonium hexachloroplatinate, platinum catalysts and nanoparticles could all generate additional value from waste thermocouples and open up additional possibilities for partner organization.

The generation of additional value from platinum in thermocouples is only a single example of how industrial symbiosis can result in enhanced recovery rates of critical materials from waste and derivable value from waste materials. Direct utilization of wastes as raw materials is a promising strategy for enhancing the circular flow of all materials throughout economies and available options for all industries should be considered. It should be the roll of scientists and engineers to develop processes and technologies which unlock the material value of wastes in the form of added value precursor compounds for direct use in manufacturing, thereby facilitating transition towards circular economy. As such technologies and processes come online the environmental, social and economic benefits associated with global resource efficiency will continue to grow.

Conclusion

Achieving resource efficiency is crucial if sustainability with our planet is to be achieved. Transition to circular economy could allow us to achieve sustainable economic development whilst reducing the ecological footprint of our lifestyles. Vital to the viability of a functioning circular economy is the generation of circular flows of materials and generation of secondary 'critical raw materials' in particular. WEEE is an extremely promising source of critical materials; however recovery rates for many critical materials remain low. Where this is due to the presence of insufficient recoverable material to justify recovery via traditional waste management pathways, industrial symbiosis and conversion of materials in wastes directly into added value raw materials can provide sufficient cost benefit to justify recovery. The recovery of platinum from filaments of waste thermocouples via their direct conversion to hexachloroplatinic acid may improve the derivable value from the material by up to five times. This is one promising strategy for enhancing platinum recovery rates. Such strategies which enhance derivable value from materials and enable direct utilization of waste as raw materials for manufacturing provide additional economic benefits. These include savings on waste management costs and potential generation of additional revenue for producers of wastes, and materials cost savings for manufacturers. Life cycle impacts of materials recovered in this way rather than through traditional waste management chains will be reduced, as will those of products utilizing these materials. Industrial symbiosis is therefore a promising strategy to enhance derivable value from materials, increase recycling rates of critical materials, mitigate resource criticality issues, accelerate transition to a functional resource-efficient circular economy and achieve sustainable economic development.

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Bioclimatic Solar Home Design in Bangkok Thailand

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Abstract
This research aimed to study the bioclimatic home design in Bangkok, Thailand, and the installation of Photovoltaic System on the roof. By collecting the climate data from sample single-story house in Bangkok, having an open courtyard of dimension 4.00 x 4.00 meters. It is observed that the key of bioclimatic solar home design comprises of house orientation with the pitch roof of 15 degrees south, and an open courtyard that gives good ventilation, adequate natural light and a suitable landscape. The garden contains various species of plants that are homes for small creatures such as squirrels and birds, and together formulating a biotope and balanced ecological system. By connecting the courtyard to kitchen, dining and living area creates a bond between the house inhabitants and nature, promoting a healthy emotional and physical well-being. The courtyard generates a micro climate in which helps reducing the ambient temperature. When adapting the bioclimatic home with 30 square meters of Photovoltaic System installed on the roof, using grid connected PV system. The inverter, with maximum power generation capacity of 3.3 kW, can supply electrical energy at an average of 12kWh/day. This helps in lowering the monthly electricity cost by 30% and decreasing the amount of carbon dioxide gas consumed in the electricity process by 8.8 kilogram per day. The return on investment will be about 10 years and 7 months. This will help to further develop zero energy home design.

Keywords: Bioclimatic house, Solar Home, Alternative Energy House, Low energy House

Introduction

This research presents a sample house that features the design of Bioclimatic Home, with the focus on saving electricity energy utilization from air-conditioning, also known as "Passive and low energy architecture (PLEA)" and with the installation of Photovoltaic System on the rooftop to generate electricity in supplement to the electricity supply from the Metropolitan Electricity Authority.

This sample house is located in Bangkok, the capital city of Thailand in the Southeast Asian region. The sample bioclimatic solar home in Bangkok is situated in a populated business district surrounded by high-rise buildings, and at 3 kilometers from Chatuchak Park, a large recreational public park in Bangkok. The house compound also comprises of a home garden that foster an urban ecological system, and also helps to reduce the urban heat island effect, thus promoting happiness for the inhabitants with a pleasant climate and green environment. The home garden also accommodates small birds and squirrels, and maintains the temperature inside the house to be within the comfort range and helps to reduce the utilization of air-conditioning system.

Bangkok is situated on the eastern bank of the Chao Phraya River at Latitude $13^{0}45'$ North, Longitude $100^{0}30'$ East, and with the intensity of solar radiation (irradiation) measured at 4.75 kWh/m^2/day±15%, and the average daily peak measurement of solar energy at 850Watt/m^2, which is ideal for installation of the Photovoltaic system.

Figure 1: Site and surrounding of a sample house in Bangkok, located 3 kilometers from Chatuchak Park. The site has an area of 730 square meters, and is surrounded by high-rise buildings.

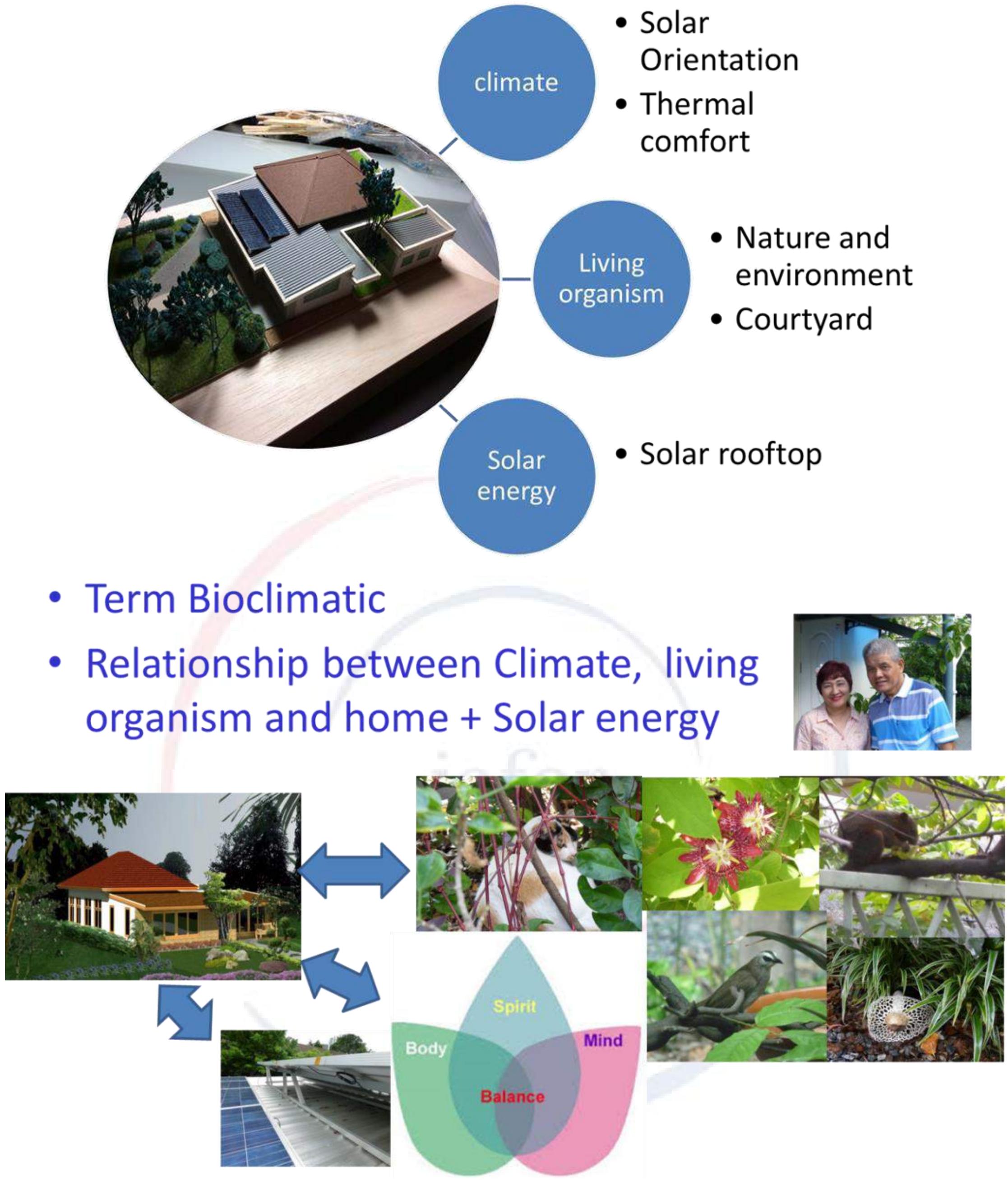

Figure 2: Diagram of the bioclimatic solar home design in Bangkok.

The climate of Bangkok, Thailand

Bangkok has the tropical climate with 3 seasons: summer season starting from mid-February until mid-May; rainy season starting from mid-May until mid-October, and winter season starting from mid-October until mid-February. The average temperature throughout the year is around 28.5^{0}C, the highest average temperature during April month measures at 35.8^{0}C, the lowest temperature falls in December month at 21.0^{0}C. The annual average relative humidity is around 72.3%, the highest relative humidity measures at 92.3%, and the lowest relative humidity measures at 43.8%, the average wind speed records at approximately 2.6 Knot, the annual average precipitation in depth of 1,337.5 millimeters (as recorded by The Thai Meteorological Department, 1980-2009). Bangkok exhibits the urban heat island effect, in which the temperature in urban area is higher than the outer city area.

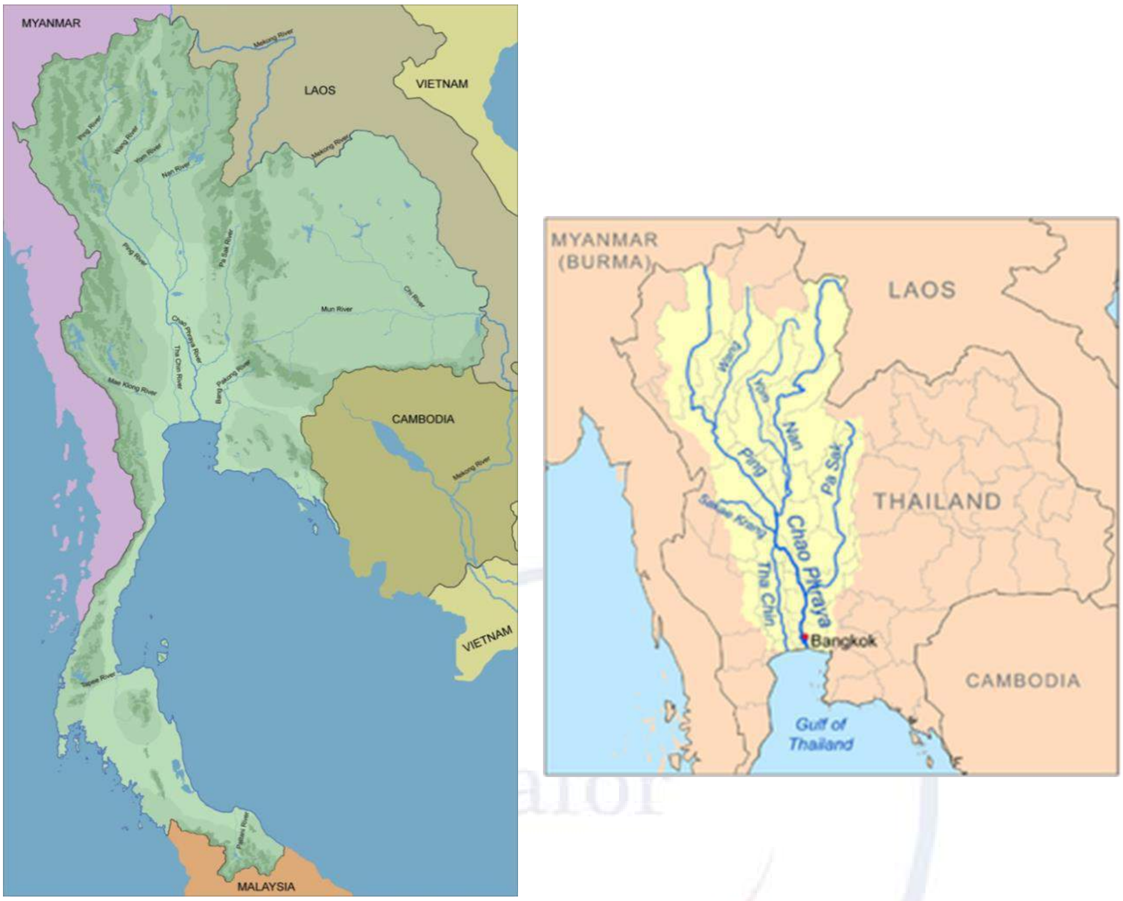

Figure 3: Bangkok city situated on the eastern bank of the Chao Phraya River at Latitude: 13°45′ N, Longitude: 100°30 ′ E.

Method of research

1. Studying the comfort climate by collecting the climatic data from a sample house, and plotting the data on bioclimatic charts.
2. Studying the eco-friendly environment, from observation of the ambiance within the garden and courtyard.
3. Studying the installation of Photovoltaic system on the rooftop, from the survey and selection of Grid tied system and Off-grid system.
4. Studying the electricity energy that is generated from solar panels, by adjusting the inclination of solar panels to correspond to the roof gradient. And the inclination of 15 degrees by theory will yield the maximum output.
5. Recording the data of electricity energy that is generated from the inverter.
6. Calculating the period for return of investment for the installation of the Photovoltaic system.

Figure 5: Photovoltaic system on the rooftop of a sample house.

The sample house in terms of passive low energy architecture and bioclimatic home in Bangkok

The sample house has a land area of 47.65 x 15.32 square meters, the utilization area of the house is 170 square meters, and the ecological open area totals up to 77%. The characteristic of the house is a single-storey house constructed from steel reinforced concrete; with the flooring as steel reinforced concrete beneath glazed floor tiles which facilitate good heat transfer to the ground; the walls are plastered with cement and glazed tiles, which exhibit high heat tolerance; the roofs are installed with metal sheets and underlined with polyurethane foam at thickness of 5 millimeters, and also installed with heat insulating material at the ceiling, made from fiberglass with thickness of 3 inches.

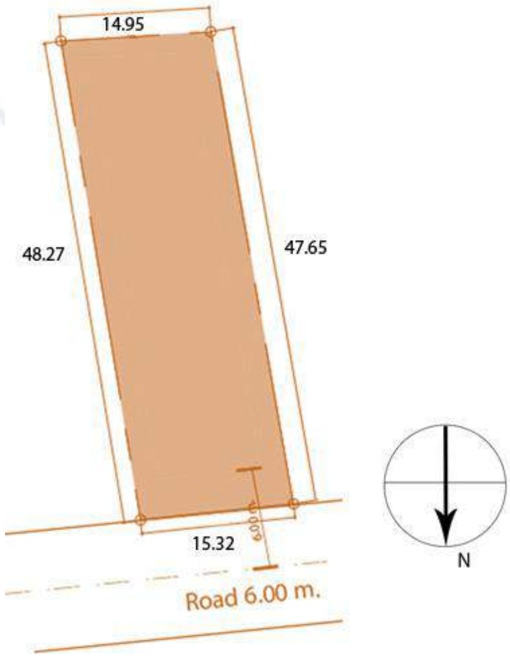

Figure 6: The land area of 47.65 x 15.32 square meters

Solar Orientation

the house plan arrangement is in accordance with the sun path diagram, in which the openings are oriented in the north and south direction to allow for the seasonal winds, whereas the east and west zones have fewer openings and with more trees to create shading against the sunlight.

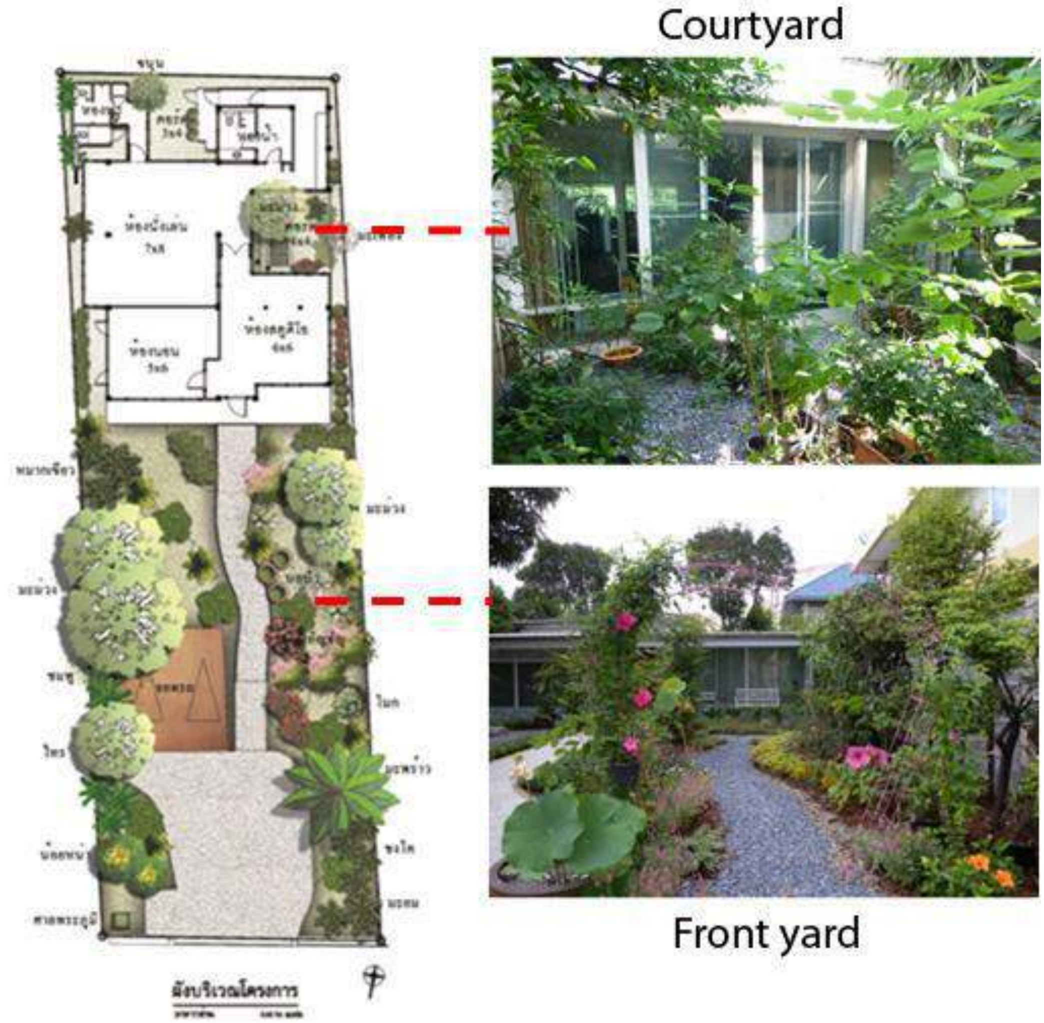

Figure 7: The courtyard with area of 4.0x4.0 square meters, the interior of the house, and the front yard.

Open Courtyard

The design for an open courtyard of size 4.0x4.0 square meters that is adjacent to the kitchen, living room, and studio room, to serve as ventilation zone and allow natural light to enter the house interior, helps to promote a close connection with nature. Whereas the front area that connects with the open front yard promotes cross ventilation and also allow natural light into the rooms. This adaptation of the climate and garden design helps to reduce the ambient temperature, and also maintains living comfort for the interior of the house.

Eco-environment

The nature-inspired garden design helps to foster the microclimate, which reduces the ambient temperature and also allows the inhabitants to connect with nature, as well as maintains happiness and health. In addition, the natural garden also serves as home to small creatures such as squirrels and various species of birds, butterflies, and so on

Figure 8: Image of a squirrel and a small bird that inhabit the courtyard.

Flexible space

The living room is interconnected with the courtyard; without partitions and doors in order to promote excellent air flow. The kitchen is set apart from the living area and next to the courtyard, which benefits proper ventilation.

Figure 9: Illustration of the cross-section of the courtyard, which connects to the living room.

Figure 10: Illustration of the house plan and courtyard.

Materials and Insulation

The utilization of construction and insulating materials installed at the roofs effectively helps in protection against heat intrusion into the house.

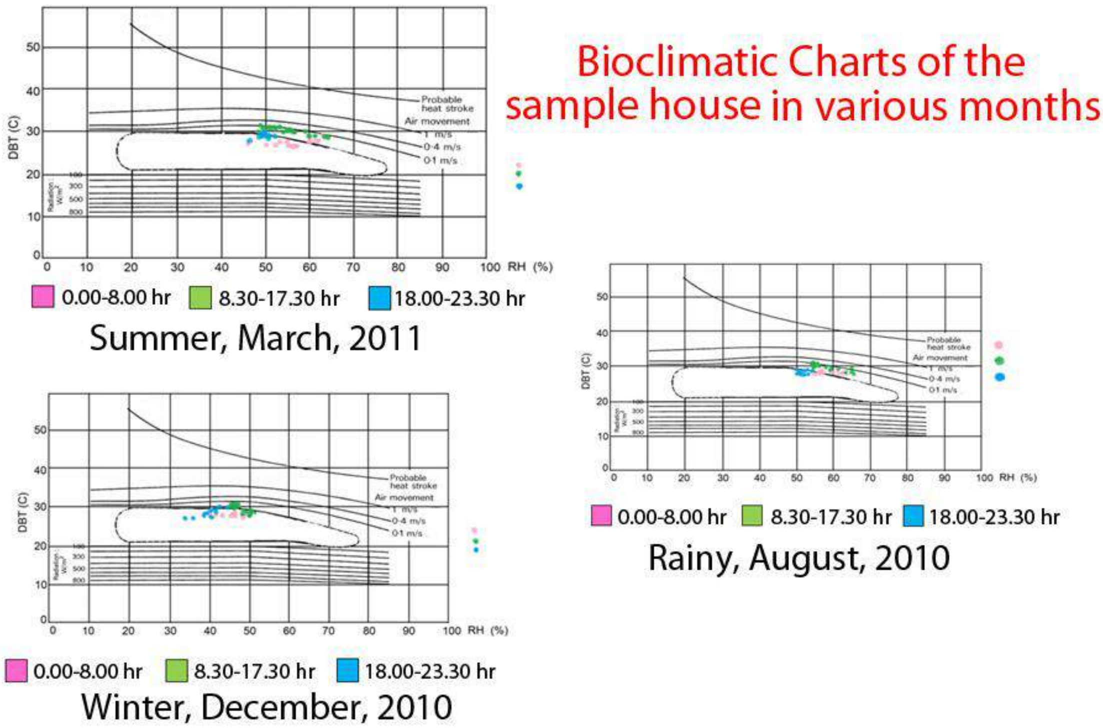

Figure 11: Illustration of Bioclimatic charts of studio room at the sample house

Photovoltaic System

the installation of solar panels on rooftop in order to generate alternative energy helps to reduce the amount of carbon and greenhouse gases, and also save electricity cost for urban houses. The selected system for implementation is the Grid tied system and installation of solar panels on the rooftop in the north direction, since this is the roof area that is not shaded by high-rise buildings and trees. The installation is tested with inclination of 5 degrees north to match the roof gradient, and elevated to an inclination of 15 degrees south; total number of 15 solar panels occupies the roof area of 40 square meters, and connected to an inverter grid tied with capacity of 3.3Kw, and then recording the electricity energy readings for comparison.

Selected system	Grid Tied system
Photovoltaic system area on roof	30 m^2
Roof area requirement	40 m^2
Inverter	3.3 Kw (ABB), Grid Tied system
Roofing	Metal sheet with insulation
Solar panels' angle and position	5 degrees' north at the north side of the sample house
Photovoltaic cell	Poly Crystalline (Suntech, STP 285) 24/VDC, 15 panels
Connecting safety device	MCCB 2 packs

Figure 12: Table illustrating the installation of photovoltaic system on a sample house rooftop.

Figure 13: Comparison chart for electrical energy generated from solar panels with inclination at 5 degrees' North (A type) producing electricity of 12-15 unit/day, and solar panels with inclination at 15 degrees' South (B type) producing electricity of 14-17unit/day.

Conclusion

Bioclimatic solar homes in Bangkok, Thailand help to reduce the utilization of air-conditioning, for the design that features an open court and the garden that surrounds the house, as illustrated in the bioclimatic chart for the various rooms in the house.

The measurements of thermal comfort in the studio room in summer, rainy and winter seasons, most of which fall in the comfort zone, as well as measurements that are slightly outside the comfort zone, and in case of utilization of ventilating fan at speed of 0.1-0.4m/sec, this will increase the level of comfort to fit in the comfort zone. Hence the bioclimatic houses help to reduce the electricity utilization from air-conditioning.

The installation of the Photovoltaic system is capable of producing electricity up to 12kWh/day (12 Unit), 4,380kWh/year, with the solar panels oriented at inclination at 5 degrees north, and placed on the rooftop. This can compensate for electricity supply from the Metropolitan electricity Authority for each month up to 30%, and with an investment return period of 9-10 years. The cost for installation is 60,000 Baht/kWp. Then, it saves electricity cost up to 1,500 Baht/month, and reduces the amount of carbon from fossil fuel on the average of 3.2 ton per year.

Suggestions

The installation of thermal insulation at the roofs is essential for reducing the heat penetration into the interior of the house.
Courtyard and plants play an important role in passive design in an urban area.
The solar panels' 'inclination at 15 degrees' south is the most effective orientation for electricity generation.

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Regional Disparity of Productivity and the Factors in Japanese Industries

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Abstract
This study examined productivity change and the factors in Japan using a data set consisting of 47 prefectures over the period from 1990 to 2009. The data set was comprised of one output and five inputs for overall industries in Japan, that is, amount of gross real product as an output, and intermediate input, number of employees, private capital stock, social capital stock and final energy consumption as five inputs. Using the data set, we measured Hicks-Moorsteen-Bjurek (HMB) productivity change index and decomposed the productivity change into three factors, technical change effects, efficiency change effects and scale change and input and output mix effects. In the process of calculating the HMB productivity index, this study applied a data envelopment analysis (DEA) to measure distance functions. From the results, this study indicated regional disparity once expanded toward 2005 and 2006, but after the years it drastically decreased in parallel with an economic downtown. From the decomposition analysis, we found that the economic downturn and the resulting decrease in regional disparities were mainly attributed to the negative impact due to the technical change component.

Keywords: productivity change, Japanese regional industries, regional policy

Introduction

Japanese economy experienced higher growth in the 1980s, when the economy achieved 4.4% annual growth rate of real GDP on average. However, it shifted to the so-called "lost decade" under the severe stagnation in the 1990s after the burst of bubble economy. Due to the stagnation, the average annual growth rate went down to 1.5% on average, and the growth rate further decreased in the 2000s, which indicated 0.6% annual growth rate of real GDP on average.

Until recently, the Japanese economy continued to suffer from a long-term stagnation. The economy experienced decreasing price levels and higher unemployment rates for more than a decade. Under such an economic downturn, Abe's Liberal Democratic Party took office after the winning of the Lower House general election at the 16th of December 2012, advocating the rebuilt of the crisis-ridden Japanese economy. The economic policy is called "Abenomics."

There are three pillars of the Abenomics. They are effective uses of fiscal policy and financial policy, and promotion of growth strategy in private sectors. In particular, productivity improvement plays an important role for the growth strategy in private sectors, because productivity growth is an inevitable source and a driver of economic development. Therefore, to suggest effective policy for the growth strategy by improving the productivity of the economy, it is necessary for us to measure the productivity growth and find specific factors that influence the growth. In addition, examining regional disparities of economic growth is important for regional policy in Japan.

The purpose of this study is to investigate the productivity of the Japanese regional economy from 1990 to 2009 using a data set consisting of 47 prefectures, and find if the regional disparity of the productivity has grown during the period. Barro and Sala-i-Martin (1995) recognized regional disparity in labor productivity in Japan from cross-section analysis. Meanwhile, Kawagoe (1999) and Togo's (2002) results based on time-series analyses are critical to the discussion. Particularly, Togo's (2002) analysis, which examined time trends in regional disparities of labor productivity for the period from 1985 to 1997, does not account for the existence of productivity convergence. This study revisits the discussion of productivity convergence and examines the productivity change in Japan using an updated data set. Further, we conduct a decomposition analysis to clarify the sources of the productivity growth in Japan during this period.

The reminder of this article is organized as follows. The methodology section provides a brief description of HMB productivity index and its decomposition. The model section specifies the HMB productivity index using mathematical expressions. The data section explains descriptive statistics of data on industries for 47 prefectures. The last section concludes this study and discusses remaining issues.

Methodology

This study applies a decomposition analysis of HMB productivity index that was proposed by Nemoto and Goto (2005). The HMB productivity index can be decomposed into four components, and the decomposable property is ideal for the purpose of disentangling the sources of productivity growth. Those four components are technical change component (TC), efficiency change component (EC), scale change component (SC) and input and output mix effects (ME).

The HMB productivity index is capable of assessing the relative importance of the factors as sources of fluctuations in productivity and has preferable property for the decomposition compared to the other popular productivity index. In particular, Törnqvist productivity index does not have an efficiency change component because it presumes the optimizing behavior of a producer. Malmquist productivity index can assess inefficiency, but it is not indicative of scale change because it is well defined only when technology exhibits constant returns to scale. Meanwhile, the HMB index provides an integrated framework in which the productivity change is fully decomposed into four components.

Model

The HMB productivity index is defined by combining Malmquist output change and input change indexes. The Malmquist indexes are based on the distance function. The Malmquist output change index that measures aggregate output change from the period t to $t+1$ is described as follows;

$$M_y^{t+1,t} = \left\{\frac{D_o^t(x^t,y^{t+1})D_o^{t+1}(x^{t+1},y^{t+1})}{D_o^t(x^t,y^t)D_o^{t+1}(x^{t+1},y^t)}\right\}^{1/2},$$

where the output-oriented distance function is defined as

$$D_o^t(x,y) \equiv min\{\delta|(x,y/\delta) \in \Omega^t\}.$$

Here Ω^t is the production possibility set consisting of any technically feasible pair of inputs and outputs at the period t. When $D_o^t(x,y) \leq 1$, the output-oriented distance function measures technical efficiency, and $D_o^t(x,y) = 1$ indicates full efficiency in the sense that more outputs cannot be obtained without increasing inputs.

Similarly, Malmquist input change index that measures change from the period t to $t+1$ is given by

$$M_x^{t+1,t} = \left\{\frac{D_i^t(x^{t+1},y^t)D_i^{t+1}(x^{t+1},y^{t+1})}{D_i^t(x^t,y^t)D_i^{t+1}(x^t,y^{t+1})}\right\}^{1/2}.$$

The input-oriented distance function is defined as

$$D_i^t(x,y) \equiv max\{\delta|(x/\delta,y) \in \Omega^t\},$$

where $D_i^t(x,y) \geq 1$ implies that the input-oriented distance function measures technical efficiency, and $D_i^t(x,y) = 1$ indicates full efficiency in the sense that inputs cannot be reduced further without decreasing the outputs.

Using the above two indexes, the HMB productivity index is defined by Bjurek (1996) as the ratio of the Malmquist output change to the input change indexes as follows;

$$HMB^{t+1,t} = M_y^{t+1,t} / M_x^{t+1,t}.$$

Since $M_y^{t+1,t}$ and $M_x^{t+1,t}$ measure changes in outputs and inputs, taking logarithms yields their proportionate changes. Thus, $\ln HMB^{t+1,t}$ measures the proportionate productivity change for the period t to $t+1$, which comprises of four components: technical change, $TC^{t+1,t}$, efficiency change, $EC^{t+1,t}$, scale change, $SC^{t+1,t}$, and input and output mix effects, $ME^{t+1,t}$. In other words, the proportionate change in productivity index and the proportionate changes in the four components are summarized below.

$$\ln HMB^{t+1,t} = \ln TC^{t+1,t} + \ln EC^{t+1,t} + \ln SC^{t+1,t} + \ln ME^{t+1,t}.$$

TC captures effects from a temporal shift of the production frontier. The production frontier changes its position in response to various shocks arising from technical advances, investment in infrastructure, and changes in the economic environment concerning production. Therefore, *TC* can be called as supply shocks.

EC measures effects arising from a deviation of actual production point from the production frontier. There are two major sources of efficiency change. (1) Variations in input utilization rates induced by demand shocks, arising from changes in exports, autonomous domestic expenditures, and fiscal policy. These are nationwide shocks. (2) Changes in managerial efficiency that are caused by idiosyncratic shocks confronted by industries.

SC measures effects of returns to scale. If technology exhibits increasing (decreasing) returns to scale, the economy will become more (less) productive by an expansion of the production scale.

Finally, *ME* will be observed if there is a change in the sectoral composition of the economy over industries that differ in terms of productivity growth. *ME* is excluded from the scale effects because *ME* is measured along a fixed ray of input and output combination for the decomposition analysis of the HMB productivity index. This is a unique feature of productivity decomposition analysis in this study. On the other hand, changes from input and output mix effects are compounded with the pure scale change in the conventional TFP analysis.

This study uses Data Envelopment Analysis (DEA) to measure distance functions. DEA is a holistic method to measure efficiency of firms, industries, and other decision-making units (DMUs). That is, Nemoto and Goto (2005) used a parametric approach to measure the distance function, while this study uses a non-parametric approach that can avoid a specification of production function. Among the various formulations of DEA model, this study applies radial DEA model.

Mathematical symbols to express production factors are summarized as follows:

(a) $X_j = \left(x_{1j}, x_{2j}, \dots, x_{mj}\right)^T > 0$: a column vector of m inputs of the j-th DMU ($j = 1, \dots, n$), and
(b) $Y_j = \left(y_{1j}, y_{2j}, \dots, y_{sj}\right)^T > 0$: a column vector of s outputs of the j-th DMU ($j = 1, \dots, n$),

where the superscript "T" indicates a vector transpose. The inequality (>) implies that the relationship is applied to all components of the three column vectors.

In addition to the above production factors, which are given to us as an observed data set, this study uses the following symbols which are unknown to us and are measured by applying DEA:

(c) $d_i^x \geq 0$: an unknown slack variable of the i-th input ($i = 1, \dots, m$),
(d) $d_r^y \geq 0$: an unknown slack variable of the r-th output ($r = 1, \dots, s$),
(e) $\lambda = (\lambda_1, \dots, \lambda_n)^T$: an unknown column vector of "intensity" or "structural" variables,
(f) ε: a small number to be prescribed by a DEA user.

The input oriented radial DEA model used in this study is described as follows;

$$
\begin{array}{lll}
\text{Minimize} & \xi + \varepsilon\left[\sum_{i=1}^{m} R_i^x d_i^x + \sum_{r=1}^{s} R_r^y d_r^y\right] & \\
\text{s.t.} & \sum_{j=1}^{n} x_{ij}\lambda_j + d_i^x \quad = \xi x_{ij} & (i = 1, \dots, m), \\
& \sum_{j=1}^{n} y_{ij}\lambda_j - d_r^y \quad = y_{rj} & (r = 1, \dots, s), \\
& \sum_{j=1}^{n} \lambda_j = 1, & \\
& \lambda_j \geq 0 \ (j = 1, \dots, n), \xi\text{: URS}, d_i^x \geq 0 \ (i = 1, \dots, m), d_r^y \geq 0 \ (r = 1, \dots, s). &
\end{array}
$$

The output oriented radial DEA model used in this study is described as follows;

$$
\begin{array}{lll}
\text{Maximize} & \xi + \varepsilon\left[\sum_{i=1}^{m} R_i^x d_i^x + \sum_{r=1}^{s} R_r^y d_r^y\right] & \\
\text{s.t.} & \sum_{j=1}^{n} x_{ij}\lambda_j + d_i^x \quad = x_{ij} & (i = 1, \dots, m), \\
& \sum_{j=1}^{n} y_{ij}\lambda_j - d_r^y \quad = \xi y_{rj} & (r = 1, \dots, s), \\
& \sum_{j=1}^{n} \lambda_j = 1, & \\
& \lambda_j \geq 0 \ (j = 1, \dots, n), \xi\text{: URS}, d_i^x \geq 0 \ (i = 1, \dots, m), d_r^y \geq 0 \ (r = 1, \dots, s). &
\end{array}
$$

Both models produce an efficiency measure, which is described as follows;

$$1 - \left(\xi^* + \varepsilon\left[\sum_{i=1}^{m} R_i^x d_i^{x*} + \sum_{r=1}^{s} R_r^y d_r^{y*}\right]\right),$$

where asterisks indicate optimal value of variables obtained from solving the models, and R is a weight given to each slack variable. R is calculated based on maximum and minimum values of each input and output data.

Data

This study uses a data set of regional industries at the level of 47 prefectures in Japan over the period from 1990 to 2009 (20 periods). The data set aggregates all industry sectors in manufacturing and non-manufacturing industries into a national total statistics. The data set is comprised of one output and five inputs. The output is a gross product in real terms, and five inputs consist of intermediate input, number of employees, private capital stock, social capital stock and final energy consumption. Table 1 provides descriptive statistics of data.

Table 1: Descriptive statistics of data

Statistics	Gross product	Intermediate input	Number of employees	Private capital stock	Social capital stock	Final energy consumption
Avg.	19,962,756	8,898,717	1,329,486	21,209,427	16,276,676	262,751
Max.	174,850,215	83,209,622	8,785,204	170,473,914	72,474,451	1,333,681
Min.	3,186,866	1,213,080	289,970	2,576,761	3,821,977	34,509
S.D.	26,120,081	11,752,210	1,425,974	25,033,049	13,543,344	259,589

Note: Gross product, intermediate input, private capital stock and social capital stock are measured in one million Japanese Yen. Final energy consumption is measured in tera-joule.

Empirical Results

Table 2 presents HMB productivity indexes of nine regions, regional averages and changes of the index or the value of lnHMB from 1991 to 2009. The nine regions are summarized from 47 prefectures, because such aggregation is often used for discussions of regional policy issues. Figure 1 depicts the trend of HMB productivity index on average for each region and total (nation-wide) average of the index.

Table 2: HMB productivity index and its change for nine regions

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hokkaido	1.008	0.993	1.008	0.975	0.991	0.994	0.989	1.005	0.995	1.018
Tohoku	0.981	0.978	0.991	0.997	0.977	0.993	0.999	1.004	0.996	1.014
Kanto	0.964	0.965	0.991	0.984	0.985	0.998	0.953	0.975	0.994	1.019
Chubu	0.988	0.980	0.997	0.982	0.996	1.009	0.992	0.994	0.998	1.036
Kinki	0.998	0.981	1.004	0.993	1.003	1.017	0.991	0.994	1.017	1.045
Chugoku	1.003	0.986	0.991	1.003	1.000	1.004	0.991	0.979	1.007	1.033
Shikoku	0.993	0.987	1.003	0.999	1.006	0.988	0.987	1.008	1.008	1.021
Kyushu	0.985	0.985	0.996	0.991	0.992	0.999	0.998	1.008	0.994	1.025
Okinawa	0.941	0.981	0.990	0.945	0.972	0.980	0.977	0.993	0.958	1.021
Avg.	0.986	0.980	0.996	0.990	0.993	1.002	0.987	0.994	1.000	1.028
HMB change	-0.014	-0.020	-0.004	-0.010	-0.007	0.002	-0.013	-0.006	0.000	0.028
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg.
Hokkaido	1.0090	0.9969	1.0311	1.0095	0.9990	1.0102	1.0074	0.9872	0.9771	1.0001
Tohoku	0.9938	1.0029	1.0161	1.0226	1.0491	1.0778	1.0392	1.0334	0.9574	1.0064
Kanto	0.9717	1.0179	1.0297	1.0090	1.0183	1.0195	1.0167	0.9926	0.9592	0.9928
Chubu	0.9893	1.0211	1.0197	1.0203	1.0374	1.0086	1.0126	0.9795	0.9371	0.9999
Kinki	0.9836	1.0397	1.0413	1.0333	1.0340	1.0501	1.0110	0.9915	0.9556	1.0096
Chugoku	1.0066	1.0122	1.0155	1.0188	1.0259	1.0249	0.9999	0.9830	0.9578	1.0022
Shikoku	1.0023	1.0238	1.0365	1.0034	1.0132	1.0324	1.0006	1.0077	0.9744	1.0049
Kyushu	0.9820	1.0206	1.0303	1.0171	1.0532	1.0223	1.0137	1.0098	0.9506	1.0038
Okinawa	1.0021	1.0048	1.0241	1.0188	1.0097	1.0094	1.0117	0.9971	0.9932	0.9910
Avg.	0.9890	1.0194	1.0268	1.0185	1.0332	1.0311	1.0140	0.9979	0.9552	1.0022
HMB change	-0.0111	0.0192	0.0265	0.0183	0.0327	0.0306	0.0139	-0.0021	-0.0459	0.0020

From Table 2 and Figure 1, we find that Japanese economy experienced increasing productivity toward 2005 and 2006, although there are temporal up and down variations through the period, then it significantly decreased after the years. Regional disparity of productivity change once became larger along with the productivity growth, but it diminished after the years in parallel with the economic downturn.

In particular, Tohoku and Kinki was two regions that revealed higher productivity growth over the period, which are 1.0096 and 1.0064 in HMB productivity index on average. On the other hand, Kanto, which includes Tokyo metropolitan area, was less than average with 0.9928. Since regional aggregation dilutes characteristics of each prefecture, the result does not deny higher productivity arising from extensive resource concentration in Tokyo metropolitan area, as often indicated in regional policy debates.

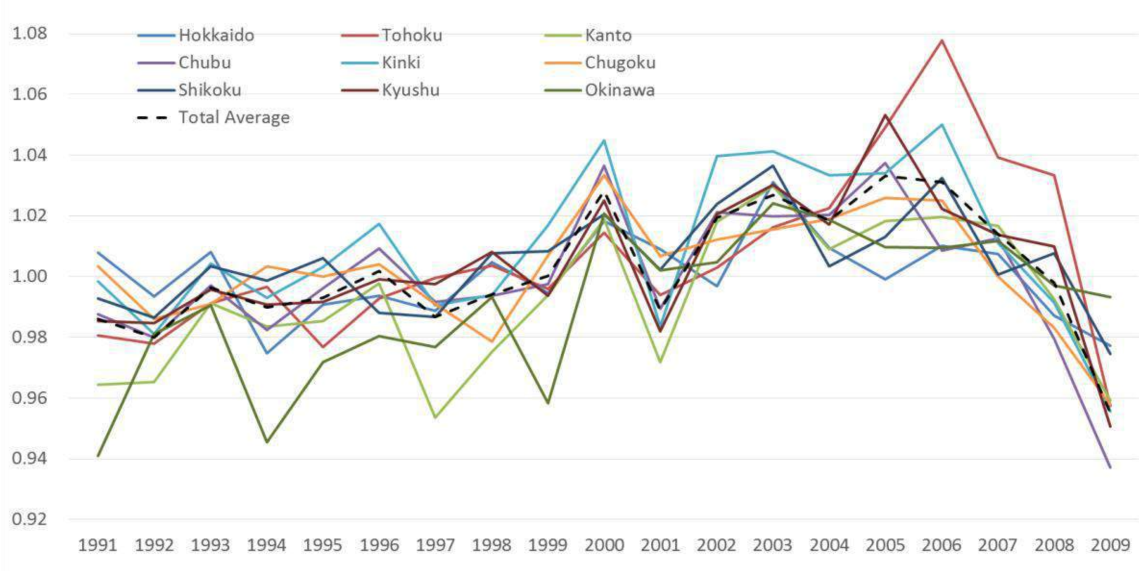

Figure 1: Trend of HMB productivity index from 1991 to 2009

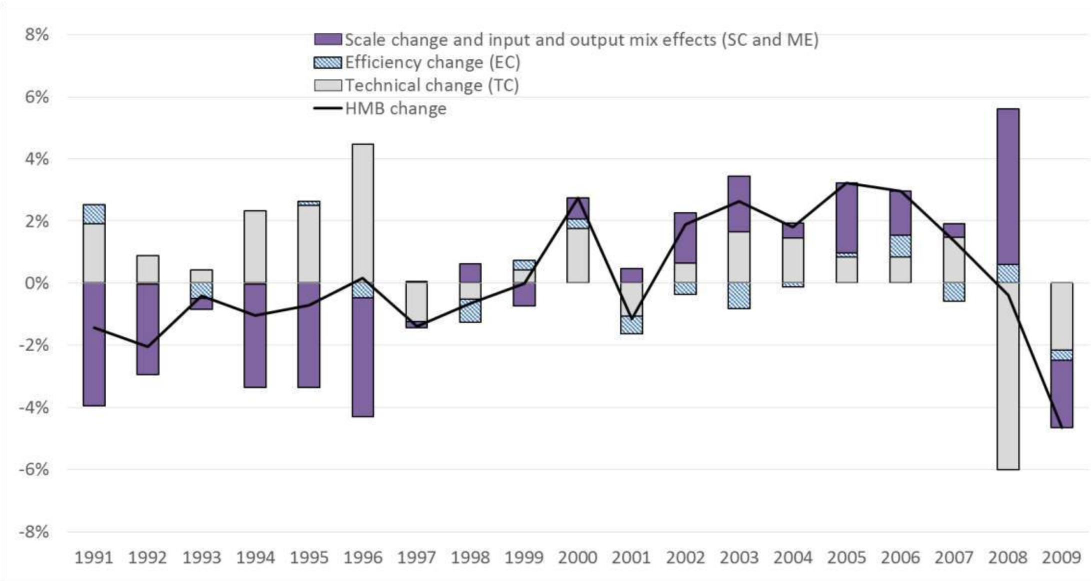

Figure 2: Decomposition of HMB productivity change from 1991 to 2009

Figure 2 presents the trend of HMB productivity change in percentage and results of the decomposition from 1991 to 2009. It should be noted that this study integrates SC and ME into one factor because of a reason for calculation.

This study summarizes three findings from the decomposition results. First, *TC* contributed to the productivity growth over the period, with the exception of a few years such as observed in negative impacts in 2008 and 2009. Second, *SC* and *ME* provided negative influences to productivity growth in the 1990s, but it changed to give positive impacts after the 2000s. Third, contribution of efficiency change to productivity growth was small over the period. That is, influences from supply shocks are more important to improve productivity growth in Japan compared to the demand shocks. Therefore, investment in infrastructure is critically important for Japanese economy, which supports shift in production frontier arising from technical advances. In addition, pursuing advantages produced from economies of scale would be a effective regional policy for higher productivity growth.

Conclusion

This study examined productivity change and the factors in Japan using a data set consisting of 47 prefectures over the period from 1990 to 2009. Using the data set, we measured HMB productivity change index and decomposed the productivity change into three factors, technical change component, efficiency change component and scale change and input and output mix effects. To measure the HMB productivity index, this study applied DEA. From the results, this study indicated regional disparity once increased toward 2005 and 2006, but after the years the regional differences drastically decreased in parallel with an economic downtown. From the decomposition analysis, we found that the economic downturn was mainly attributed to the negative impact due to the technical change component, and it influenced across a wide region of Japanese economy. These findings give us an idea that it is important for productivity growth in Japanese regional economy to promote technological advances that is realized by effective investment in infrastructure.

There are two tasks that should be overcome in future. First, HMB productivity index is capable of decomposition into four components. However, this study decomposed the productivity change only to three components due to calculation issues. Thus, this study does not separate input and output mix effects from scale change component. To complete the decomposition analysis by fully utilizing the virtue of HMB productivity index, this study needs to conduct additional calculations of DEA efficiency using different combinations of output and inputs. Second, the period covered in this study is from 1990 to 2009, but it needs to be further extended to examine recent policy effects of Abenomics. This is important because Japanese economy is recovering from the “lost two decades,” after the bubble economy. These are two remaining tasks of this study.

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Discussion on the Elements of Listed Energy Companies' Environmental Information Disclosure in the New Context of China's Environmental Legal System

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Abstract
Energy industry is a representative industry in heavy pollution industries. The listed companies in energy industry, due to their particularity in terms of industry attributes, scale and stakeholders, are confronted with great (internal and external) environmental risks. At present, the securities market of China is undergoing a major restructuring. China’s Ministry of Environmental Protection (MEP), however, has transferred the rights of IPO environmental protection inspection in 2014, and handed environmental protection verification of listed companies to market entites; after issuing of the new Environment Protection Law of P.R.China, China has fully entered an era of environmental justice specialization. With further accumulation of environmental risks of listed companies, they will encounter more serious ordeals. It is necessary to take Environmental Information Disclosure at listed company IPO inspection stage as an essential means to realize "secondary source risk control". This research analyzes environment and legal risks in the new context of China’s environmental legal system as well as performs sorting up of environmental information disclosure elements through discussion on corporate environmental responsibility, environmental justice specialization, green finance, social supervision system from the aspect of Environmental Law.

Keywords: China’s environmental legal system; Environmental information disclosure; Sustainable development; Secondary source risk control

I. Introduction

Energy industry is a representative industry in heavy pollution industries. Listed companies in energy industry encounter great environmental risks, which can be classified as "external environmental risks" and "internal environmental risks". "External environmental risks" refer to adverse effects on environment caused by enterprises; and "internal environment risks" refer to enterprise' benefit risks due to detrimental behaviors to the environment. The prevention of such two kinds of risks takes sustainable development as the core. The difference is that the prevention of "internal environment risks" sets enterprise sustainable development as objective. The "external environment risks" set environment sustainable development as objective.

The potential external environment risks of energy industry are extremely huge. In China, within the heavy pollution industry scope identification issued by official side, energy industry accounts for a proportion over 20%. Internal environment risks resulted from external environment risks are aggravating. Such aggravating is originated from combined action of external environmental risks, laws and regulations, among which laws and regulations are "multiplier[i] variables"(see Figure1). For listed energy companies involving numerous stakeholders, it is extremely essential to control external and internal environmental risks as well as realize internalization[1] of outer environmental costs. In addition, from the aspect of collectivity[2] in terms of academic significance, to conduct studies on energy industry environment issues, firstly, can compensate for the deficiency of specialized research in energy field; secondly, can avoid the influence from fixed thinking modes in traditional system or judgment which will probably lead to insufficient of cognition on "energy" characteristics, thirdly, will increase cases handling technical supports and master information accurately.

With the issuing of the newly modified Environmental Protection Law of P.R.China (hereinafter referred to as the new Environment Protection Law), listed companies' environmental risks have been further accumulated. Environmental information disclosure, as an effective method of communication between enterprises and the public, is of vital importance.[3] Moreover, it is an effective method for environmental risk control of listed energy companies. Environmental information disclosure can motivate companies to improve the capability of responding to environmental risks in the future. [4]Furthermore, adequate environmental information disclosure has positive significance for both company investors' decisions and public assessment: To disclose greater amounts of information lead to less underpricing in general and higher valuation overall.[5] Undoubtedly, performing enterprise self-discipline check and public supervision through information disclosure before listing is one measure belongs to beforehand prevention measures to a certain extent. Additionally since its priority degree is lower than other measures, we named it "secondary" source risk control.

[i] Multiplicative relationship, namely: external environment risks * legal policy regulation ≈enterprise internal environment risks. Since factors which affect enterprise internal environment risks also include public opinion and public influence, thus "≈" is applied.

II. Basic theory and approach

1. Core basic theory[ii]: Legal system of energy and environmental legal system

With increasingly emerging of environmental issues, the society plays great expectations on enterprises, the main body of production activities, and has enhanced regulations on enterprise regulatory system. The impact of [6]securities laws and regulations' changes on listed company is self-evident, one influence worth of discussing on "energy" listed companies is from variations of environment correlative factors in securities laws and regulations; the impact on "energy" listed company of environmental laws and policies is based on the core theory of "energy environmental protection". (See Figure 2)

Energy has close relationship with environmental protection. Innovation and deepening of energy environmental systems are inseparable to energy sustainable development. Environment protection is also a principal line for energy law revolution. [7]The fundamental philosophy of "harmonious development of energy and environmental protection" runs throughout energy laws preparation in China. [8] After issuing of the new Environmental Law, it has become a fundamental law in China's environmental law field. It possesses the property as expectant basic law[iii] and is now the supreme law in China's environmental legal system. It is the reason for setting Environment Protection Law as discussion core of "external factors".

2. Logical method: Divergent researches and converse studies

Divergent researches ——To conduct researches on environmental information disclosure elements of listed company, we set Environment Protection Law as discussion core of "external factors". Generally speaking, its "external factor" shall include external and internal laws and regulations of energy environmental protection. However, they are still within environmental law category. Therefore, we set the new Environment Protection Law as center and take provisions changes of the new Environment Protection Law as reference. Furthermore, we perform discussion on China securities regulatory system adjustment that is indicated by modification of Securities Law of China in 2015 to master listed energy companies' environmental information disclosure elements under "The New Normal"[iv]. (See Figure 3)

[ii] Performed research on energy listed companies environment information disclosure under the new context of China Environment Law. The basic theory not only include " energy environmental protection", but also other aspects such as energy safety, risk prevention and control, enterprises and environmental sustainable development, information disclosure. Due to space limitation and the main purpose of the paper, only energy environmental protection is specified in detail.
[iii] China's socialist legal system has been established, however, there is no environment protection law available. It is subordinated to Law of Economy. At the beginning of amendment of Environment Protection Law, experts in Environment Protection Law area strong appealed to determine its juridical status, however, without successful results eventually. In official statement of the new Environment Protection Law, it is determined as playing fundamental and basic roles.
[iv] "New Normal" was proposed by Erian, the president of The U.S. Pacific Fund Management Companies. It refers to low increasing process of economy after crisis of international finance. Starting from stage characteristics of economic development, Chinese government provided a new definition referring to a new development trend which will continue for a period of time. Refer to Chen Qiqing(2010). Correct Understanding and Adaption to "New Normal". China National Conditions and Strength,10,22.

Converse studies ——To conduct converse studies according to the research of traditional environmental protection verification and disclosure requirements as well as the research of the new context of China's environmental legal system. In the two aspects, the later one is the focusing point of the research as shown in Figure 3. It reversely promotes and systemized listed energy companies environmental information disclosure elements by taking specific requirements of environmental system such as "corporate environmental responsibility strengthening", "environmental justice specialization", "green finance", "social supervision system" as retracing points.

III. Discussion on new context of China's environmental legal system and the Elements

There are no detailed, systematic laws and regulations on environmental information disclosure of listed companies in China. No formal environmental information disclosure system has been established at present. [9]Currently, the environmental information disclosure institutional framework of China is composed of scattered regulations (no laws involved).[10]The causes of the situation include: on the one hand, before issuing of the new Environment Protection Law, environmental illegal cost of pollution enterprises in China is low, so is environment illegal external cost the influence of which is not great. Therefore, ignoring environmental information disclosure as an important mean for "secondary source risk control"; on the other hand, "green securities", "green credit" are under developmental stage without comprehensive correlation established; besides, in the past, environmental protection verification of listed companies were mainly conducted by government environmental protection department, under the circumstance of which, the government is at active status and internal environment risks were dispersed to a certain extent.

1. Revision of Securities Law and "No. 149 document"

The amendment of Securities Law of China has been taken into consideration for long time. In the amendment draft released on April 20, 2015, registration system program is specified and stock issuance verification system is canceled. The adjustment of securities supervision system in China is to set information disclosure as central content in natural and to make market participants to assess asset quality, investment value of issuer. Registration system and verification system are not completely separately. For example, when the United States is implementing registration system and focusing on information disclosure, it has been gradually enhancing substantive reviewing on some issuers with high risks, as well as implementing coordinating registration system with authorization characteristics or performing approval system of substantive approving. Undoubtedly, listed energy companies[11] are within the range of such high-risk issuers. Therefore, it is necessary to make information disclosure system do more. Closely associated with this, Ministry of Environmental Protection of China issued Notification on Reform and Adjustment of Environmental Protection Verification Working System (EI 2014[149]), "No. 149 Document" for short, which canceled environmental protection verification for listing and reduced some other unnecessary pre-verification.

Specific to this, China Securities Regulatory Commission (CSRC) presented that environmental legal compliance has always been a key point for CSRC issuing verification. In the future, information disclosure requirements and agency verification responsibilities on environmental protection will be further enhanced.

When combining with amendment of Securities Law and "No. 149 Document" contents, first of all, actually there is no change on environmental protection verification requirements performed by CSRC. It was just transferred the provisions to IPO environmental information disclosure. Enterprises will be subject to stricter environmental disclosure requirements, especially those in high-risk industries, such as energy industry. Secondly, it is noteworthy that the abolishment of a large number of listing environmental protection verification documents makes environmental information disclosure system that composed of relevant regulations fall into difficult situation once again. In order to ensure institutional framework not "collapsing", although relevant documents and provisions have been abolished, substantial contents except for procedural rules, such as verification scope and standards still can be continually used during practical application process.

2. New Environment Protection Law of China

The revised Environment Protection Law was issued on April 24, 2014 and was put into force on Jan. 1, 2015. Although the new Environment Protection Law has enhanced government responsibility and social responsibility, however, not weakening environmental responsibility of enterprises: The legal responsibilities become stricter. In terms of legal responsibility type, the new Environment Protection Law has performed effective integration of environmental criminal liability, civil liability, administrative liability. In terms of legal responsibility implementation, the new Environment Protection Law applies daily penalty, frozen, distraining, detain and other measures which provide legal guarantee for duty fulfillment.

As indicated in the Table 1, the new Environment Protection Law has strengthened entity responsibility of enterprises on environmental pollution (Table 1: item 1-5). Furthermore, on the premise of expanding rights of competent department of environmental protection, it actually intensified a crack down of on environmental illegal activities. The internal environment risks of energy industry and other high-risk fields have sharply increased (Table 1: item 6-9). In addition, the proposal of other relevant systems is closely related to enterprises behavior and interests. All variations on such items are important reference for listed energy companies' environmental information disclosure. For part of them, disclosure elements can be extracted directly from specific contents of the new Environment Protection Law, such as item 1, 2, 3 and 5. For the other part, disclosure elements can be extracted indirectly from specific contents of the new Environment Protection Law, such as 9, 10, 11 and 12.

How to generate indirectly extracted disclosure elements? As shown in Table 1 and Figure 3, the indirectly extracted disclosure elements are mainly from three aspects, namely "environmental justice specialization", "green finance requirements" as well as "other laws and regulations on environmental information disclosure":

Environmental justice specialization ——Environmental justice is the main mode to transfer enterprise external environment risks into internal environment risks. It is a carrier of the external cause to work. The life of law lies in implementation. Justice is the most formal and ultimate law enforcement mechanism. [12]China's environmental justice specialization was originated from 2002. The issuing of new Environment Protection Law has established a foundation for the concept of environmental justice specialization. On the one hand, the operation of environmental judicature is based on democratization of modern environmental management. Social public demands have become an important driving factor for environmental justice mechanism starting up, running as well as effects implementation. Thus it has become an essential mark for environmental judicial specialization and mechanism establishment. Public participation in environmental justice mechanisms is a deeper layer of judicial democratization and socialization. On the other hand, compared to traditional judicial litigation mechanism, evidence verification of environmental judicature has stricter requirements on technical rules. From the two aspects, China's environmental judicial sets trial as the core, and mainly includes judicial case transferring (link between administrative law and criminal law), environmental damage identification, compensation for damages, public interest litigation and so on.

Judicial case transferring mainly refers to transfer environmental case to certain content of severity to judicial department for processing. Besides judicial custody transfer specified in Clause 63 of Environment Protection Law, it mainly presents "link between administrative enforcement of environmental laws and environment criminal justice." In the new Environment Protection Law, only regulatory Environmental Law applicable to criminal judicatory of the environment and resource offense is Clause 69. But through applicable standard, the environmental criminal liability shall be introduced to specific implementation of Criminal Law of the People's Republic of China and Criminal Procedure Law of the People's Republic of China. Similarly, [17]civil litigation will be introduced to Civil Law of the People's Republic of China, Tort Liability Law of the People's Republic of China etc. For both civil and criminal cases, evidence verification is the key point. Consequently, evidence type and verification method have become basis for environmental justice evidence verification. Evidences are often the consequences resulted from corporate behaviors. Therefore, such evidences requirement should be included to research category of disclosure elements.

Environmental judicial authentication is of vital importance for environmental justice and with decisive function for environmental justice results. In June 2014, the Supreme Court of China declared clearly that the comments on enhancing communication between environment and resources protection administrative law enforcement organs as well as judicial authentication competent departments and promoting improvement of environmental judicial authentication and damage consequence assessment mechanism.[13] Since Environmental judicial authentication is directly related to case nature, penalties, damages, it is a key point associated with internalization of environment cost, the elements of disclosure shall absorb appraisal contents and requirements of environmental judicial authentication ——especially reference in energy industries. Thus it can be conducted reversely that what enterprises' behaviors are on the edge of illegal. It is conducive to prediction of external and internal environmental risk and further perform effective information disclosure, costs control and risk reduction.
Environment public interests litigation is an important form of environmental justice

and enterprise social supervision. China has been accelerating preparation of environmental public interest litigation judicial interpretation: Further indicate plaintiff qualification, prosecution conditions, jurisdiction, burden of proof sharing, evidence verification, litigious claim scope, legal responsibility bearing, judgment and implementation, private benefit lawsuit and public interest litigation linking and other specific standards. Among which prosecution conditions, burden of proof sharing, evidence verification, litigious claim scope, legal responsibility bearing should be included into research scope of disclosure elements. The reasons are the same with that for judicial transfer and judicial authentication.

In conclusion, with deepening of specialization of China environmental justice specialization the determination generated by aforementioned contents are closely related to trial results, which will further affect enterprise environmental costs. We should take judicial specialization elements as a database in researches on disclosure elements.

Green finance —— "Green-credit Policy", "Green Insurance", "Green Securities" which jointly form China's green financial system. Based on the adjustment of new Environment Protection Law, we mainly set Green Securities and Green Insurance as the main factors. Before discussion of the two aspects, it is necessary to pay attention on the regulation of "credit file" specified in Clause 53 Item III of the new Environment Protection Law: Environment protection and other relevant departments shall record environmental illegal information of enterprises and institutions and other production operators into enterprise social credit archives and show lawbreakers list to the public in a timely manner. An outstanding feature of China's environmental legal system is "cooperative supervision". Thus for enterprises with environmental blemishes, securities market supervision department can limit those enterprises' listing process or can stop continuous fund-raising for those listed companies, which has verified once again that under the new context of China’s environmental legal system, external environment risks will cause increasing of internal environment risks for high-risk industries such as energy industry. “Risk” runs through all links from insurance theory to practical operation. Insurance is a kind of “claim transfer” as well as “risk diversification” based on risk judgment. [14]

Green insurance[v] is an insurance to compensate for the damage to a third party caused by enterprise contamination accident.[15] It is important to note that the insurance premium of environmental liability insurance is in direct proportion to enterprises environmental risks. If the risk is extremely high, the high premium will make enterprises suffer from heavy burden. [16] Insurance companies also need to perform enterprise risks evaluation, prevention and control, during which enterprises shall provide corresponding environmental information. Thus insurance types, requirements and insurance premiums are reference elements for studies on environmental information disclosure.

"Green Securities", as an important part of green finance. It is a modern securities pattern that includes environmental protection verification, environmental performance evaluation and environmental information disclosure into securities market indicator. [17]Environmental information disclosure is a footstone of Green

[v] No discussion on insurance type involved in the paper. It is discussed based on commercial insurance.

Securities, most of discussions and researches set environmental accounting information studies as core. [18] Gree and Bebbington (2004) proposed that environment accounting refers to accounting items responding to environmental matters.[19] Information disclosure is an essential basis for interest relevant parties to make correct decision. Therefore, environmental accounting information is an important element for environmental information disclosure of listed energy companies.

"Green-credit policy" focuses on source control and restrict its production scale expansion fund source; in "Green insurance", high-risk enterprises are to eliminate malpractice through purchasing insurance; "Green securities" set entry threshold for enterprise that hope to seek financing by listing on the stock market, and contain excessive expansion through regulating of social fund-raising. [20]Performing converse studies that starting from environmental information requirements in the above three policies is quite benefit to extract the essential elements of environmental information disclosure.

Other laws and regulations on environmental information disclosure——Mainly refer to other environment information disclosure regulations that aimed to ensure right of public acquisition especially the environmental information disclosure requirements in these regulations. In Dec. 2014, MEP issued Environment Information Disclosure Method of Enterprises and Institutions, which specified that major pollutant discharging entities shall show basic information (including main production, business operation and management services, products and scale), pollution discharge information(including pollutants, discharging method, discharge outlets and arrangement, total pollutant discharge, over emission status of main pollutants and characterized pollutants, as well as pollutant emission standard, verified emission amount), construction and operation status of pollution control facilities, environmental impact assessment of construction projects and other environmental protection administrative permission, environmental emergency contingency plans and so on by means of information or disclosure of information, news media, hotline, enterprises' information equipment etc. The enterprises failed to show such information according to provision shall be subject to penalty. In April 2015, China General Office of the State Council issued Government Information Disclosure Key Points of 2015 that enhanced contents of state-owned enterprise as well as environment information disclosure, focusing on the requirements to disclose nuclear and radiation safety approval information, as well as radiation environmental quality information of nuclear power plants. Other applicable standards include Cleaner Production Promotion Law of P.R.China, Environment Information Disclosure Rules (Trial) in 2008, National Major Monitored Enterprises Self-monitoring and Information Disclosure Rules (Trial) et. al.

4. Supporting systems of the new Environment Protection Law

The new Environment Protection Law of China is also known as the most rigid Environment Protection Law in China's environmental management history. For certain items that can be applied as indirect reference of the research, we should pay attention to a series supporting regulations of new Environment Protection Law (See Table 2). The severity of "penalty" is the reason why we say it is "rigid". For example, according to Implementation of Daily Penalty Regulation in Environmental Protection

Competent Departments, it can be seen that information on pollutant emission, discharging outlets arrangement, monitoring data record method, running information of anti-pollution facilities etc. shall be focused on. And another example: Notification on Implementation of Environmental Civil Public Interest Litigation System provides directional guidance for evidence material required for People's Court, including EIA documents, environmental approval and regulatory, pollutant emission, administrative punishment and punishment basis etc. We could deduce conversely the elements of listed energy companies' environmental information disclosure elements through specific contents of the regulations.

IV. Conclusion

With the termination of listed companies environmental protection verification, China's securities regulation has gradually transferred to "registration system", on the one hand, the environmental information disclosure responsibilities have been completely transferred to the market and the intermediary institutions increased responsibilities; on the other hand, for energy enterprises, being limited by lack of environmental expertise, it is impossible to perform comprehensive verification.

For energy heavy pollution industry, environmental protection issues have always been a key filed concerned by CSRC. Then how to improve environmental information disclosure system? Energy industry encounters huge environment risks. With listing of a company, various kinds of risks will expand correspondingly. To realize "secondary source risk control" by means of "environmental information disclosure" is an approach to control expansion of risks. Environmental risks are classified as "external environment risks" and "internal environment risks". The classification standard to distinguish external and internal is not as risks originated from internal or external, but the external or internal risks resulted from. The natural attribute of an enterprise is to pursuit for interests. It is necessary to perform internal risks control thus to ensure enterprise benefit. However, the cause for internal environment risks is external environment risks under the effect of laws and regulations and regulatory documents. In other words, without constraint of laws and regulations and regulatory documents, external environment risks resulted from pursuing of benefit maximization will not pose any threat to enterprise.

With strengthening of sustainability, the influence and constraint on environmental information disclosure behaviors of enterprises from relevant laws and regulations become more and more obvious. Maxwell et. al. (1998) proposed that regulatory factor, referring to current or prospected regulations on environmental information disclosure, is an important driving factor for environmental information disclosure. [21]Thus it can be indicated that on the one hand, environmental information disclosure of energy enterprises require more perfect overall system as well as professionality; on the other hand, during the process of improving environmental information disclosure, we should pay attention on effects of environment regulations, selectively inherit the previous environmental information disclosure system as well as perform sorting up on relevant factors of Environmental Law and regulations.
Although China environment departments no longer take responsibilities on listing

environmental protection verification, and relevant documents and provisions have been abolished, substantial contents except for procedural rules, such as verification scope, standards still can be used as effective reference for IPO intermediaries to perform environmental protection verification. Consequently, the previous scopes, methods etc., are still essential indicators for listed energy companies' environmental information disclosure. In terms of verification objectives, mainly cover 16 industries, in which energy industries mainly include thermal power generation, petrochemical, coal and mining. Combining with classification of China's energy industry, it can be expanded to coal, electricity, petroleum, natural gas, nuclear power, certain renewable energy and energy conservation industries. [22] Verification contents include: environmental protection technical report, "environmental impact assessment", implementation of "three simultaneousness", implementation of pollutant discharging license, total emissions of main pollutants, pollutant emission status, industrial solid waste and hazardous waste disposal, steady running of environmental protection facilities, if any banned substance exists, status of enterprise environment regulatory authorities and management system building, if any environment violation.[23]

Through divergent researches and converse studies, the elements obtained by the study can be generally concluded as two layers, namely "specific elements" and "pocket elements":

"Specific elements" refer to basic specific elements of listed company environmental information disclosure (or so called "elements"), for example energy type, manufacturing technique, pollution prevention and control technology, environmental responsibility files, related personnel list, monitoring equipment status, original data, main pollutants and discharge way, emission concentration and total, overload emission status, etc.. All these elements are from (or based on): relevant laws and regulations related to the new Environment Protection Law.

"Pocket elements" refer to a packet include specific elements. For example, energy and environment accounting reports, environmental liability insurance, environmental protection credit etc. are pocket elements including "specific elements". In further studies, the "pocket" should be under down-break studies in the future.

In conclusion, when applying environmental information disclosure to realize "secondary source risk control", we shall take adequate consideration on the effects of laws and regulations during formation of risks, and set risk factors as environmental information disclosure elements to disclose properly by means of enterprise self-audit, public informed as well as specification verification.

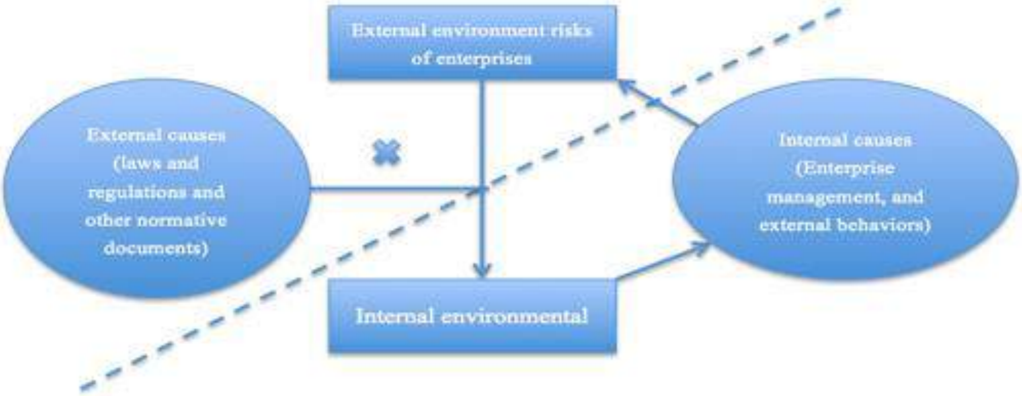

Figure1: Environmental risk balancing of energy enterprises

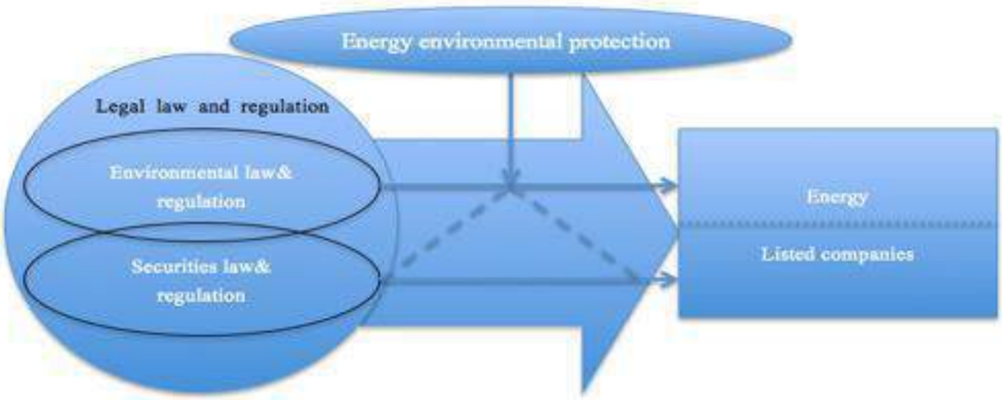

Figure2: Internal environmental risk factors of listed energy companies

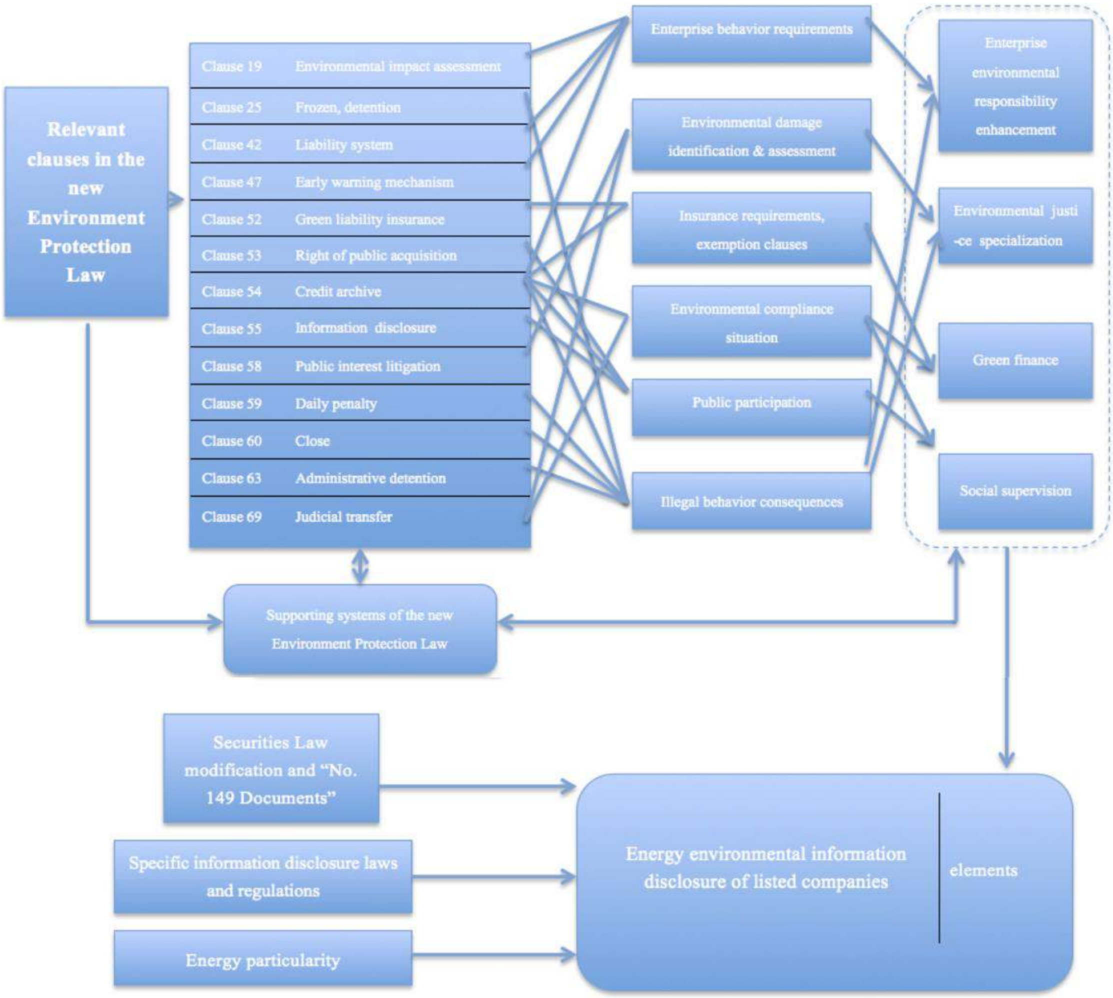

Figure 3: Elements Sources of Energy Environmental information of listed companies

		Clause	Contents description	Disclosure elements/other references
1	Enterprises' main body responsibility	Environmental impact assessment (Clause 19)	It expanded project scopes requiring environmental impact assessment: Specified that all items exploitation and utilization planning as well as projects with influence on environment have to be assessed on impacts to environment. Otherwise, it shall not organize implementation or under construction. Enterprise scope, EIA contents	Enterprise scope, EIA contents
2		Accountability system (Clause 42)	Stipulated that enterprises and institutions with emission pollutants shall establish responsibility system to specify responsibilities of person in charge and relevant staff. Major pollutant discharging units shall install and use monitoring equipment in accordance with relevant provisions of the state and monitoring specifications to ensure that monitoring equipment can run normally and keep original monitoring records.	System documents, Responsible personnel or relevant personnel list, Monitoring equipment status, Original data
3		Early warning mechanism (Clause 47, item III)	Enterprises and institutions shall prepare environmental emergency contingency plan in accordance with relevant provisions of the state, as well as report to competent departments of environmental protection and relevant departments for filing.	Predetermined precept documents, Ancillary facilities
4		Credit file (Clause 54, item III)	Implement pollution enterprise blacklist system, record environmental illegal information into enterprise social credit archives and show lawbreakers list to the public in a timely manner.	Directly refer to government list. Securities market supervision department can limit those enterprises' listing process or continuous fund-raising for those listed companies.
5		Information Disclosure (Clause 55)	Major pollutant discharging units shall show the name of main pollutants, emission method, emission concentration and total amount, overload emission, and construction and operation of pollution control facilities to the society, and accept social supervision.	The name of main pollutants, Emission method, Emission concentration and Total amount, Overload emission status, Facility status
6	Expanded competent department of authority	Frozen, detention (Clause 25)	Pollutants emission in violation of provisions of laws and regulations may cause pollution facilities frozen, detention by environment agencies.	Compliance verification
7		Daily penalty (Clause 59, item I)	Introduced daily penalty system and enhanced fines illegal dredge, increased illegal cost.	Compliance verification, Company's assets status
8		Closure, shut down (Clause 66)	For enterprises with over pollutant emission exceeding pollutant cap control, the competent departments of environmental protection may order them to take production restraint, suspend production for remediation; If the circumstances are serious, upon approval of the people's government, may order the enterprises to shut down.	Compliance verification
9		Administrative detention/justice movement (Clause 63, 69)	For infringing company, the directly responsible personnel will be subjected to administrative detention implemented by government department in charge of environmental protection or other relevant departments to public security organization. If the case constitutes a crime, shall be investigated for criminal responsibility according to law.	Compliance verification, environmental damage appraisal requirements (may coincide with item 1-5)
10		Environmental liability insurance (Clause 52)	Environmental insurance system is specifically proposed in legislation which encourages enterprises to purchase environmental pollution liability insurance.	Insurance amount and types (For enterprises not purchased any insurance, shall take insurance conditions as reference)
11		Right of public acquisition (Clause 53)	Citizens, legal persons and other organizations enjoy the rights to obtain environmental information, participate and supervise environmental protection.	Implementation of corporate responsibility specified in information disclosure laws and regulations
12		Public interest litigation (Clause 58)	The organizations of environmental nonprofit litigation have been broadened and paths for the public to participating in environment protection have increased. Litigation risks of enterprises will increase, and litigation costs will increase correspondingly.	Compliance verification, litigious claim scope, Public welfare lawsuit liability, Environmental damage appraisal factors (may coincide with item 1-5), Scope of execution and degree

Table 1: Relevant clauses affecting disclosure in the new Environment Protection Law

Time	Doc. name	Issued by	Doc. No.
Regulations issued by Ministry of Environmental Protection (MEP)			
Dec. 2014	Implementation of Daily Penalty Regulation in Environmental Protection Competent Departments	MEP	Min. Order No. 28, 2014
Dec. 2014	Implementation of Frozen and detention in Environmental Protection Competent Departments	MEP	Min. Order No. 29, 2014
Dec. 2014	Implementation of Production Limiting, Shutdown for Remediation in Environmental Protection Competent Departments	MEP	Min. Order No. 30, 2014
Dec. 2014	Environment Information Disclosure Regulation for Enterprises and i nstitutions	MEP	Min. Order No. 31, 2014
Dec. 2014	Process Method of Emergent Environmental Incident	MEP	Min. Order No. 32, 2014
April 2015	Systematic Management List of Environmental ImpactAssessment on construction project	MEP	Min. Order No. 33, 2014
April 2015	Emergency Environmental Accidents Management Method	MEP	Min. Order No. 34, 2014
Normative Documents of the State Council			
July 2014	Guiding Instruction of the State Council on Accelerating Promotion and Application of New Energy Automobile	General Office of the State Council	General Office No.35,2014
Sept. 2014	Guiding Instruction of the State Council on Further Promotion of Paid-use of Emission Rights and Trading Trials	General Office of the State Council	General Office No.38,2014
Dec. 2014	Guiding Instruction of the State Council on Enhancing Government Website Information Construction	General Office of the State Council	General Office No.57,2014
Dec. 2014	Guiding Instruction of the State Council on Enhancing Environment Supervision	General Office of the State Council	General Office No.56,2014
April 2015	Guiding Instruction of the State Council on Printing Government Information Disclosure Key Points of 2015	General Office of the State Council	General Office No.22,2015

Table 2： Main supporting systems of the new Environment Protection Law

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The Construction of Low-Carbon Renewal System of **Rural Community**

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Abstract

Global climate change has been an impending cosmopolitan issue influencing human survival and development. As the basic functional unit, community is the basic space to achieve low-carbon and use sustainable idea. To cope with climate change will require substantial and sustained reductions of greenhouse gas emissions and low-carbon technology is the inevitable choice of global development. China is a large agricultural country, and the number and the average of existing rural buildings is huge so it is urgent to conduct low-carbon retrofitting of rural community and set up evaluation method of its low-carbon level to promote new rural construction. This paper proposes low-carbon renewal KPI of rural community from five aspects: layout planning, traffic and road, architecture planning and design, environment engineering and municipal engineering. Than we build an performance evaluation system of low-carbon renewal system for rural community renewal in china. The system will be used to indicate low-carbon degree for rural community renewal. Finally, the paper selects a rural community in Hubei Province as a case for practice.

Keywords: climate change; low-carbon; rural community ; KPI

Introduction

Global climate change has been an impending cosmopolitan issue, and leads to a whole new batch of problems which seriously threaten the living environment and health of humans. Countries around the world have realized a high degree of unification on controlling the emission of carbon discharge as the effective measures and method towards slowing up the climate change[1][2]. The Fifth Assessment Report (AR5) of IPCC argues that more than half of the observed increase in global average surface temperature since the 1950s was caused by the human influence. Based on the CMIPS models, it is projected that global warming will continue. Relative to 1986-2005, the global mean surface temperature by the end of the 21st century will increase by 0.3-4.8℃. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions and low-carbon technology is the inevitable choice of global development.

The number and the average of existing rural buildings in China is huge. Statistics show that rural people has reached nearly 0.618 billion, accouting for 45.23% of the whole until 2014. The overall gross area is 27.8 billion square metres and most of them don’t use low-carbon technology. As the development of rural economy and the improvement of people’s life quality, the energy demand for rural community increases rapidly. Existing rural community waste resources and destroy the environment, which also could hardly meet the strong demand for living function and quality of existing rural community. So it is urgent to conduct low-carbon retrofitting of rural community and set up evaluation method of its low-carbon level to promote new rural construction. With the widely spread of the concept of low-carbon, low-carbon community has become a new model of rural development in China and the construction low-carbon renewal system of rural community in China of has attracted many scholars. Research in this field mainly concentrated in the design of evaluation method and choosing of index system[3]-[7]. However, the above research mainly focused on low-carbon urban community while low-carbon renewal on rural community is less involved. Furthermore, they ignore the differences between the community and use the same set of index system to evaluate different communities. The evaluation results are not comparable and it's also hard to find a set of complete index system to evaluate all communities. Faced with the problem, we built an evaluation index system for low-carbon community renewal for rural community in china.

Analysis of the Low-carbon Renewal KPI of Rural Community

Key Performance Indicators (KPI) of Low-carbon Renewal of Rural Community

Low-carbon Rural community emphasizes on carbon emission reduction and carbon sink extension. It demands compact space planning , flexible traffic system , low energy consumption buildings, livable community environment ,higher energy use efficiency, perfect municipal facilities , low-carbon and environmental protection consciousness as well as effective public participation ability[8]-[10]. According to "Technical Guideline for Low-carbon Community Planning " involved in project of "National Science and Technology Support Program for the 12th Five-year Plan of China" compiled by us, the practice of low-carbon Rural community has some of the following aspects.

(1) layout planning
As the basis of low-carbon community planning, layout planning should involve a comprehensive investigation and consulting about the details of the community and the surrounding environment facilities. The content of layout planning involves community site selection, overall layout and Land layout.

(2) traffic and road
Traffic carbon emission is one of the main carbon sources of community. To build low-carbon traffic system is a main measures of reducing energy consumption and carbon emissions. The content of traffic planning involves road network system and traffic system.

(3) architecture planning and design
Building is the biggest carbon source of community. Low-carbon buildings need to save resources, protect the environment and reduce pollution, and can also provide people with health, applicable and efficient space. The content of architecture planning and design involves architecture layout, form and structure ,energy and equipment.

(4) environmental engineering
Feasible environment planning is a precondition for residents to enjoy a better life and could promote the harmony of nature. The content of environment planning involves community water environment, garbage disposal and community greening system.

(5) municipal engineering
As part of the government-led public service system and also the foundation of community construction operations management, community municipal engineering has an important position in the construction of low-carbon community. The content of municipal engineering planning involves water supply engineering, water sewerage engineering and energy system.

Structure model of KPI based on ANP

The relationships between Key Performance Indicators (KPI) of Low-carbon Renewal of Rural Community are expressed by the Tab.1. The last side of the table column identifies the corresponding influence index of the secondary index.

Tab.1 The relevance among KPI

indicator	first grade indicator	second level evaluation index	influence index
	layout planning U1	community site selection U11	U12,U13,U21,U22,U41,U42,U51,U52, U53
		overall layout U12	U11,U13,U21,U22,U31,U43,U44,U51, U52,U53
		Land layout U13	U11,U12,U21,U31
	traffic and road U2	road network system U21	U12,U13,U22,U31
		traffic system U22	U11,U12,U21,U31
	architecture planning and design U3	architecture layout U31	U11,U21,U13,U21,U22,U43,U44
		form and structure U32	U11,U31
		energy and equipment U33	U11,U31
	environmental engineering U4	community water environment U41	U42,U43,U44,U52,U53
		garbage disposalU42	U12,U22
		community greening system U43	U11,U12,U21,U33,U44
	municipal engineering U5	energy system U51	U11,U31
		water sewerage engineering U52	U11,U21,U31,U51,U53
		water supply engineering U53	U11,U21,U31,U51,U52

Considering low-carbon community system has high complexity, and some factors have influence on others, we use Analytic Network Process(ANP) to analyze influence and feedback inside. This method can help to raise the scientific of the low-carbon evaluation system. Based on the relevance among KPI the In table 1， we use Super Decisions (SD) Software to construct ANP structure model of low-carbon community, shown in Fig.1.

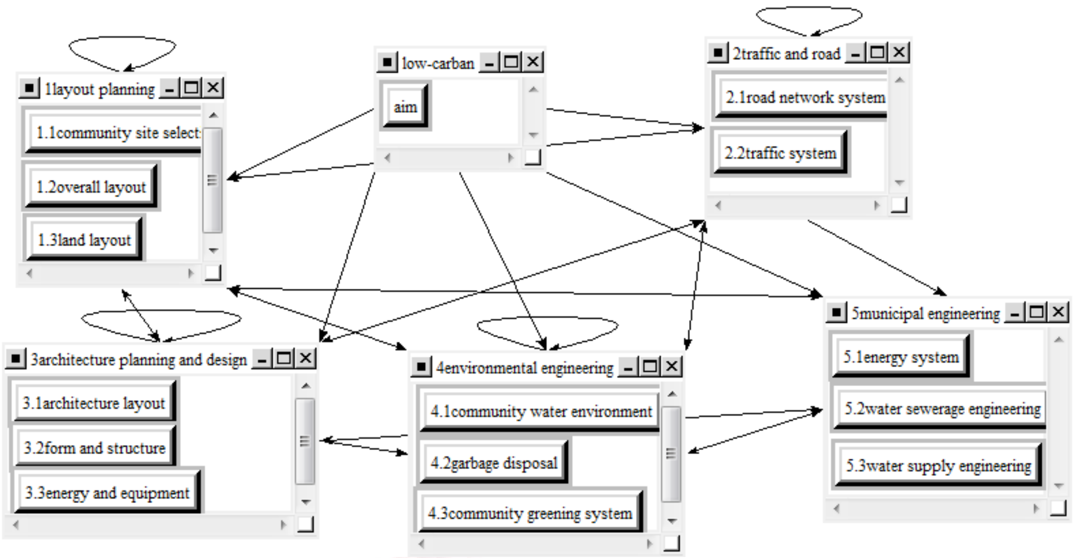
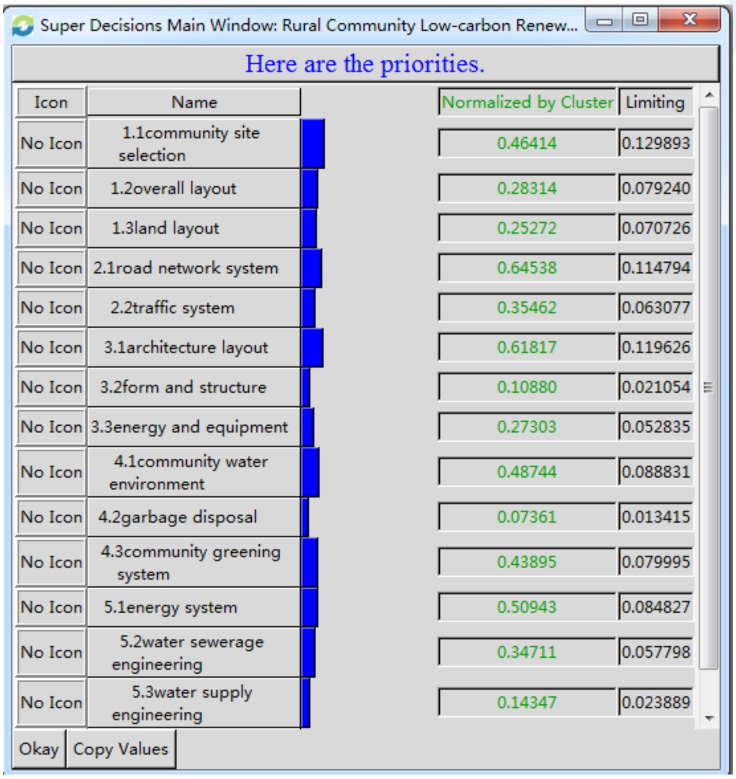


Fig.1 Structure model of index system based on ANP

After construction of the ANP structure model, we invited four experts who have taken part in the community's planning and design to do cluster comparison and node comparison and put the average data into Super Decision software. The software can automatically generated Unweighted Super Matrix, weighted Super Matrix, Limit Matrix and Cluster Matrix which can infer the weight of each index. Results of node weights which are shown in Fig.2.


Super Decisions Main Window: Rural Community Low-carbon Renew...

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	1.1community site selection	0.46414	0.129893
No Icon	1.2overall layout	0.28314	0.079240
No Icon	1.3land layout	0.25272	0.070726
No Icon	2.1road network system	0.64538	0.114794
No Icon	2.2traffic system	0.35462	0.063077
No Icon	3.1architecture layout	0.61817	0.119626
No Icon	3.2form and structure	0.10880	0.021054
No Icon	3.3energy and equipment	0.27303	0.052835
No Icon	4.1community water environment	0.48744	0.088831
No Icon	4.2garbage disposal	0.07361	0.013415
No Icon	4.3community greening system	0.43895	0.079995
No Icon	5.1energy system	0.50943	0.084827
No Icon	5.2water sewerage engineering	0.34711	0.057798
No Icon	5.3water supply engineering	0.14347	0.023889

Okay Copy Values

Fig.2 Results of node weights in SD Software

Performance Evaluation of Rural Community Low-carbon Renewal

The procedures of fuzzy synthetic evaluation

This thesis, based on fuzzy mathematics theory, applies the method of fuzzy comprehensive evaluation into the Performance evaluation of the Rural Community. When Carrying out the method of fuzzy comprehensive evaluation, what is important is to establish the assessment factors system and to define the relative weights and we use ANP structure model to get the weight.

The procedures of fuzzy synthetic evaluation approach are as follows:

(1)Determine the set of basic criteria/factors C = $\{c_1,c_2,..,c_m\}$, where m is the number of criteria.
(2)Determine the set of grade alternatives E = $\{e_1,e_2, \ldots,e_n\}$, where n is the number of alternatives. For example, e_1 = very low; e_2 = low; e_3 x= mod erate; e_4 = high; and e_5 = very high. Grades will be given for each alternative, such as 1 = very low; 2 = low; 3 = moderate; 4 = high; and 5 = very high.
(3)Determine weight for each criterion/factor W = $\{w_1,w_2, \ldots,w_m\}$. The weight of each criterion can be obtained by various approaches, for example, ANP used in this paper, expert scoring, etc.
(4)For each criterion, an evaluation is a fuzzy subset of grade set, whose membership function can be established by the risk assessment group.

The procedures of Performance Evaluation

(1)establish the evaluation set
As for low carbon community, we can establish evaluation set for low-carbon degree C = {c1, c2, c3, c4 ,c5} = { high, relatively high, moderate, relatively low, low }.

(2)Determine the single factor fuzzy evaluation matrix
We selected 10 experts in the field of low-carbon and judge the second level evaluation index respectively. Single Factor fuzzy evaluation matrix could be got by statistics.

$$U(x_i) = \begin{Bmatrix} u_{11} & u_{12} & u_{13} & u_{14} \\ u_{21} & u_{22} & u_{23} & u_{24} \\ \vdots & \vdots & \vdots & \vdots \\ u_{n1} & u_{n2} & u_{n3} & u_{nn} \end{Bmatrix}$$

x_i means first level indicators, u_{nn}means the degree of membership about the second level evaluation index towards evaluation set.

(3) Single factor fuzzy evaluation

We can reach the score of Single factor fuzzy evaluation by the following formula.

$$B_i = W_i * U(x_i)(i = 1,2,3,4,5)$$

w_i means the weight for each second grade indicator and W = {w_1,w_2, …,w_m} is generated by the SD software.

$$U = [B_1 \quad B_2 \quad B_3 \quad B_4 \quad B_5]^T$$

(4) Fuzzy comprehensive evaluation

We use the formula of B = W * U to Calculate fuzzy comprehensive evaluation score. W means the weight for each first grade indicator W = {w_1,w_2, …,w_m} and is also generated by the SD software.

(5) The evaluation conclusion

By the value of the elements in matrix B, We can get the conclusion of fuzzy comprehensive evaluation of the community.

Case study

Yanhe Eco-village is located in mountainous area in Xiangyan city of Hubei province, China. It has 12 million m^2 land including 7.33 million m^2 forest, 0.64 million m^2 basic farmland, 0.66 million m^2 tea garden, 0.07 million m^2 construction land 0.01 million m^2 water area and other land. We could view the community clearly from Fig.3 to Fig.6.

Fig.3 General planning of village construction

Fig.4 Architectural designing of green farmer house

Fig.5 Eco-building in yanhe new village

Fig.6 Old house renewal demonstration

We selected 10 experts in the field of low-carbon and judge the low-carbon effect in Yanhe Eco-village and the results are shown in Tab.2.

Tab.2 Statistic results for experts' opinions on low-carbon factors

first grade indicator	second level evaluation index	Expert evaluation score(low-carbon degree)				
		high	relatively high	moderate	relatively low	low
layout planning 0.279859	community site selection 0.46414	0.7	0.2	0.1	0	0
	overall layout 0.28314	0.6	0.1	0,3	0	0
	Land layout 0.25272	0.2	0.6	0.2	0	0
traffic and road 0.177871	road network system 0.64538	0.3	0.2	0.4	0.1	0
	traffic system 0.35462	0.2	0.3	0.5	0	0
architecture planning and design 0.193515	architecture layout 0.61817	0.5	0.3	0.2	0	0
	form and structure 0.10880	0.2	0.8	0	0	0
	energy and equipment 0.27303	0.1	0.4	0.4	0.1	0
environmental engineering 0.182241	community water environment 0.48744	0.2	0.6	0.2	0	0
	community greening system 0.07361	0	0.4	0	0.4	0.2
	garbage disposal 0.43895	0	0.6	0.2	0.2	0
municipal engineering 0.166514	energy system 0.50943	0.4	0.4	0.2	0	0
	water sewerage engineering 0.34711	0.3	0.7	0	0	0
	water supply engineering 0.14347	0.2	0.5	0.3	0	0

Fuzzy comprehensive evaluation:

$$B = W * U$$

$$= \begin{bmatrix} 0.279859 & 0.177871 & 0.193515 & 0.182241 & 0.166514 \end{bmatrix}$$

$$* \begin{bmatrix} 0.5453 & 0.2728 & 0.1819 & 0 & 0 \\ 0.2645 & 0.3645 & 0.3064 & 0.0645 & 0 \\ 0.3581 & 0.3817 & 0.2318 & 0.0273 & 0 \\ 0.0975 & 0.5853 & 0.1853 & 0.1172 & 0.0147 \\ 0.3366 & 0.5185 & 0.1449 & 0 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.3428 & 0.4080 & 0.2084 & 0.0381 & 0.0027 \end{bmatrix}$$

$$\max(B) = \max \begin{bmatrix} 0.3428 & 0.4080 & 0.2084 & 0.0381 & 0.0027 \end{bmatrix} = 0.4080$$

Form the result of the Fuzzy comprehensive evaluation, low-carbon degree of Yanhe Eco-village can be identified based on the light of maximum subject degree and the result is relatively high.

Conclusion

The aim in construction of low-carbon renewal system of rural community in China is not only to guide the construction of low-carbon rural community but also to provide t rural community residents a harmonious, comfortable, green and healthy life. Many standards have yet to emerge and the technology in rural community renewal is still in flux and we wish to put forward a more complete KPI and performance evaluation system in the future.

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A Study on the Energy Certified and Consuming of the Supermarkets in Taiwan

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Abstract
The European Union issued the "EPBD (Energy Performance of Building Directive)" in 2009, as a building energy consumption labeling standards. Taiwan's government to conform to the international trends, try to establish building energy certification especially for the retail store. The number of the country more than 1,000. Because the area in the supermarket is large, illuminate, air conditioning and a large number of refrigeration equipment, therefore the supermarket is the high energy consumption type. The average annual power density "EUI (Energy Use Intensity)" is 677 [kWh/(m2.yr)], the average annual consumption of electricity is up to 1,024,276 [kWh/yr] above. Due to the indoor area and different types of supermarket, we can't define a single EUI standard, this study through the "building dynamic partitioning EUI index " method, classify the space functions of supermarket six kinds of different energy densities, for: area A (arcade district), area B (warehouse and other space such as corridors, counters, stairwells, elevators, toilets, etc.), area C (refrigerated and frozen zone such as freezers area and equipment space), area D (food processing area such as kitchen), area E (office), area F (general goods area). When evaluating the future of the supermarket energy consume, as long as calculation the area and EUI through the dynamic EUI energy consumption evaluation method, we can immediately get a supermarket energy consumption standard, not only can be used to diagnose energy rationality of existing supermarkets, but also help the new supermarket energy forecast in the future.

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Research Origin and Purposes

EU issued the "Energy Performance of Building Directive" (EPBD) in 2009, enforcing the labeling of the building energy consumption level. The countries in EU are mandated to obtain the energy certificate, the building owners shall improve buildings to reach the energy-saving reference value specified by laws. They are graded so that the public can know the building energy consumption. In response to the international trend, Taiwan's government has conducted research on the building energy certification. As the "supermarket" is of high energy-consuming commercial buildings, it is ranked as preferential object of study to respond to the future trend of "EPBD". There are five major supermarket operators in Taiwan, the total number exceeds 1,000 (Table 1). Taiwan's supermarkets have long opening hours, and sell a variety of cold food. The annual energy consumption of a 24-hour opening supermarket is above 1 million [kWh/yr], and the monthly mean energy consumption is 83,000 [kWh/month], meaning that the supermarket is of high energy-consuming industry. The purposes of this study are: To survey and analyze the energy-consuming equipments and current operating condition of fresh food supermarkets, such as refrigerating equipments, air-conditioning equipments, lighting equipments, other equipments and number of visitors, to create the actual operating state of fresh food supermarkets. To analyze the above data to create the EUI (Energy Use Intensity) grading standards, to evaluate the rationality of energy consumption of the existing fresh food supermarkets, and to predict the estimation equation for the energy consumption of the future establishment, providing the business with evaluation tools and helpful to the promotion of the future Energy Certificate system.

Table 1. The supermarket operators and number in Taiwan

Supermarket operators	Taiwan Fresh	Jasons	MATSUSEI	Wellcome	Pxmart
Number	42	12	69		735

Basic survey of supermarkets

This study surveyed 38 supermarkets of representative "Taiwan Fresh" group of supermarket practitioners. The results can display the operating and energy consumption conditions of supermarkets.

Supermarket area analysis.

The space of supermarket is divided into "sales" and "warehouse" areas, which vary with the location and establishment year of supermarket. The mean area is 1,588 m^2, the standard deviation is 548 m^2. The largest area among the samples is 3,575 m^2, the minimum total area is 627 m^2, the difference is 5.7 times. The supermarket area is mostly 1,401~1,800 m^2, accounting for 39% of total quantity (Figure 1). According to the supermarket area ratio, the sales area and warehouse area of fresh food supermarket are influenced by the site condition, establishment year and service increase. The sales area-warehouse area ratio is mainly 1.01~1.60. The stores with an area ratio higher than 2.8 times mostly have undersized back area and poor materials circulation. If the area ratio is lower than 1.0, meaning that the warehouse space exceeds sales area. The benefit is too low for the operators (Figure 2).

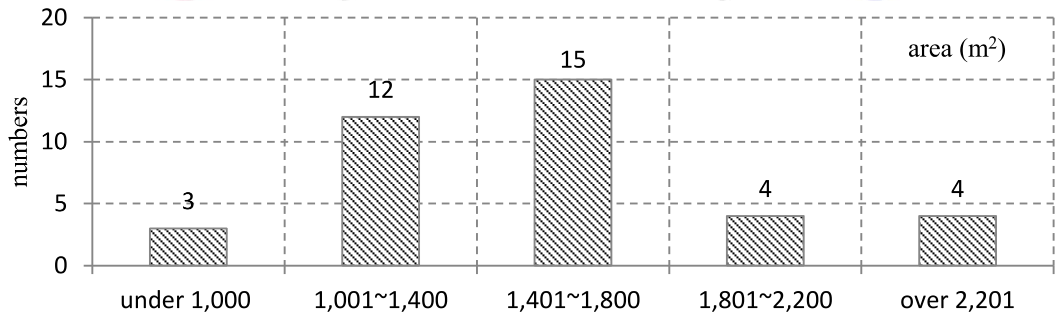


Figure 1: The supermarket area distribution

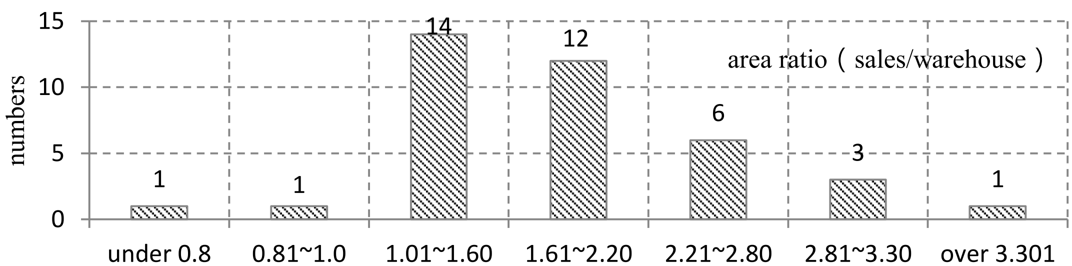


Figure 2: The supermarket sales area and warehouse area ratio

Number of supermarket visitors.

The supermarkets have different numbers of visitors as they are located in different places. The annual mean number of visitors is 349,658 person-times (about 350,000 persons), and the standard deviation is 84,606 persons. The store with the largest number of customers attracts almost 587,000 person-times annually. The store with the smallest number of customers has only two hundred thousand person-times. The mean annual number of fresh food supermarket visitors is mostly 350,000 person-times (Figure 3).

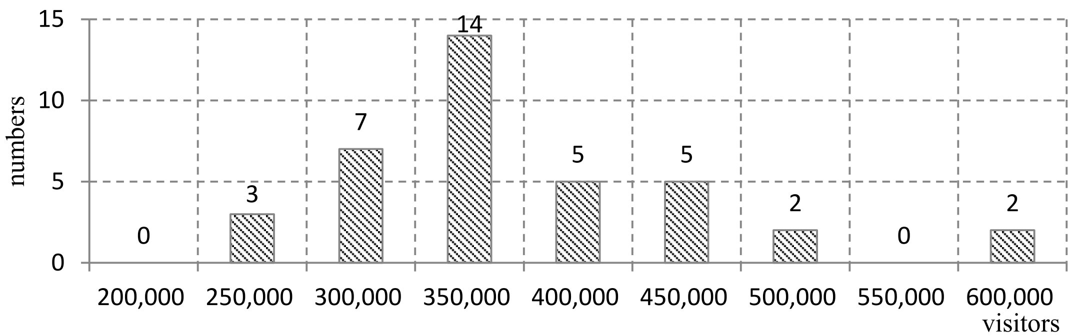


Figure 3: Number of supermarket visitors

Energy use of supermarkets

Annual energy consumption and EUI statistics of supermarkets.

There are large differences in the annual energy consumption of supermarkets due to different sales areas, numbers of visitors, equipment efficiencies and warehouse areas. The mean annual energy consumption is 959,165 [kWh/yr], and the standard deviation is 264,002 [kWh/yr]. Generally, a large supermarket has a high energy consumption. The energy consumption is positively correlated with the sales area. The correlation R is .7 (Figure 4). There is no obvious correlation between the energy consumption and the number of visitors. The correlation R is .24, meaning that the number of visitors has no significant impact on the energy consumption of fresh food supermarkets. The energy consumption is still related to the machine efficiency, quantity and operating time (Figure 5). In addition, the building energy consumption can be evaluated by the "annual EUI". The mean EUI of supermarkets is 637 [kWh /(m^2.yr)]. The EUI of 22 branches among the investigated samples is 501~700 [kWh/(m^2.yr)] (Figure 6).

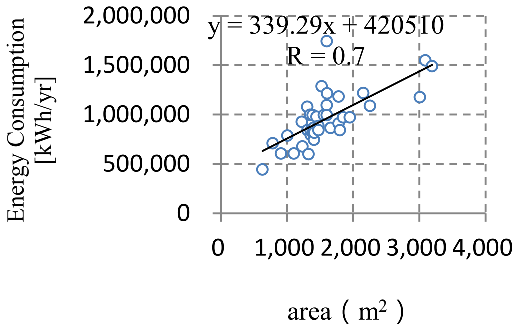


Figure 4: The correlation of supermarket area

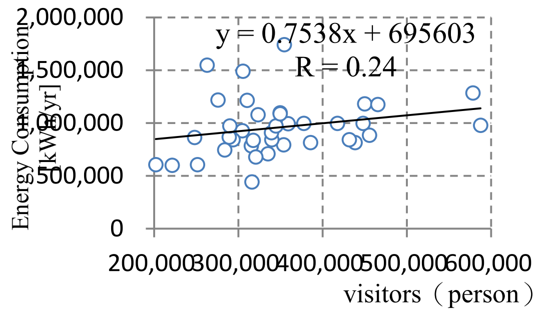


Figure 5: The correlation of visitors and energy consumption

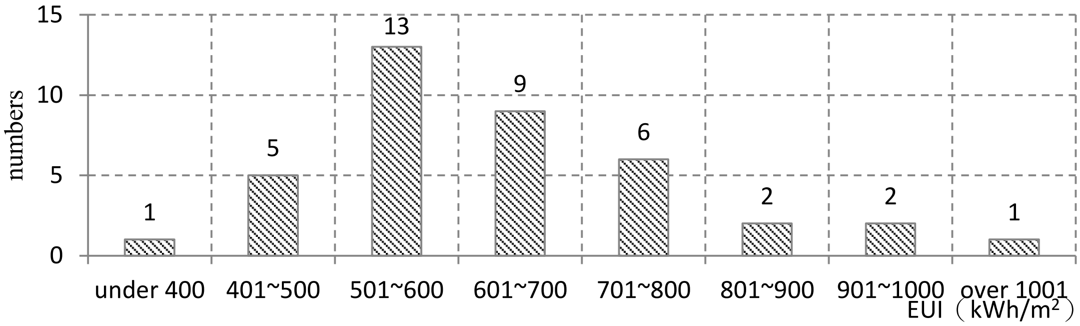
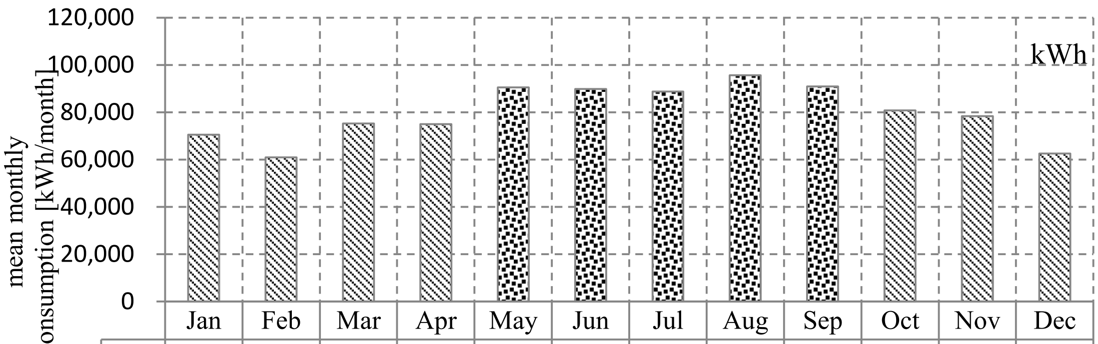


Figure 6: EUI of supermarkets distribution

Monthly energy consumption statistics of supermarkets.

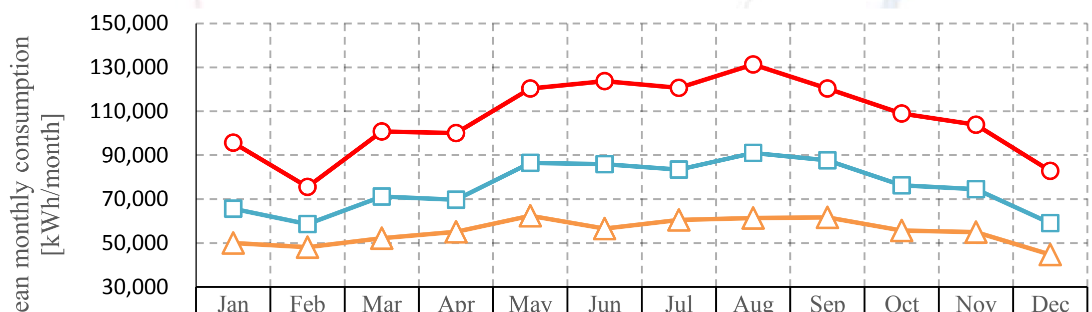
The supermarkets have the highest monthly energy consumption in August. The mean monthly consumption is 95,636 [kWh/month]. The energy consumption in February is minimum 60,972 [kWh/month] (Figure 7). The mean monthly consumption in summer is 1.27 times of that in non-summer. Due to high atmospheric temperature in summer, the refrigerating equipment load is much higher than that in winter. The annual energy consumption is divided into high energy consumption, medium energy consumption and low energy consumption levels in this study. All the samples are sequenced according to annual energy consumption, the total energy consumption below 800,000 kWh is set as low energy consumption level (first 25% of samples), that between 800,000 and 1,000,000 kWh is medium energy consumption level (middle 45% of samples), and that above 1,000,000 kWh is high energy consumption level (last 30% of samples) (Figure 8).

Low energy consumption level: the monthly mean energy consumption of this type of supermarket changes slightly. The mean monthly consumption is 55,264 [kWh/month], and the mean energy consumption in summer is 1.14 times of that in non-summer. Medium energy consumption level: the mean monthly consumption of this type of supermarket is 75,732 [kWh/month], but the energy consumption peak begins in summer (May to September). The mean energy consumption in summer is 1.24 times of that in non-summer. High energy consumption level: the mean monthly consumption of this type of supermarket is 106,983 [kWh/month], and the mean energy consumption in summer is 1.26 times of that in non-summer.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
kWh	70,56	60,97	75,22	75,00	90,52	89,85	88,73	95,63	90,96	80,84	78,34	62,50

Figure 7: Mean monthly energy consumption of supermarkets in Taiwan



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Lv.	95,682	75,522	100,70	100,06	120,25	123,64	120,64	131,28	120,37	108,93	103,80	82,871
Medium Lv.	65,520	58,530	71,149	69,636	86,421	85,847	83,323	90,997	87,627	76,246	74,490	58,996
Low Lv.	49,945	48,072	52,219	55,122	62,396	56,563	60,538	61,346	61,694	55,708	54,925	44,644

Figure 8: Compare the monthly energy consumption levels of supermarket

Supermarket equipment energy consumption ratio.

The electrical equipments of supermarkets are divided into four main classes: (1) air-conditioning equipments: various air conditioners, switched on/off with opening hours; (2) lighting equipments: supermarket lighting is approximately divided into two types, fluorescent lamps, metal halide lamps; (3) refrigerating equipments, large-scale low temperature refrigerating rooms; (4) other equipments: ovens, cash registers, microwave ovens. In terms of energy consumption ratio, the air conditioning accounts for about 6.7%, lighting accounts for about 23.7%, refrigeration accounts for about 57.7%, other equipments account for about 11.9%. The refrigerating equipments have the maximum energy consumption in supermarkets (Figure 9). This study used hand-held temperature and humidity recorder to measure the temperature of the refrigeration area of supermarket. The results showed that the cold air from the open refrigerators makes the air temperature around the area at 16.0~21.2℃, which has made customers feel cold and wasted energy. The cold overflow of refrigerated cabinets is a universal problem in Taiwan's supermarkets.

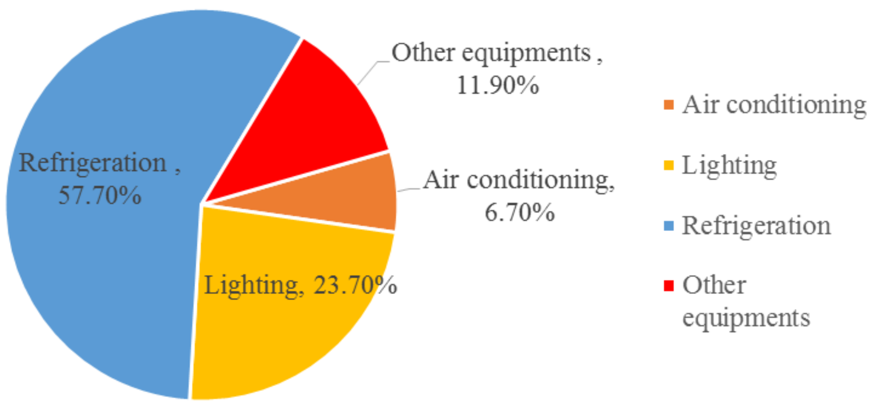


Figure 9: Energy consumption ratio of supermarkets

Indoor physical environment characteristics.

The sales area temperature range is 22.3~25.6℃, different from the standard indoor temperature 26℃ of commercial space required by Taiwan government. In other words, the air overflow from refrigerated cabinets in Taiwan's supermarkets results in too low indoor temperature. The temperature of the refrigerating cabinet area is 16.0~21.2℃, which gives people cold feeling.

A hand-held illuminance meter is used to measure the illuminance in the center of sales area and shelf area. The illuminance in the sales area is still kept at 407~567 [lx]. If the sales area is planned aiming at lighting density of 20 [W/m^2], the luminance level is acceptable.

Rapid estimation and grading of supermarket energy consumption

Dynamic EUI energy consumption evaluation method.
This study used "building dynamic EUI". The areas of different operating characteristics in the supermarket were divided, and the building energy was simulated by standardization. The EUI of six major areas in the supermarket was calculated from the standardized occupant density, equipment quantity and efficiency, operation mode, and standard building shell design. The "dynamic EUI" of the supermarket was calculated by area weighted average according to the spatial composition of supermarket. This method can estimate the energy consumption rapidly for supermarkets of different operating characteristics, more objective than the mean EUI of supermarkets. The six major areas are: Area A (arcade area), Area B (warehouse and other spaces, e.g. aisles, counters, staircases, elevators, toilets and so on), Area C (refrigeration area in sales area: the area of refrigerated cabinets in the sales area, machine rooms for backend equipments), Area D (food processing area: kitchen, cold storage for frozen food), Area E (office), Area F (dry stock area in sales area: shelf area of dry stock area) (Table 2). Take a supermarket as an example, this supermarket plane subarea usage mode is shown this figure (Figure 10). The EUI was calculated by weighting after division, and the standard EUI value of the store was 600 [kWh/(m^2.yr)]. The reasonable energy use of supermarkets can be evaluated rapidly by using this method in the future.

Table 2: Different subarea EUI of supermarket

Subarea	Division	EUI
A	Arcade area	115
B	Warehouse and other spaces (aisles, counters, staircases, elevators, toilets)	306
C	Refrigeration area in sales area: area of refrigerated cabinets, machine room for backend equipments	2000
D	Food processing area: kitchen, cold storage for frozen food	215
E	Office	130
F	Dry stock area in sales area: shelf area of dry stock area	428

Figure 10: Calculated the standard EUI of supermarket by dynamic EUI evaluation method

Supermarket energy consumption grading mode: **Relative EUI grading mode.**
This grading mode compares the "dynamic EUI value" with the "actual operation EUI value of fresh food supermarket". If the "estimated value" is greater than the "operation value", meaning that the energy consumption of store is lower than normal operation (Eq.1). The comparison value within ±5% is in reasonable range as "basic grade". A larger difference leads to a higher grade. On the contrary, if the difference is negative, the energy consumption of the evaluated store is relatively high, classified as "negative Grade I". This mode evaluates the conditions of the store, so it is "relative EUI grading" mode (Table 3).

Table 3: Supermarket relative EUI grading interval

-10.1~-15.0%	-5.1~-10.0%	±5%	5.1~10.0%	10.1~15%
Negative Grade II	Negative Grade I	Basic grade	Grade I	Grade II

$$\Delta R = \frac{Ea-Eb}{Ea} \qquad \text{(Eq.1)}$$

ΔR: Energy consumption efficiency ratio Ea: Estimated value: dynamic EUI value converted from area, or calculated value of EUI estimated by standard equipment energy consumption Eb: Operation value: EUI value of actual operation of fresh food supermarket

This method uses EUI high and low points for grading, if the supermarket implements various energy-saving means to reduce energy consumption, or the supermarket has a few equipments and relatively low annual energy consumption. This mode is in the concept of normal distribution. When the mean EUI is 637 [kWh/(m^2.yr)], in positive and negative standard deviations (standard deviation 149), this range covers 97.37% of samples. Referring to EU "EPBD", the minimum and maximum EUI values of the cases are determined. The minimum to the maximum EUI are equally divided into Grades A, B, C, D, E, F and G. In this figure, darker green represents lower EUI, it is low energy-consuming fresh food supermarket. If the EUI of a supermarket is 920 [kWh/m^2.yr], it is Grade E of relatively high EUI store (Figure 11).

Figure 11: EUI grades of supermarket in Taiwan

Conclusion

Energy consumption characteristics of supermarkets.

The mean area of Taiwan's supermarkets is 1,100~1,600 [m^2]. The annual mean number of visitors is about 349,658 person-times (about 959 [persons/day]). Larger supermarket scale usually has higher energy consumption. The energy consumption is in highly positive correlation with sales area, but there is no obvious correlation between energy consumption and number of visitors. The average annual energy consumption of supermarkets is 959,165 [kWh], and the mean EUI is 637[kWh/(m^2.yr)]. The mean energy consumption of supermarket at high energy consumption level in summer (June~September) is 1.33 times of the mean energy consumption in non-summer (October~December and January~ May). It is related to large increase in energy consumption of air conditioning and refrigerating equipments. The energy consumption ratios of various equipments of supermarkets are: air conditioning energy consumption 7%, lighting 35%, refrigeration 52%, other equipments 6%. The energy consumption of refrigeration accounts for over 50% of total energy consumption. The mean area of refrigeration accounts for about 27.0% of sales area.

Energy certification of supermarkets.

This study proposes two energy consumption grading modes, which are "relative EUI grading mode" and "absolute EUI grading mode". The "relative EUI grading mode" evaluates the energy consumption based on the conditions of supermarket. If the EUI of actual operation is higher than the standard value, the energy conservation can be further improved. The "absolute EUI grading mode" refers to EU "EPBD", classifying the EUI of Taiwan's supermarkets into A~G grades. The EUI of actual operation is put in comparison directly. It is a simple mode compared with "relative EUI grading mode", but this method has not considered different operating conditions of supermarkets (some supermarkets have more refrigerating equipments, some lay emphasis on general shelf area). Therefore, the "relative EUI grading mode" is recommended.

This study hopes that the preliminary survey of supermarket energy consumption can help Taiwan push the "Building Energy Certificate System" in the future to match the increasing trend of building energy consumption efficiency in the world.

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Light Pollution Mapping of Urban Human Activity and Land Zoning

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Abstract
Sky glow, a kind of light pollution, which brightens the night sky significantly results from the spill light of inappropriate or over-designed artificial lighting. It not only affects astronomical observations, but disturbs ecology system and wastes lighting energy. In fact, urban light pollution is related to artificial lighting made from human activities and nighttime urban facilities. However, former relative researches mostly concerned how to utilize remote sensing to evaluate large-scale sky glow for astronomy, not for urban or architectural lighting to improve the real environmental problem.

The purpose of this research is to find the relation between sky glow and urban planning, especially urban population and land zoning. The study surveyed the sky glow and then mapped it in Taichung City, Taiwan. Firstly, it measured sky glow by sky quality meter (SQM) across the whole metropolitan area by 133 points, and transformed GIS data into light pollution map with Surfer software. Secondly, it combined the light pollution map with local population density and land zoning to analyzing the local-scale sky glow causes. The result showed that high-density commercial areas have more severe light pollution, and the average brightness is 772 times of the natural moonless sky. This research provides an innovative methodology to estimate local-scale sky glow, and helps people recognize how the light pollution is to improve urban nighttime living environment in the future.

Keywords: light pollution, sky glow, GIS, sky quality mete

Introduction

Negative environmental impacts generated by nighttime lighting system are collectively called light pollution, among which "sky glow" refers to the increase in brightness of the night sky due to the scattering of the ground artificial light through atmospheric dust and suspended materials to the sky. Italian scholar Cinzano synthesized night-sky brightness distribution map by satellite telemetry data. At present, about two-thirds of the current world population lives in areas of light pollution threat, a quarter of the people cannot directly view the Milky Way with their naked eyes（Cinzano et al., 2001）.

Light pollution in large cities is more severe, where natural moonless night-sky brightness average is 21.6 mag/arcsec^2, equivalent to the luminance value of 2.1×10^{-4} cd/m^2. The night-sky brightness in Beijing is 1.3×10^{-2} cd/m^2, the luminance value of Tokyo and Osaka is about 5.8×10^{-2} cd/m^2, and that in Shanghai's commercial district is about is 1.0 cd/m^2（Li,2006）, all of which are a hundred times more than natural night-sky brightness. Increased night-sky brightness affects stargazing and means unnecessary lighting energy waste, increased CO_2 emissions and the impact of natural ecosystems.

Recent studies on the sky glow have been conducted. In addition to the first light pollution distribution map made by Cinzano using the US defense satellite DMSP and GIS（Cinzano et al., 2001）, there are studies using GIS and remote sensing method to study spatial distribution of the population and light pollution（Elvidge et al.,1997）. Regarding the prevention of sky glow, internationally, lamp "uplight pass ratio (ULR)" of No. 150 technical report（CIE, 2003） of International Commission on Illumination (CIE) is the specification recommendations.

Research Purpose

The sky glow is mainly caused by the "uplight" and "ground-reflected light." The methods to determine sky glow in the past such as satellite telemetry mostly were proposed by astronomers. However, light pollution discussed in astronomy or physics presents the macroscopic results in the wide range, and cannot exactly reflect the detailed urban design and lighting plan relationship, therefore, the urban light pollution problem can be improved in smaller scale urban planning and lighting design.

On the other hand, nearly 60% of the population in Taiwan live in light-polluted areas of high night-sky brightness. Coupled with a particular phenomenon of Taiwan's densely populated area and the mixed zoning of residential and commercial areas, urban light pollution is particularly serious. However, the study of urban light pollution in Taiwan is in an early stage. Therefore, it is necessary to understand the urban light pollution through sky glow survey and provides basic information to do the follow-up study. The purposes of this study are as follows: (1) To combine GIS to build urban night-sky brightness map ; (2) To analyze the impact of urban landmarks, main roads, and commercial centers on sky glow.

Theory and Method

“Sky glow” is the night sky brightness increase. In general, night-sky brightness is used to assess the degree of sky glow in the measurement unit of luminance (cd/m^2) or equal per square arcsec (mag/arcsec^2), which means every level magnitude differs by 2.512 times in brightness. International Astronomical Union (IAU) established in 1979 “International Standards of Dark Sky Night”. It defines the natural moonless night-sky brightness in the case of no light pollution is 21.6mag/arcsec^2. In full moon, the natural night-sky brightness is 16mag/arcsec^2. At present, CIE 150-2003 technical report is generally used as the main basic specifications of sky glow (CIE, 2003). Its “ULR” is defined as the ratio of “light uplight flux against the total flux of all lamps” to limit the spill light of the lights to avoid light pollution.

The most direct way to observe sky glow is “the computation of the number of visible stars”. The observer computes the number of stars in the night sky of a certain region in accordance with the magnitudes of well-known stars. The method can be applied in the observation of a wide range. However, naked eye observation is not suggested as there will be a considerable degree of error (CIE, 1997).

Walker’s Law （Walker, 1977） is generally used to estimate the night-sky brightness. By using the scientific quantitative formula and the “urban population” and “distance from the urban center” as the assessment factors of sky glow, the increase in night-sky brightness from the 45° perspective of the observer in the direction of the urban center can be measured. In general, Walker’s Law is applicable to the assessment of various types of sky glow. However, it is not suitable for the densely populated Asian cities without obvious boundaries.

Satellite telemetry can obtain light pollution distribution of a wide range. Many studies have used the night satellite photos taken by DMSP for wide range light pollution mapping and analysis(Cinzano et al.,2001; Garstang, 1986; Elvidge et al.; 1997 Chalkias et al.,2006). Satellite telemetry can measure the light divergence of the common outdoor lighting fixtures, such as mercury vapor, high pressure sodium vapor lamps, and low pressure sodium vapor lamps. Moreover, it can display the ratio of “artificial sky brightness light” and “natural sky brightness” by different colors.

Sky Quality Meter (SQM) is an economic and convenient night-sky brightness measurement tool with the measurement unit of mag/arcsec^2. SQM sensor combines near-infrared filters, so that results are similar with the perceptions of the human eye(Cinzano et al.,2005). At the same time, a small induction range can avoid the influence of ambient lighting. Due to small size, easiness to carry, it has recently become one of the commonly used instruments in night-sky brightness measurement and astronomical events.

Night-Sky Brightness (NSB) measurement

According to literature, the sky glow assessments from the astronomy perspective mainly display the wide-range phenomena of a wide range by using satellite telemetry. Most of studies in urban architecture fields have used handheld photometer to measure the small field (Pun & So, 2012）. As this study focuses on the urban architecture research field, the latter investigation method was adopted. Meanwhile, based on geopolitical relations, Taichung, the third-largest city in Taiwan was selected as the research subject.

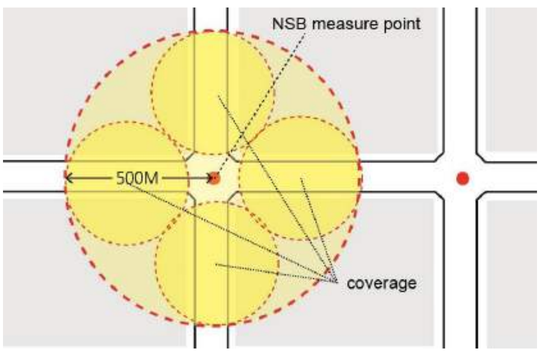
For the convenience and accuracy of measurement, this study used SQM as the instrument to measure night-sky brightness. Smaller readings of SQM mean greater light pollution. In addition, due to the building density in Taiwan's cities, the field view of the sky from the ground is relatively smaller. To avoid excessive and unnecessary light, the instrument SQM-L of FWHM (Full Width at Half Maximum) at 20° was used in this study (Table 1).

Table 1: The characteristic of SQM-L

SQM-L	characteristic	Illustration
	Handheld	Unit： mag/ arcsec^2
	Narrow Field of view	HWHM ~10° , FWHM ~20
	Single reading	No continues reading
	Small &Portable	Monitor sky brightness in a few seconds

For the consideration of the convenience of mobile measurement, by following the concept of "urban road network", the 18 major roads running through Taichung were selected as the measurement routes. The measurement was taken at every 1 km to obtain the data of network distribution (Fig.1). This study also selected 6 representative urban landmarks to measure the NSB to supplement the road measuring points. The 6 landmarks were Taichung Metropolitan Park, Taichung Industrial Park, Phase 7 Central Business District, Yizhong Street Business Circle, Fengchia Night Market Business Circle, and SOGO Taichung Business Circle.

To reflect the real NSB, measurement should avoid direct exposure to artificial light and the shading of buildings or trees. SQM-L measuring points should be set at a distance equal to the height of the facility. If there were an artificial light source nearby, it should keep at least a distance of more than 10m (Fig.2)（Pun & So, 2012）. As NSB is mainly subject to the influence of "astronomical twilight", "cloudiness" and "moon phase", therefore, the measurement time was after 20: 30 and before 23: 00. In addition, to avoid the collection of data when cloudiness changes, the investigation was conducted in days between the new moon and the full moon of sunny weather.



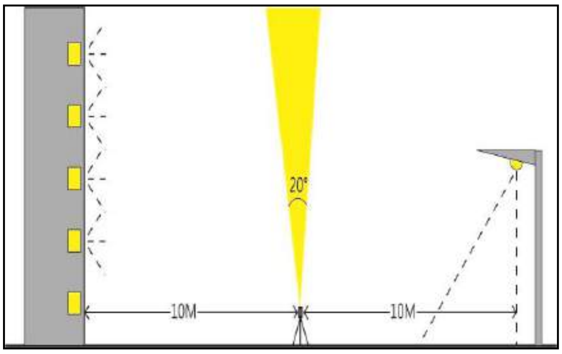
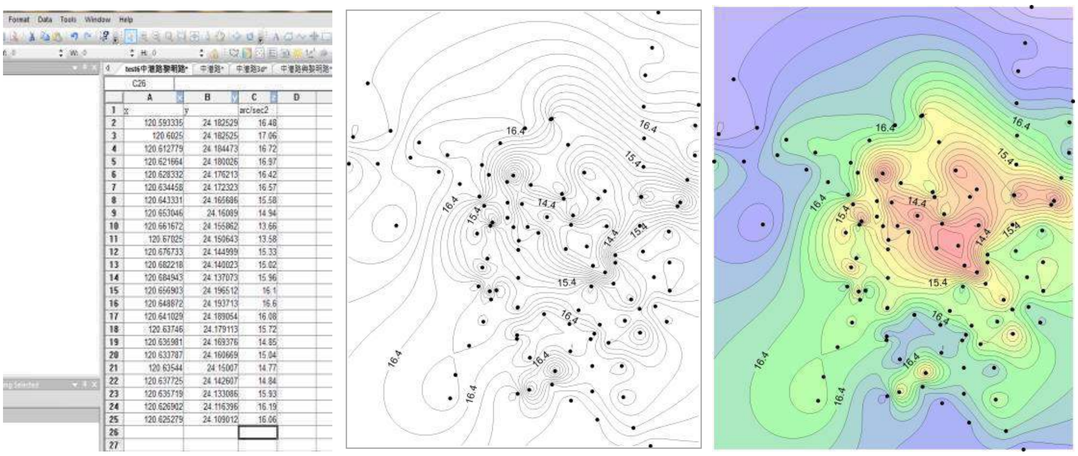


Figure 1: measurement point layout　　　　Figure 2: measure point

Establishment of NSB mapping

To combine the investigation results with GIS geographic information to facilitate the reading and interpretation of NSB, this study used Surfer software to describe investigation results and GIS in contour images to get the mapping of light pollution in a regional scale. Therefore, each measuring point of NSB was positioned by GPS to record the longitude and latitude of the location.The information of 133 measurement points were converted into XYZ three-dimensional coordinates. X represents longitude, Y represents latitude, and Z represents the measured NSB. Then, Surfer software was applied to convert the data into grid to plot the map of NSB (Fig.3).



(1) XYZ Data file　　(2) Post map　　(3) Contour map

Figure 3: Steps of NSB mapping

NSB analysis in Taichung City

In this study, NSB was used to assess the degree of sky glow in the unit of "mag/arcsec^2". Smaller readings represent brighter sky and more serious light pollution. By integrating the investigation results of 133 measuring points of 18 main roads in Taichung, it is found that the NSB of "Gongyi Rd. (14.60 mag/arcsec^2)" is the highest, followed by "Daya Rd.-Zhongqing Rd. (14.73 mag/arcsec^2)", which are the major traffic roads of Taichung (Fig.4). As the measurement range of this study has covered the range of Taichung, the average value of all measuring points at 15.78

mag/arcsec^2 can be regarded as the average NSB of Taichung. It is nearly 212 times of the natural moonless NSB, suggesting the light pollution is serious.

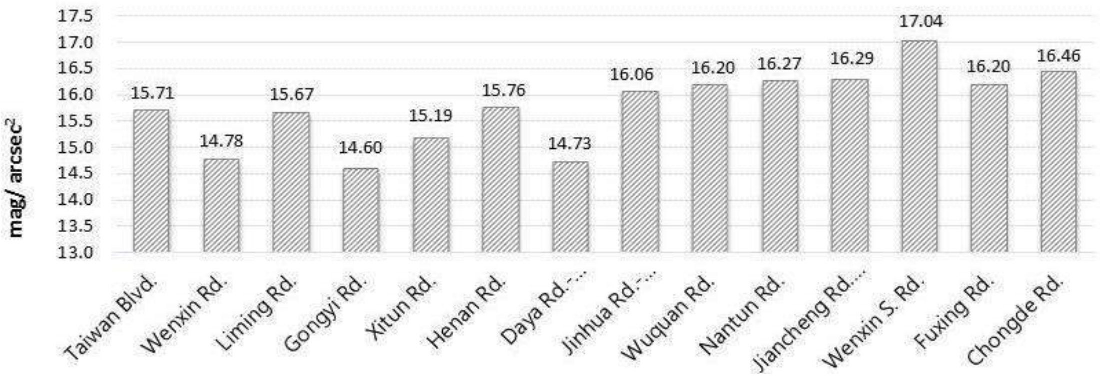


Figure 4: NSB of 18 main roads in Taichung City

Regarding the landmark measuring points, due to heavy human flow and more lighting equipment of signs and boards in the business area, the NSB of the four business areas is relatively high and the average NSB is up to 14.38 mag/arcsec^2. The average brightness is 772 times of the natural moonless NSB with the NSB of SOGO business area at 13.66 mag/arcsec^2 is the highest. The sky glow of Taichung Industrial Park and Taichung Metropolitan Park with fewer human activities is relatively lower. The NSB of them is 17.7 mag/arcsec^2 and 17.82 mag/arcsec^2 respectively, which is in the range of natural NSB(Fig.5).

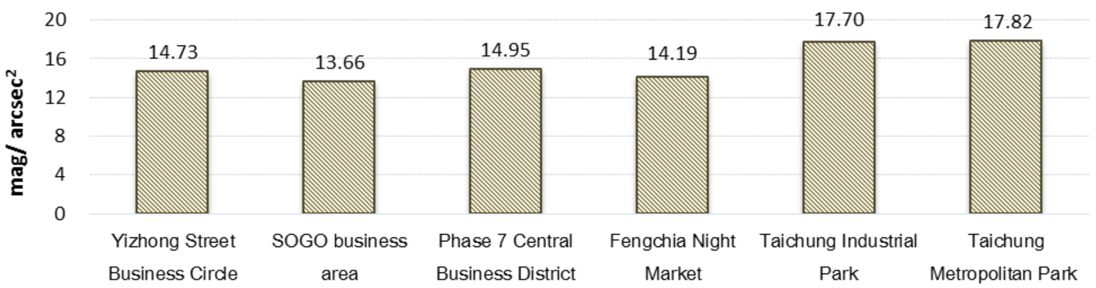


Figure 5: NSB of landmarks in Taichung City

NSB map and urban Light Pollution Analysis

The NSB data of 133 measuring points were plotted into Surfer to present the light pollution map of Taichung. Areas of bright colors and closer to the red color have higher NSB (Fig. 6). In the NSB map, the light pollution of Taichung City is separated by the outer ring road “Huanzhong Rd.” and “railway”. The downtown area to the east of Huanzhong Rd. and the west of the railway has the high NSB while the area to the west of Huanzhong Rd. has apparently low NSB. If the average NSB of the “downtown area” is 14.38 mag/arcsec^2, then the average NSB of “suburbs” represented by Taichung Industrial Park and Taichung Metropolitan Park is 17.76mag/arcsec^2. They differ by about 22.5 times in NSB. In addition, a few important roads such as Taiwan Blvd. have serious light pollution due to heavy traffic flow and human flux as well as booming business activities.

NSB of urban landmark distribution relationship is separated by Huanzhong Rd. The business areas to the east of Huanzhong Rd. are peak areas of high NSB and the most seriously light-polluted areas of Taichung. SOGO business area is the area of most serious light pollution in Taichung, and it expands along the neighboring 60m Taiwan Blvd. By comparison, Taichung Metropolitan Park and Taichung Industrial Park to the east of Huanzhong Rd. are relatively darker as compared to the neighboring area.

Taichung covers a total area of 163.42 square kilometers. The residential area is distributed in downtown and other outer areas. The commercial area is mainly distributed in the old city area and the area along Taiwan Blvd. The commercial area's NSB is roughly separated by Huanzhong Rd. The NSB of the business area to the east of the road is between 13 and 15 mag/arcsec^2 while the NSB of the commercial area to the west of the road is between 15 and 17 mag/arcsec^2. Although the area from the railway station to the downtown is a business area, it is decadent and thus the NSB is relatively darker (Fig.7).

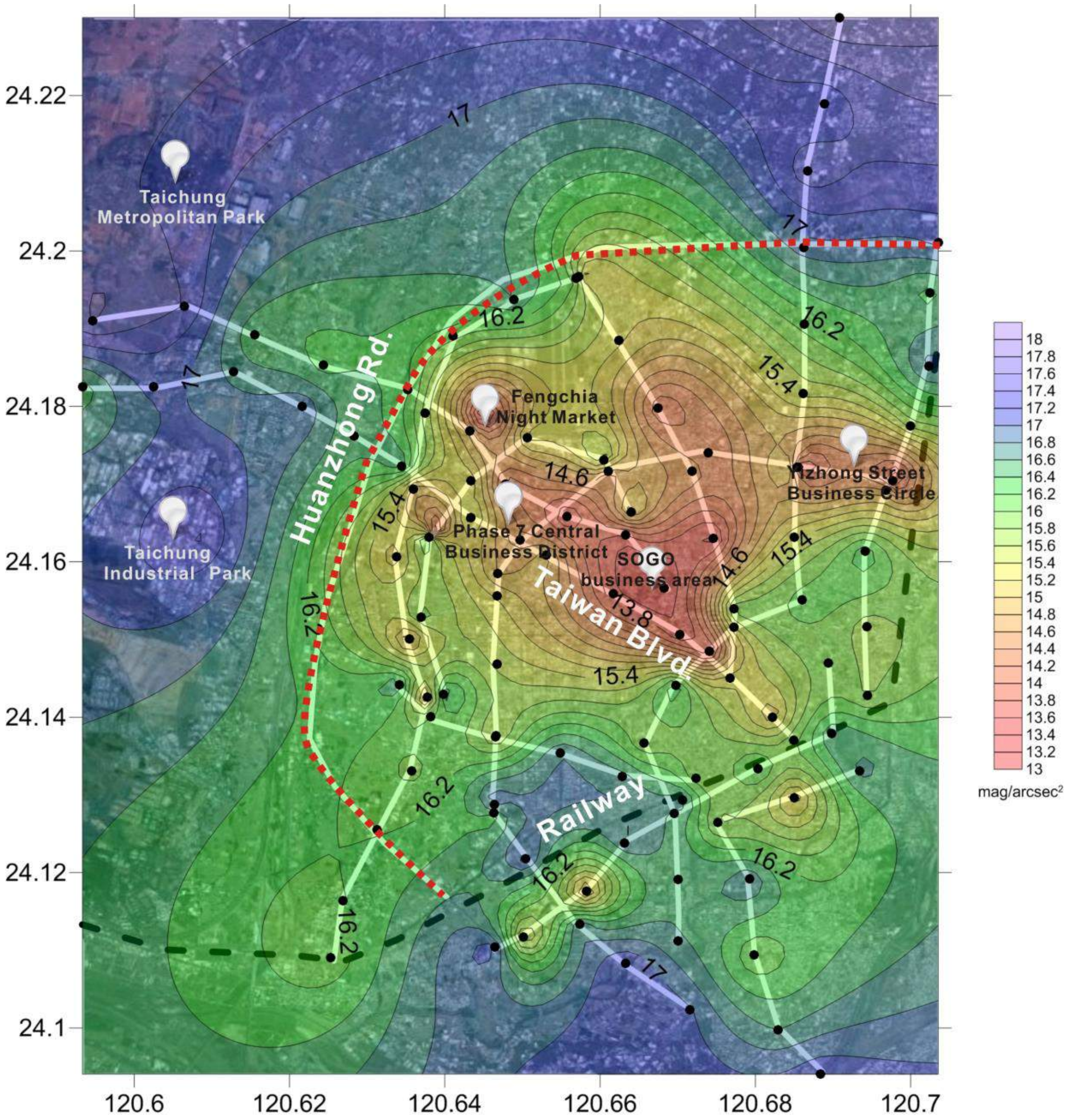


Figure 6: NSB map of Taichung City

On the other hand, the corresponding relationship of the residential area location and NSB distribution is not apparent. The NSB of the residential area to the east of Huanzhong Rd. is between 13 and 15 mag/arcsec^2, and it is between 16 and 18 mag/arcsec^2 in the area to the west of Huanzhong Rd. The area to the west of the road is low-density residential area with low building coverage ratio and floor area ratio as well as fewer artificial lighting sources. In the area to the east of Huanzhong Rd., the high-density residential area is close to the neighboring commercial area with high building coverage ratio and floor area ratio as well as more artificial lighting sources and more serious light pollution (Fig.8).

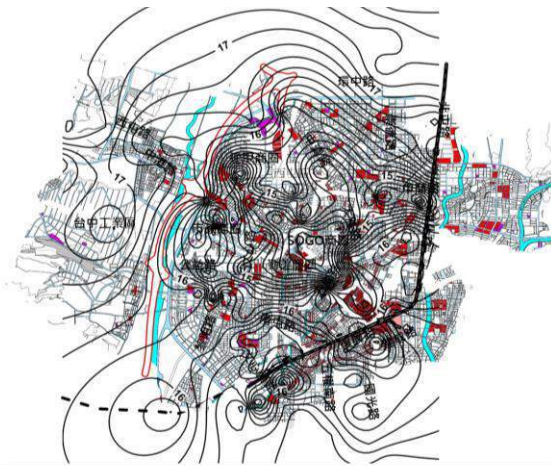


Figure 7: NSB map of commercial area   Figure 8: NSB map of residential area

Because urban lighting luminaires vary with land zoning, the NSB differs from zones, too. For example, besides basic road lighting, there are usually more lighting devices in commercial area, such as advertising lighting and landscape lighting. It makes the light pollution in commercial area worse than other urban zones. In this research, the NSB of commercial area in Taichung City was 15.08 mag/arcsec^2, of residential area was 15.71 mag/arcsec^2, and of industrial area was 16.76 mag/arcsec^2(Table 2) .

Table2 : NSB of different land zoning (mag/arcsec^2)

Commercial Area	Residential Area	Industrial Area	Agricultural Area
15.08	15.71	16.76	16.72

Conclusion

This study used SQM-L to measure Taichung's NSB. Furthermore, by combining with GIS to describe the light pollution map, this study analyzed the relationship between urban landmarks, main roads and the business area, and NSB while providing the research method to preliminarily getting the urban texture and light pollution relationship. It is suggested that subsequent studies may discs the correlation of population density, floor area ratio, road luminance and other urban composition factors with light pollution. A NSB forecasting model can be proposed as the basis for subsequent application and analysis.

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Soil Water Repellency a Global Phenomenon: Impact, Measurement and Mechanisms

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Abstract
Food security and production is a major global issue. It has become essential to work the land efficiently, through better soil management and agronomy, whilst protecting the environment from air and water pollution. The reduced ability of some soils to become wetted and absorb water - soil water repellency - is a major environmental problem in many parts of the world. It can have serious environmental implications such as increased overland flow and soil erosion, poor uptake of agricultural chemicals, and increased risk of groundwater pollution due to the rapid transfer of contaminants and nutrient leaching through uneven wetting and preferential flow pathways. The initial degree of water repellence of the soil surface is usually assessed by measurement of the soil-water contact angle, whilst the time-dependent wettability is most commonly assessed by measuring the time taken for water drops to eventually penetrate the soil completely. Both chemical and physical factors play a role in determining soil water repellency. Organic compounds deposited on soil mineral or aggregate surfaces have long been recognised as a major factor, and the surface structure of the soil has also been implicated particularly in influencing soil-water contact angle. Here we discuss the environmental impact of soil water repellency, the factors and mechanisms which are thought to be important in causing repellency, the way repellency is measured and classified, and our current work on the significance of surface structure in influencing solid-water contact angles for non-planar surfaces such as soils.

Keywords: soil, water-repellency, contact-angle, surface-structure, environment

Introduction

Soil water repellency is the reduced ability of some soils to be wetted and absorb water. It is a global phenomenon that can lead to major environmental problems. It can have serious environmental implications such as increased overland flow and soil erosion, poor uptake of agricultural chemicals, and increased risk of groundwater pollution due to the rapid transfer of contaminants and nutrient leaching through uneven wetting and preferential flow pathways.

When a drop of liquid is brought into contact with a flat solid surface, the final shape taken up by the drop, and the solid-liquid contact angle, Θ, depend on the relative magnitudes of the molecular forces that exist within the liquid (cohesive) and between the liquid and solid (adhesive) (Jaycock and Parfitt, 1981). The term wetting is often used loosely, for practical purposes it is usually said if $\Theta>90^o$ the liquid does not wet the solid and if $\Theta<90^o$ the liquid does wet the solid, although strictly wetting only occurs if $\Theta=0$.

Soil water repellency has been researched extensively, particularly over the last few decades, and researchers continue to investigate the chemical and physical factors behind this phenomenon in an attempt to understand how and why it occurs, and how it may be reduced and managed.

Here we briefly discuss the environmental impact of soil water repellency, the factors and mechanisms which are thought to be important in causing repellency, the way repellency is measured and classified, and our current work on the significance of surface structure in influencing contact angles on non-planar surfaces such as soils.

We also note that the study and understanding of liquid/surface contact angles is important in other disciplines and in a number of industries, such as flotation, painting and weather-proofing (Pashley and Karamen, 2004).

Impact – Environmental Implications

Soil water repellency can have serious environmental implications. If water cannot infiltrate and be absorbed into the soil, there is risk of overland flow. This can lead to flooding and enhanced soil erosion. Overland flow, in particular, has been linked to fire-induced or fire-enhanced water repellency by wildfires (Mainwaring, 2004). Water repellency also indirectly contributes to soil erosion by wind as soils can become more susceptible to erosion when left bare and dry, which is more likely to occur in soils that are water repellent (Carter, 1990).

Soil water repellency can also lead to the poor uptake of agricultural chemicals which is particularly important for food security. If agrochemicals, fertilisers and water cannot penetrate into the soil profile where required, it is likely to lead to decreased soil fertility, patchy crops and increased disease levels, leading to reduced overall yields and production. There is already an increased pressure on food production due to a growing global population and managing soil water repellency is likely to become increasingly important to ensure global food production.

Another environmental issue linked to soil water repellency is the increased risk of groundwater pollution by the rapid transfer of contaminants and nutrient leaching due to uneven wetting and preferential flow pathways. Valuable nutrients can not only be leached out rapidly through flow pathways within the soil profile but also, as a result of these, fail to reach other parts of the soil, which can lead to crop and soil nutrient deficiencies. Preferential flow paths can also lead to the depletion of plant available water (Dekker and Ritsema, 1996). Groundwater pollution through the leaching of nutrients and agrochemicals too rapidly through the soil profile can also be a serious issue resulting in pollution of water sources which in turn may affect aquatic habitats and water quality.

Whilst many of the environmental implications of soil water repellency are detrimental, there are also some beneficial effects. Water repellent soils have been used to direct the flow and collect runoff in drought-prone areas (Blackwell, 2000); they can also be used to prevent water loss through evaporation by creating an upper layer of soil that acts as an effective mulch which reduces the capillary rise of water (Wallis and Horne, 1992); and many plants have also now adapted to survive in severely water repellent conditions (Mainwaring, 2004).

Mechanisms

Both chemical and physical factors play a role in determining the occurrence and severity of soil water repellency.

Chemical factors

Organic compounds deposited on soil mineral or aggregate surfaces have long been recognized as a major factor for causing/inducing soil water repellency. The main groups of organic compounds involved are long chain acids, alkanes, amides, aldehydes/ketones and sterols (Mainwaring *et al*, 2004; Morley *et al*, 2005). Aliphatic hydrocarbons and polar substances with amphiphilic structures are considered the two chemical compounds regarded as most important in causing soil hydrophobicity (McIntosh and Horne, 1994). Mainwaring *et al* (2013) found that a combination of long chain acid and alkane to be most effective at inducing water repellency, but the extent of water repellency induced on acid washed sand varied considerably with compound type.

Organic compounds with hydrophobic properties are present as a coating on soil mineral and aggregate surfaces and also as interstitial matter. Within a soil, a mixture of wax-containing globules, clean soil particles, completely or partly coated soil particles and hydrophobic remnants such as roots, leaves and stems may be present. Possible sources of these compounds include: plant roots which can provide lipid-rich organic matter; surface waxes that can be mechanically eroded from plant leaves; fungal hyphae which can contain hydrophobic compounds; and lipids from the decomposition of 'litter'. Wildfires can vaporize and alter organic matter, some of which condenses back into the soil (DeBano, 2000).

Physical factors

As well as chemical factors, the surface structure of the soil influences water repellency.

Physical factors such as particle size can influence the occurrence and severity of soil water repellency. It has been reported that for soil samples obtained from grass and forest areas the finer sieve fraction shows the most severe water repellency (Doerr *et al*, 1996; Rodriguez-Alleres *et al*, 2007). Sandy soils have the lowest specific surface areas, so a given amount of hydrophobic material will affect a greater proportion of particles in a sandy soil than in a loamy or clayey soil (Woche *et al*, 2005). Surface roughness affects interfacial energies and therefore individual particles can amplify the contact angle of the soil water repellency (Ahn, 2014).

Measurement Techniques

The initial degree of soil water repellency is usually assessed by measurement of the soil water contact angle, whilst the time-dependent wettability is most commonly assessed by measuring the time taken for water drops to eventually penetrate the soil completely.

Water Drop Penetration Time (WDPT) Test

The time-dependent wettability is most commonly assessed by measuring the time taken for water drops to eventually penetrate the soil completely, the Water Drop Penetration Time (WDPT). The methodology of WDPT tests is discussed in greater detail in Doerr (1998) and more recently by Hallin *et al* (2013). Dekker *et al* (2009) classified soil water repellency in six classes from 0 to 6 going from wettable to extremely water repellent as WDPT increases. It is a crude measurement of the severity of water repellency but can be a useful and straightforward method for use in both the laboratory and in the field.

Contact Angle

The initial degree of soil water repellency can be assessed by measurement of the soil-water contact angle and this is often done using the sessile drop method (Bachmann *et al*, 2000). Liquid water has a high surface energy, or surface tension. Solids with low surface energies (or low surface tensions), such as hydrocarbons are not wetted by water and have water repellent surfaces, whereas solids with high surface energies such as silica are wetted and have wettable surfaces. The contact angle between a liquid and a solid surface is determined by the balance of interfacial tensions of the three phases present (solid, liquid and vapour) (Jaycock and Parfitt, 1981). A liquid drop with high surface tension resting on a low energy solid forms a spherical shape with a high contact angle. As the solid surface energy increases, the drop forms a flatter, lower profile shape and gives a lower contact angle (Llewellyn, 2005). Hence, a large contact angle indicates high water repellency, and a low contact angle indicates a hydrophilic surface.

In general, the measured contact angles of irregular surfaces are higher than those of a flat surface of the same material. Understanding the amplification of contact angle by surface structure has for many years been based on the theoretical models of Cassie and Baxter (1944), for bridge-like wetting over the top of protrusions, and Wenzel (1936) for complete wetting of a jagged surface. Both models are based on the thermodynamics of surface energies, i.e. the contact angle is calculated from the energy required to expand the surface. In the Cassie-Baxter model this energy is great that for a flat solid surface because the water drop hangs in the air between the protrusions, and thus expansion of the 'surface' requires expansion of both the water-air and water-solid interfaces. The surface has an apparent surface energy lower than that for the flat solid surface because it is a mix of solid material and air. The decrease in surface energy can be calculated from the geometry of the surface, e.g. Cassie and Baxter gave an analysis of a 'surface' made of equally space thin round wires. In the Wenzel model the energy is greater for the irregular surface because the 'true' liquid-solid contact area is greater than the 'apparent' surface area because of the surface roughness; Wenzel introduced a roughness factor into the surface energy equations to account for this.

In order to apply the Cassie-Baxter model to soils, McHale *et al* (2005) developed a geometric model of the soil surface in which soil particles were approximated as smooth spheres in a hexagonally packed arrangement. The Cassie and Baxter model (1944) was then applied to their model which includes, as a parameter, the inter-particulate distance which allows for the effect of imperfect packing. The inter-particulate distance is zero for perfect close packing and as the inter-particulate distance increases, the solid-liquid interface fraction decreases while the liquid air interface fraction increases and consequently the contact angle increases according to the Cassie-Baxter equation (Ahn, 2014). However there were some limitations to the model as it failed to include the effect of particle surface texture (Ahn, 2014).

Even though still widely used, there is currently much debate in the literature about the validity of these models and their applicability to soil science and soil water repellency. In 2007 Gao and McCarthy challenged the validity of the Wenzel (1936) and Cassie and Baxter equations (1944). They argue that it is contact lines and not contact areas which are key to determining contact angles. Gao and McCarthy (2007) argue that the interactions that take place between the liquid and solid at the 3-phase contact line is responsible for determining the contact angle and this is not linked to the interfacial area within the contact perimeter.

At the moment contact angles are used by soil scientists as an empirical measurement as they are widely used and relatively straight forward to carry out. It is important to remember that contact angles can be affected by many variables that include: temperature, relative humidity, surface roughness, droplet volume and sample preparation

Current Work – an experimental approach to evaluate the suitability of Cassie-Baxter for non-planar and irregular surfaces and application to soils

Both the Cassie and Baxter (1944) and Wenzel (1936) equations have adjustable parameters which can be used to fit data, and as a result these models can almost always give a fit for contact angle measurements. However, the required fitting parameter values are sometimes found to be physically unreasonable. For example, in the case of Cassie and Baxter the inter-particle distance (i.e. the length of the air gap between particles) is an adjustable parameter which, for the best fit to the experimental data, is often required to be bigger than physically sensible. A better approach to examining the suitability of the Cassie-Baxter equation for irregular surfaces would be to replace this adjustable parameter with a measured parameter. However, for soils there is the difficulty of inhomogeneous particle sizes, variable particle surface roughness, and essentially unknown particle packing arrangements. The literature to date has used soil and semi-homogenous glass spheres or semi-homogenous roughly close-packed spheres, so modelling of the data is complicated by particle inhomogeneity and variable packing efficiency. In answer to this we are taking a fundamental approach to this problem, and exploring contact angles on precisely controlled surfaces. In earlier work (Ahn, 2014) we used homogenous, water repellent silanised glass spheres, and recently we have used coated steel spheres and rods of very precise size which can be close packed and held in place using magnetic strips.

Methodology

In work by Ahn (2014) chemically hydrophobized glass beads were fixed using double adhesive tape on a flat microscope slide, or held on printed plastic templates by applying pressure and heat. For our current work, homogenous metal spheres were coated with paraffin wax using a rotary evaporator, and then fixed onto a magnetic strip attached to a microscope slide to achieve closely packed arrays (Fig.2).

Distilled water was placed onto surfaces using a syringe with a blunt tip needle (19 gauge Luer-Lock blunt ended needles, Sylmaster, UK). Approximately 5µl of water was expelled from the syringe to make a small hanging drop on the tip of the needle and the syringe was lowered until the drop contacted the surface. Then water was dispensed at the rate of 100µl min^{-1} to let the drop advance upon the surfaces (Ahn, 2014), until a final drop volume of 85µl was obtained. Contact angles were measured using videos (6.25fps) recorded using the EasyDrop FM40 KRAUSS goniometer. The left and right contact angles as viewed in the instrument at each advancing angle were averaged from the appropriate video stills using the Drop Shape Analysis (DSA) 100 software package (Ahn, 2014). At least 15 advancing angles per sample were taken at intervals through the video footage and averaged to give the overall result.

Preliminary Results

Measuring contact angles on smooth solid surfaces is relatively easy as the plane of the solid/liquid interface is easily recognizable. The placement of the horizontal baseline (see Figs 1 and 2) is key to obtaining an accurate contact angle for the surface being measured within the DSA software. Once placed in the appropriate place the droplet contour can be extracted using the DSA software and an average contact angle measurement from the left and right side angles can be obtained. For paraffin wax on a glass microscope slide we found a water-solid contact angle of $111.7^o \pm 0.6^o$ in reasonable agreement with the literature value 111^o (Jaycock and Parfitt, 1981).

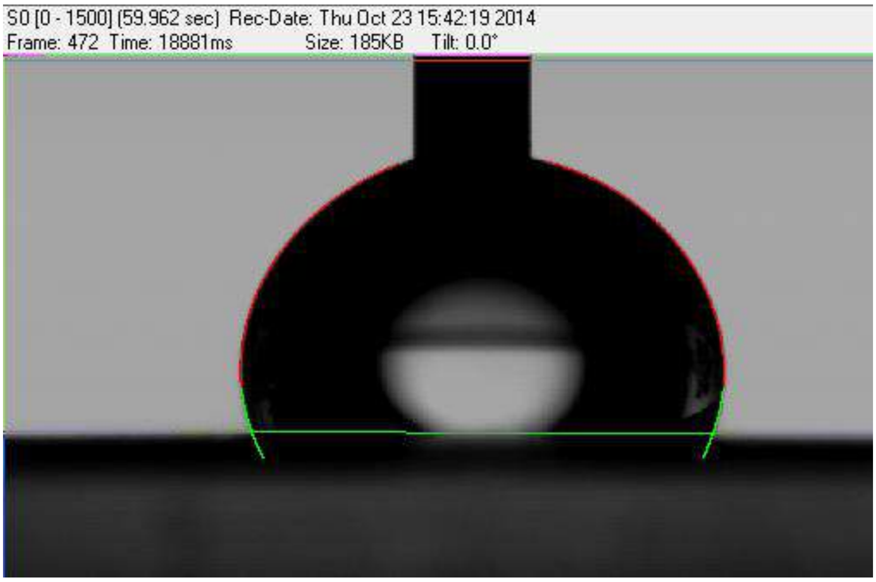

Figure 1 Video still of water droplet on a planar surface coated in paraffin wax with droplet contact angles extracted using DSA software

Figure 2 shows the video still for one of our precisely controlled homogenous close packed metal sphere surfaces. The 1mm diameter metal spheres are coated in paraffin wax and the advancing contact angle on this surface is 133.7^{o} ±0.9^{o}. This is considerably higher than the 111^{o} for a flat paraffin wax surface, and higher than the value of 129.8^{o} we have calculated using the modified Cassie-Baxter equation for close-packed spheres. Furthermore, we calculate fitting the data to Cassie-Baxter with a free fit inter-particulate distance would require an inter-particle air-gap of about 0.08 mm whereas these particles are perfectly close-packed without any inter-particle air-gap.

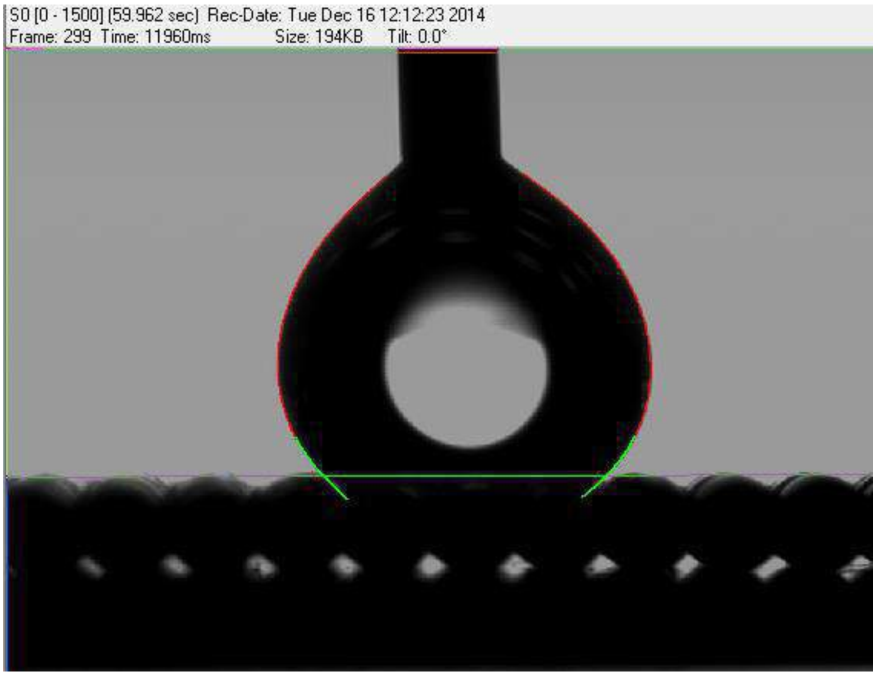

Figure 2 Video still of water droplet on a precisely controlled model surface of metal spheres coated in paraffin wax with droplet contact angles extracted using DSA software

All of our results to-date give contact angles that are larger than those calculated using the Cassie and Baxter equation. We are currently tentatively examining alternative interpretations of the origin of the apparent large contact angles on non-planar surfaces based on the way the droplet sits on the surface, in particular the geometry of the particle water drop interface and its relation with the choice of 'horizontal' reference line in the instrumental analysis.

Conclusions and Future Work

Based on our preliminary results with precisely controlled non-planar surfaces we find that the Cassie-Baxter (1944) model does not fit our experimental data; the experimental contact angles are bigger than those predicted by application of the Cassie-Baxter model.

We are currently examining alternative interpretations of the origin of the measured large contact angles on soils and other non-planar surfaces. Future work will include using model systems with different spheres sizes and different organic coating, as well as surfaces made with mixed spheres of various sizes and coatings along with different packing arrangements. Following this, application of knowledge gained from these studies of precisely controlled surfaces will be made to model soils, made up of sand grains with organic coatings, and then extended to natural soils.

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Renewable Energies Inbetween Landscape and Landmark: Case Studies

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Introduction

When do renewable energies become architecture and landscape?
When can they be considered a plus for a landscape?
These are the key questions of the study carried out by the local unit of the Politecnico di Milano as part of the Program of National Interest (PRIN) financed by the Ministry of Education, University and Research[1].

After the identification of an organized information system, several case studies were analysed and this led to a first classification of the energy systems, based on the size, source, power, ... it was then studied a method that could allow to define which system, more than others, could be positive and appropriate for a given territory. Many are, in fact, the techniques for the analysis and management of the impact that changes can have on a man-made system: multidimensional investigations, multi-criteria[2], multivariate analysis[3], complex assessments borrowed from landscape ecology[4].

All these techniques, however, seem to assume that the landscape is an unmodifiable good to be preserved and that any human action, especially related to energy systems, should be related to the production of the minimum possible impact. The starting point here wants to be different, as different is the concept of landscape and different is the idea of Energy Systems (ES), considered not as just plants, but as indivisible union of the plant with its support and its functions and therefore with the place in which it is located. In this sense, the ES has all the features to be considered a landmark, as marker of land and reference point. (Golledge 1987).

The concept of landscape

From the European Landscape Convention, it is necessary to introduce an extensive and dynamic concept of landscape. It can also be said that the need to define landscape should be strongly criticized and that the landscape should instead be read as what by nature can never be a fixed and always considerable element, but is instead subject, as all the elements that are part of a pattern to all the possible mutations, both with creative and destructive effects (Zagari 2006).
Landscape is not to be considered as a notion, but as a faithful expression of existence, a revealed truth itself, not a geographical theory or aesthetic value (Dardel 1986).
It is clear and universally accepted that all[5] the landscapes are defined by man: from the places that belong to them, human beings modify the existing determining

[1] The National research project "La difesa del paesaggio tra conservazione e trasformazione. Economia e bellezza per uno sviluppo sostenibile" (Coordinatore Nazionale prof. Carlo Truppi), involves 7 research local units (Università degli Studi di CATANIA, Università degli Studi NAPOLI FEDERICO II, POLITECNICO DI MILANO, II UNIVERSITÁ DI NAPOLI, Universitá degli Studi di GENOVA, Università degli Studi di PALERMO, Università telematica UNINETTUNO). Prof. Elisabetta Ginelli is the responsible of Milan local unit "Gestione del rapporto tra sistemi energetici e paesaggi".
[2] Cf. Nijkamp 2008, Jorgensen 2008, Theodor 2013.
[3] Cf. Paolillo 2013, Harris 2014.
[4] Nadai and Van der Horst, 2010; Stremke, 2010; Van der Horst and Vermeylen, 2011; Blaschke et al. 2012; Pasqualetti, 2012; Howard et a. 2013.
[5] Even in extreme places, considered natural, is possible to trace human actions: even in Antarctica or on Everest can be found inorganic wastes and residual gases produced by human actions.

landscapes, which are therefore a not only aesthetic situation (figurative and strongly connected to appearance) but they are primarily an ethical situation, as human actions that create landscape are actions directed and designed towards an aim from nature in its cosmic expression man has shaped the landscape forms, both those observed, beyond his control, both those freely created. Theoria[6] has always transferred an anthropic essence on natural environment.

Landscape is therefore, also, "result of man's activity on nature" (Venturi Ferriolo 2002, p.11). In these terms, therefore, it is to reject that the notion of landscape was born in romanticism as aesthetic vision of nature. It is a cross-referring topic, even if considered with different focuses, in all eras of human activities. For the ancients it represented the overall scope of human life.

In a specific society, interest and taste for landscape painting rise and fall in close association with the interests and tastes that society manifests with a more or less defined imprinting in the natural landscape. From the social point of view and perception of the landscape, it is interesting to consider the concept of the "law of inertia of the landscape" (Sereni 1961): the landscape, once fixed in determined shapes, tends to perpetuate them, even when technical, productive and social relations that have influenced its origin are not there anymore, until new and more decisive development of these relationships don't come over.

One of the few definitions that can certainly be attributed to landscape is that it is an abstraction of man caught between ethics and aesthetics: man creates a landscape (one of many that can be created) contemplating (aesthetic) a portion of that reality in which it is immersed, to which it belongs and in which it operates (ethics) in absolute freedom. In these terms, therefore, we can consider landscape as a "contemplation horizon, product of freedom, a result of art, the effect of action of men" (Venturi Ferriolo 2002, p.16), or "nature changed by man throughout history "(Venturi Ferriolo 2002 p.143).

It can therefore be said that man creates landscape with a dual connotation: on one hand, he shapes the places in which he lives according to the spirit of their time and on the other, he gives the places he observes an aesthetic imprint that distorts and unifies at the same time the places themselves. When it comes to energy landscapes, this is even more undeniable.

The ES between energy landscape and energy landmark

People have always changed and shaped the places they lived in for energy purposes: dug the earth to extract coal and oil, cut trees to produce heat, changed the course of rivers by harnessing the power of water to produce kinetic energy, built immense waterways (Roman aqueducts and others) to quench and entertain entire cities, has built windmills to wrest land from the sea.

[6] Theoria is the contemplation of the divine in the world, but in the direction of Greek ethos as all active life and contemplation, where the sacred and the landscape found an immanent undisputed unity. Cf. Meschiari 2008.

The transformation of resources into energy is therefore an aspect of the landscape that can be traced through the centuries of history and comes up to the present days, validating the adjective of "energy" landscape.
Usually "energy landscape" is recognized by the scientific community as the shape it can take a molecular entity or the spatial interrelation of molecules and molecular forces.

Here, instead, we give the term "energy landscape" the same dignity of the term landscape in a broad sense, recognizing the strategic role of the ES in modelling and defining landscape, both a profoundly anthropic landscape (cities) or a para-natural landscape.

Within the energy landscape are then identified some elements that stand out compared to others because they are dimensionally larger or more salient or more meaningful: these landmarks are here considered in perception and functional terms (Mainardi 1994). Perceptual because they depend on the relationship they have with the subject-observer and on the cognitive value that is attributed to them; functional as they are important for the subject who must carry out certain actions in that given context (Axia 1986).

Figure 1: Bilbao Guggenheim Museum (source: www.guggenheim-bilbao.es)

A famous example of a building that has become iconically landmark of a city is the Guggenheim Museum in Bilbao, which has assumed the same value of the Eiffel Tower in Paris: the building is both a symbol, a reference point for moving within the city. If the Eiffel Tower wanted to be a sign of the provisional value of the French technique for a temporary[7] event, the Guggenheim was consciously wanted to give the opportunity to know the Capital of the Basque Country in the world, for an economic and cultural purpose.
If, however, a Roman aqueduct is seen as an integral part of the landscape and is reasonably protected as a World Heritage Site, different is the perception of the new

[7] Built for the Universal Exhibition of 1889, it was supposed to be demolished the following year.

energy production systems of the recent years. But what is the difference between a hydroelectric plant built in the early '900 and any of todays hydropower plants that get continuous attacks because they change irreparably the land we live in? In the end even the sluices designed by Leonardo da Vinci on the Adda River and on the Navigli canals in Italy have heavily modified the landscape, but they are today protected and a museum was opened (Eco-museum Leonardo da Vinci).

With this point of view, the established systems of analysis of the impacts of energy systems, borrowed from environmental assessment regulations, are difficult to apply. This paper aim is to try to identify a methodological analysis that can help unravel the apparent conflict between energy systems and landscapes.

Following the idea of landscape as described above, the ES can be considered as landscape when their number and their distribution[8], their historical sedimentation[9], their perception addiction[10] makes them recognized as part of the landscape, where nothing particularly relevant stands out among the rest.

However, if an ES is able to emerge in the surrounding landscape, and to leave a substantial and recognizable mark that influences the entire context and that orients the perception and the movements of men, then we are facing an energy landmark. This is not necessarily positive: sometimes the ES have positive effects on their area of influence, sometimes negative. The analysis methodology will try to highlight the indicators and the factors that can help generate consistent and conscious choices on the overall judgment of an ES, from certain categories that consider the relationship between ES[11] and the landscape in which it is placed.

These categories have been identified in: conservative static, energocratic and refounding, as shown in the following table.

[8] Such as the transport of electricity pylons.
[9] The hydroelectric power plants of the early '900.
[10] TV antennas on the roofs of houses.
[11] Both as landscape and as landmark.

Table 1. The relationship energy/landscape

relation energy/landscape	*example*
conservative static, in which the ES is introduced for an absolute necessity, but which must be the least visible possible. This is the case of listed buildings or places considered as "untouchable", in which, with a certain hypocrisy, the presence of an ES is accepted only if very discreet or better yet out of sight, as the landscape - the observers - would consider it as an object lodged where it does not belong and misrepresentative. One example is the Paul VI Hall in Vatican City, covered with hundreds of photovoltaic tiles, but totally invisible to anyone not at the same height of the dome of Michelangelo.	 Photovoltaic plant on the roofing of the Paul VI Hall in Vatican City. Source: www.vatican.va
energocratic, is the case when the economic needs/regulations consider above all technical aspects so there is a show off of the ES with the sole aim of producing the most profit directly and immediately. It is often the action of the individual or of a few, with purely economic personal goals. One example is the Big Solar Furnace Tashkent, Uzbekistan of 1987, a huge facility for solar concentration where even the figurative aspect is so iconic of the aggressive and assertive way it stands in the surrounding landscape.	 Big Solar Furnace Tashkent, Uzbekistan. Source: www.rinnovabili.it
refounding, when inserting an ES is an opportunity to design relationships, is an opportunity for multidisciplinary and participatory projects that activate differentiated and integrated decision-making levels and skills. An example of this approach is the project BIG of a biomass cogeneration plant in an urban park in Uppsala in Sweden, where a system that is usually confined to the suburbs is placed within a project of an urban park and it's the heart and the core also on a visual point of view.	 Biomass cogeneration plant in Uppsala (Sweden). Source: www.archdaily.com

This initial categorization appears certainly to consider all the ES, but it can, maybe, be further articulated to outline the useful categories for the definition of design and landscape programming guidelines. For this reason it was necessary to introduce a method of analysis for the definition of categories that can provide more detailed and advanced interpretation keys.

Analysis methodology for energy systems and landscapes

The method adopted for the analysis of the ES can be summarized as follows:

step 1) structuring of the information apparatus for the analysis of the energy system
step 2) identification of methodological principles, objectives and requirement categories: the eco-sustainable approach.
step 3) functional parameters for a "perceptual" classification
step 4) interpretation method
step 5) results

Step 1
Structuring the information system for the analysis of the energy system and first results

The method has provided a definition of the parameters that could allow the collection, the accurate selection and, subsequently, the classification of case studies in parallel with investigations on the currently used methods in the planning and evaluation of the impacts of infrastructure in a determined area. More than 150 case studies were selected and ranked according to the energy source, the size, geographic field and scale, to cover an extremely broad scenario including: significant case studies acknowledged as positive, the less known and significant cases and the cases considered negative for their impacts on the surroundings. The following are the analysis parameters for the case studies:

Table 2. Analysis parameters for the selection of case studies[12]

analysis parameters	*parameter definition*	*reference scale*	*specifications*
scale field	it identifies the relationship between the energy system and the number of users of the energy produced	land	the produced energy is for large scale distribution
		urban	The produced energy is for the near surroundings
		building/product	The produced energy is for the single building and/or product

analysis parameters	*parameter definition*	*parameter sub-category*	*specifications*
geographic field	considered as the morphology and the type of area in which the energy system is placed	natural	where man did not change any structural functional and morphological component, and where there aren't any anthropization processes
		rural/para-natural	where man has partially changed one or more structural, functional or morphological components and where there are human settlement processes of a limited size
		rural landscape with high biodiversity level	where man has modified strongly the biotic and abiotic structure and where the ecological functions are oriented to the maximization of food production for humans or farm animals
		rural landscapes with low biodiversity level	where human intervention was more intense and extended so there is a reduced vegetation system
		peri-urban	where man has profoundly changed the biotic and abiotic structure and where the ecological functions and the energy and matter flow allow the carrying out of duties and human activities such as living, production, trade and transportation.
		urban landscapes	where man has profoundly changed the biotic and abiotic structure and where the ecological functions and the energy and matter flow allow the carrying out of duties and human activities such as housing, production, trade and transportation.
		industrial landscapes	where man totally modified the biotic and abiotic structure and where the ecological functions and the energy and matter flow allow the carrying out of productive activities.

analysis parameter	*parameter definition*	*parameter sub-category*	*specifications*
production system	relation between systems according to energy production	diffused	system designed to be reiterated, through independent elements
		concentrated	geographically localized system, created to be independent from a network

[12] Each plant system can have various sizes, which are not related to the comparison between the different systems, but related to individual systems taken into account.

analysis parameter	*energy source*	*parameter sub-category*	*specifications*
energy source	sun	direct thermal	use of the direct solar radiation to produce hot water
		concentration thermal	use of solar radiation mediated by mirrors and concentrators to produce superheated fluids with which also produce electricity
		photovoltaics	production of electricity directly from solar radiation
	water	hydroelectric power plant	high power plant (mw) that uses large water drops to produce electricity
		tides and flows	production of energy from kinetic energy of tides and flows
		mini hydro	small energy production using small water drops
		mill	direct production of kinetic energy from small water drops
	wind	wind turbines	use of wind to produce electricity
	geothermy	active	heat production through the use of heat pumps
		passive	use of geothermal heat to produce electricity
	hydrogen		production, storage and transport of hydrogen as an energy source
	kinetic movement		use of small kinetic energies to produce electricity for self-consumption
	waste		direct combustion of waste or waste derivatives and biomass for the production of electricity
	fossil resources		combustion of fossil resources for the production of electricity and / or heat

analysis parameter	*location*	*parameter sub-category*	*specifications*
location	earth		system placed on the ground (directly on the ground or placed on buildings or artefacts)
	sea	out of the water	floating or partially out of the water systems
		sea bottom	anchored to the seabed, invisible from the surface systems

analysis parameter	*parameter definition*	*parameter sub-category*	*specifications*
use	end user of the produced energy	auto-production	system developed for the production of energy only for auto-consumption or consumption of a directly connected user
		for export	system developed for the production of energy intended for remote users (it requires a dedicated energy transportation system)

analysis parameter	*parameter definition*	*parameter sub-category*	*specifications*
size	system power related to the current production technical features[12]	s	minimum serviceable power from a technical point of view
		m	medium power usually in use for that system size
		l	great power system above the general in use power
		xl	maximum in use power

This series of parameters allowed to structure an information system able to place any case study within its reference scenario, creating an information sheet structured in four parts:

- heading information: provide the specific case study position within the scenario of reference cases and detect the consistency and the specific nature of the case;

- definition of case study: in addition to the energy source data, are here provided technical / physical data, the typology of intervention, production data, the degree of reversibility, the players involved, the procedures and the realization process, the year of implementation;

- geographical area: Identifies the context in which the energy system is placed, through climatic, energetic, landscape and geography parameters;

- energy system: it expresses precisely the specific characteristics of the analyzed and contextualized system.

The result is providing information on the ES according to the relationship between area, context / building in which it is placed, as well as information techno-typological detailed data.

Step 2
Identification of methodological principles, objectives and requirement categories: the eco-sustainable approach.

Eco-efficiency is the main concept for this research and is the major goal. It's considered here as the way in which energy resources are managed to meet human needs (OECD 2001), in a logic of greater welfare with a reduced use of nature through performance, better effectiveness and in relation to the lower energy requirements postulated by technological innovation. Eco-efficiency, following whose definition are interpreted the four dimensions of sustainability (environmental, economic, social, institutional), adds an additional category, the "physical" dimension, recreating a pentagon that starting from the work of Nijkamp (Nijkamp 2008) or Gülümser (Gülümser 2009) is set up in five inalienable requirement classes[13] (Tab. 1) related to the prevailing interpretive approaches borrowed from the five dimensions of sustainability: Eco-compatibility, multifunctionality, profitability, utility, cultural consensus, social acceptability and institutional partecipability.

[13] Cf. Project no.217213, Project acronym: SMILE, Project title: Synergies in Multi-scale Inter-Linkages of Ecosocial systems. Socioeconomic Sciences and Humanities (SSH). Collaborative Project FP7-SSH-2007-1. Stakeholder-based PENTAGON models. Deliverable 19, WP 5. Project coordinator: Jarmo Vehmas.

Tab. 3. Eco-efficiency dimensions

main objective	eco-efficiency				
dimension	**environmental**	**spatial**	**economic**	**social**	**institutional**
requirement class	eco-compatibility	multi-functionality	profitability, utility	cultural consensus	social acceptability
definition	it implies ascertaining the feasibility of dialogue between physical environment and built environment that unfolds in the measurement of the input and output streams from one system to another	hybridization, capacity of the object to perform more functions together, contemporarily and in time	cost-effectiveness in the relationship between man and environment, ability to generate income	people's behaviour (lifestyle, culture change in values and in their hierarchy) acceptance of change, now and over time. high level of knowledge in the "cost-benefit valuation" (bottom up)	collaboration and involvement degree; partecipability = (institutional) as the ability to create synergy among stakeholders (from an international level to a local level) (top down)

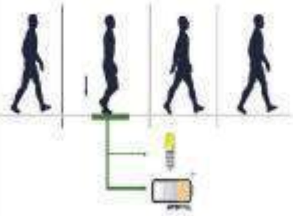
These dimensions, that are the equivalent of macro-categories of analysis, allow a first interpretive reading of the analyzed interventions. They also allow the selection of some paradigmatic case studies that indicate an energy system characterized by an ability to repay the value of the different considered dimensions and in which results clear a number of objectives. The degree of eco-efficiency of each case was examined in the different components of the overall performance, elaborating detailed swot analysis for each of the five dimensions and a synthesis for a final comparison. The comparison of the analysis for the various dimensions provides a comprehensive and multidisciplinary description of the ES and is useful as a starting point for a systematic complex analysis, as a basis for the development of useful tools and behavioral patterns for the development of policies / projects (Ginelli and Daglio 2014).

The most significant cases that have emerged from this step of the analysis are discussed and analyzed from other points of view in the third phase.

Step 3
Functional parameters for a "perceptual" classification

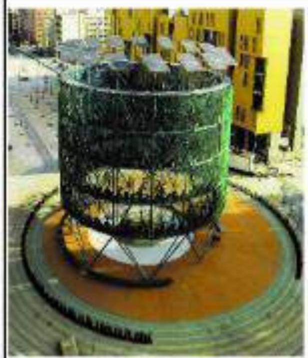
The analysis of case studies, both as general categories of PS, and as ES of significant and specific case studies, disclosed common denominators that can highlight those cases that, more than others, were welcomed favorably by stakeholders.
During this step recurring events emerged. They have been synthesized and summarized in the following table in general categories and sub-categories. Please note that the examples are not exhaustive of the class but were considered significant to explain, through images, the illustrated concept.

Tab. 4. Parameters for a "perceptual" classification of case studies[14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37]

parameters	*sub-parameters*	*specifications*	*Case studies*	
visibility	visible	Visible ES from public spaces		wind turbines: they are exposed and visible
	invisible	Non visible ES from public spaces		kinetic energy systems positioned on the ground

[14] Image source: www.patrimonioculturale.enea.it
[15] Image source: www.mimoa.eu
[16] Image source: www.moradavaga.com
[17] Image source: www.moradavaga.com
[18] Image source: www.jourda-architectes.com
[19] Image source: www.smartcityitalia.net
[20] Image source: www.fbm.it
[21] Coverage of the Library of the School of Architecture at the Politecnico di Milano. Photo of the author (© G. Pozzi).
[22] Image source: www.a2a.it
[23] Image source: www.rinnovabili.it
[24] Image source: www.buffalo.edu
[25] Image source: www.autobrennero.it
[26] Image source: www.greenrail.it
[27] Image source: www.rinnovabili.it
[28] Image source: www.a2a.it
[29] Image source: www.skyscraperpage.com
[30] Image source: www.coopcomunitamelpignano.it
[31] Image source: www.a2a.it
[32] Image source: www.a2a.it
[33] Photo of the author (© G. Pozzi).
[34] Image source: www.newsenergia.com
[35] Armadillo system installed in Monza IT, Photo of the author (©G. Pozzi).
[36] Image source: www.theguardian.com
[37] Image source: www.theguardian.com

parameters	*sub-parameters*	*specifications*	*Case studies*	
time (age)	Historical archeology	> 150 years		Roman aqueducts near Rome. Other examples: Dutch mills, salt marshes, ...
	Industrial archeology	150 years > 30 years		historical hydropower plants: in this case Valchiavenna
	contemporary	30 years >	The majority of RES	
	New systems	prototypes or experimental	there are many cases of RES that had a large media launch, but for which there is no trace in the current production	

parameters	*sub-parameters*	*specifications*	*Case studies*	
time (duration) = trasportability	temporariness	trasportability		Eco-Boulevard, Madrid: temporary systems for urban requalification. They can also be transportable generators and / or for the emergency.
	Short duration	disassemblable		temporary and demonstrative systems: Moradavaga SWING[14], electricity generation swing.
	stability	non transportability	The majority of RES	

parameters	*sub-parameters*	*specifications*	*Case studies*
level of anthropogenic stratification	new		 OFF-grid street lamps at Bargallò, Spain.[15]
	Building requalification		 requalification of abandoned warehouse Halle Pajol, Paris[16]
	Urban requalification		 requalification of a neighbourhood in MarseilleFR through thalasso thermal energy.[17]

parameters	*sub-parameters*	*specifications*	*Case studies*
manufacturability (size)	small		 photovoltaic tile[18]
	medium		 photovoltaic plant of medium size[19]
	large		 incinerator with teleheating system Silla 2 in Milan[20]
	extralarge		 the three gorges dam on the Yangtze River, in Hubei, China[21]

parameters	*sub-parameters*	*specifications*	*Case studies*	
usability	practicability	in paths		Buffalo Solar Strand: photovoltaic park with classrooms and outdoor paths.
	protection	as covering, railing, guard rails, gutters		photovoltaic railing and guradrails photovoltaic parkings. Here the Brennero highway in Italy[22]
	walkability	systems that exploit the kinetic energy of vehicles and / or pedestrians		Greenrail: railroad ties that generate electricity to the passing of trains[23]

parameters	*sub-parameters*	*specifications*	*Case studies*	
physical proximity	proximity	to the built environment		wind turbine on the Tour Eiffel, Paris[24]
	distance	from the built environment		hydroelectric plant in Temù IT[25]

parameters	*sub-parameters*	*specifications*	*Case studies*
decisional proximity	TOP DOWN		 Kaoshiung stadium, T. Ito, 2009, Kaoshiung, Taiwan[26]
	BOTTOM UP		 cooperative photovoltaic panels in Melpignano IT[27]

parameters	*sub-parameters*	*specifications*	*Case studies*
appearance	care for the building envelope		 waste to energy incinerator in Brescia IT: particular attention to the envelope and chimney[28]. To this category also belong all cases of rehabilitation of old plants
	"basic" building envelope considering only engineering needs		 thermoelectric plant in Monfalcone IT[29]

parameters	*sub-parameters*	*specifications*	*Case studies*
target	demonstrative/didactic/iconic		 photovoltaic panels on the roofing of Circolo Magnolia (Milano IT)[30], because of a non optimal performance and placement the project was primarily for marketing.
	economic / energetic		 photovoltaic park in the countryside in Lombardia IT[31]
	regulatory compliance		 solar thermic panel on the roofing (regulatory requirement for the production of hot water)
parameters	*sub-parameters*	*specifications*	*Case studies*
functionality	monofunctional		 off shore wind turbines, Thanet Wind Farm, Thanet Disctrict (Kent), UK[32]
	multifunctional		 requalification of an abandoned warehouse Halle Pajol in Paris[33] with inclusion of multiple public and private functions: the photovoltaic roof shelters also open spaces for orchards and common areas.

The table above clarifies some parameters that can be used in the classification of ES from a point of view of their perception. The different exposed general categories are commented as follows:

Visibility

Not necessarily an invisible ES is well accepted: assigning resources for an invisible object could be a not appreciated choice if the purpose of the intervention is to promote renewable energy or publicize the actions of the stakeholders or whether the intervention wants to be iconic and easily recognizable.

Time (age)

Since landscape has a great inertia[38], the ES that are part of the landscape from a long time are perceived as an integral part of the landscape itself. Contrariwise what is introduced quickly or simultaneously is perceived by the observer as extraneous and negative. Each transformation should therefore be guided slowly and introduced gradually (with the appropriate involvement and participation of the population).

Time (duration) = transportability

This category is closely linked to the concept of transportability. If we consider time as duration it results clear that a temporary intervention that responds to targeted needs for short periods is likely to be welcomed in any case better than long-lasting or permanent interventions. Conversely, temporary interventions often have much higher economic and management costs in proportion than long-term interventions that make them less attractive.

Level of anthropogenic stratification

This category tries to clarify the relationship between the ES and the place/support in which it is placed. The introduction of an ES from scratch is, especially in a fragile and stratified area, almost always the most critical choice. The ES can and should be an opportunity to regenerate an area, a neighborhood, a building, facing therefore the proposed project not only as a location for a new facility but as an opportunity to insert an object that creates profitable relationships within that area.

Manufacturability (size)
The size determines, for most of the energy systems, the problems and the potentials linked to the size of the ES (in terms of physical size and power): for each size there is an establishment of bonds and relationships with the landscape that are different and sometimes in conflict, so that the variation of size can vary the perception and the quality of the intervention. The size of an ES is a key element in the evaluation of its impact: not always the optimal size on a purely engineering point of view is the best for the area in which it is placed. The tendency nowadays goes towards small sizes, linked in a network, able to gather more support and reduce the possible negative effects connected with energy concentration.

Usability
The ES are not only technical systems: they are necessarily objects that can offer other benefits. They can provide shade, shelter from the rain, protect from falls or noise, or may form the floors to walk on.

[38] In physics object with a great mass effort to change their status (from stillness to motion and vice versa); in the same way landscape that remains in stasis for a long time struggles to accept changes.

Physical proximity

The NIMBY phenomena are often the main obstacle to the new ES: everyone is ready to support the needs of modern and useful plants, but if you put them far from their home or from their neighborhood is better.

Decisional proximity

Think global, act local: the acceptance of an ES is subject to the knowledge of the changes that it implies, in a positive or negative direction (what can I give up to get more ...) by the population involved in decision-making.

Appearance

The architectural design of the first hydroelectric power stations were entrusted to Italian great architects (Piero Portaluppi and Gio Ponti among all). After that, unfortunately, the power stations have abandoned the need to give the architectural object a special care, considering only plant and engineering needs. In recent years there has been a return to the care of the ES: the redevelopment of a plant considers today also the rehabilitation of the building envelope, giving the appearance of the plant a key role of interface with the landscape. It is also true, however, that these operations are sometimes only of green-washing, aimed mostly to direct more attention to the "body" that the content of an ES.

Target

Every ES has itself 'the opportunity to pursue multiple objectives: the basis is necessarily the economics and energy aspects along with regulatory compliance. Some interventions may have a not sustainable energy or economic efficiency, instead they are born with the purpose, not always explicit, to be interventions in some way didactic, in which the expected results are not directly economic or energy oriented.

Functionality

A PS is usually only monofunctional.
An ES must be multi-functional: it must be able to bring to itself or generate, directly or indirectly, synergies and secondary functions that justify the presence, investment and costs, and that will have returns in terms of global surplus value, not only directly for the investor, but also for all the citizens.

Step 4
The interpretation method

The Lynch analysis (Lynch 1969) is still useful and contemporary.
Born to define the cities' categories of interpretation, it resulted useful for an ES analysis. In fact, it provides keys to understand the relationship the ES have with their environment.
From the various parameters that emerged in the previous stage, it is easy to deduce the categories and sub-categories that reflect the work of Lynch and that are are inspired by his expectations and impressions.

We here report as an example two categories: margin and series. These two categories suggest why power lines (that can be considered as a series because separate objects and distant - the cables are invisible) are considered having less impact than wind turbines. These are often placed on a ridge, side by side, marking a border or a margin, and they cut a landscape and fragment the continuity of perception, making them usually unpopular and not accepted.

Table 5: Classification of the perception image of the ES in landscapes.
Interpretations, definitions and related study cases.

general category	*key words*	*definitions*	*study cases*
image (Lynch)	path	continuous connection system of places and elements	photovoltaic guard rails, collection of kinetic energy from roads and railways
	margin	not viable linear border, disruption of linear continuity, barrier, no penetration, disruptive, insulation	wind turbines positioned on ridges
	neighbourhood	homogeneous urban areas with some general features, perceived as a unit	sustainable eco-neighbourhoods
	hub	strategic points (as a conjunction of paths or concentrations of some features)	photovoltaic roundabouts
	reference	external punctual indications with a variable scale	recognizable ES and recognized as belonging to a specific place or area
	series	series as perceived in time	power lines

Find below, some significant case studies relative to the definition of the image they are related to, divided according to the interpretations described above, in the awareness of a biased partiality and incompleteness.

Path
 Figure 2. integrated photovoltaic system in the highway guard-rail. Autostrada del Brennero IT. source: www.autobrennero.it
The case of an ES that becomes part of a path expresses clearly how energy and its technology follows man in his travelling: the photovoltaic guardrail is emblematic of the possibility of using a necessary support (the physical barrier of the motorway) in a multi-functional and cost-effective way.

Margin
 Figure 3. wind turbines in Toscana IT. source:www.rinnovabili.it
Wind turbines work very well in high and isolated places, between valleys and gullies. For this reason the mountains and hills ridges are ideal for their installation. This however amplifies the separation feature that a ridge already exerts: the compact row of wind turbines is perceived (this is also in planes) as a barrier and not as a series of isolated objects. The fact that they are moving also generates a feeling, not at all justified, of danger for human or flying fauna. They are in fact a separating wall and therefore are perceived as hostile and limiting physical freedom of movement and freedom of looking beyond them.

Neighborhood

Figure 4. Vauban Freiburg. Picture from the author (© E. Ginelli).

The Vauban district of Freiburg is one of the first examples of "sustainable" bottom-up neighborhood, wanted by inhabitants themselves with the intention of creating an organized portion of the city that operates in a coordinated and energy self-sufficient way, with high levels of energy and materials saving, and the maximum use of renewable energy. Hence the idea of ES is brought to a district level: the whole project is designed as a single ES, where the houses with their own solar greenhouses, the multilevel parking with photovoltaic roof, the tele-heating plant and wind turbines contribute to people's welfare and to sustainability for the overall intervention.

Hub
 Figure 5. Photovoltaic roundabout in the area of Padova IT. Source: www.unionedeicomunipadovanordovest.it
A roundabout is a focal point for drivers: this can be the occasion to accomplish an ES used as a roundabout and at the same time as a point that gives a place a specific recognizability and makes it different from many other, anonymous, roundabouts cemented or infested by weeds.

Reference
 Figure 6. The incinerator of Brescia IT. Image font: google maps.
Along the undifferentiated industrial and artisanal Lombard suburbs, you meet, at one point, an element that alerts, without a doubt, the arrival in Brescia: it is the waste to energy incinerator of A2A, which provides heat and electricity to a large part of city. The design of the building envelop was very nice and particular attention was given to the chimney, asking the intervention of Jorrit Tornquist, painter and expert in colour and light. The intent was to disguise as much as possible the chimney with degrading and iridescent colours of blue and grey, similar to Lombard sky. The result has been to create an object, perhaps not quite camouflage, but that seems highly recognizable and fluidly communicate with the landscape of the suburbs, valuing perceptually also the adjoining highway infrastructure. This is an emblematic case of how an SE is able to transform a space (indefinite highway) in a place (the highway near Brescia).

Series

Figure 7. Power lines near Bereguardo IT. Photo of the author (© G. Pozzi).

The power lines are always perceived as isolated aligned elements, with a rhythmic pattern that will lead back to the idea of "series". This is also the case of the new power lines of Terna in Bereguardo in Italy, which, in addition to the characteristic of the common power lines, are particularly visible to be the result of focused design as a result of an international competition.

Conclusions

Step 5
Results

The classifications proposed can be further developed and enhanced by a final categorization that is of a wider range compared to what has been proposed.
To this categorization belong ES that establish a relationship with the landscape identity: they are born with the will to be iconic and "special". They can be single design objects, thus connoting strongly a point in the landscape (**landmark**). Or they can be a series of objects, coordinated or repeated, though always with a strong formal characterization and, sometimes, unquestionably artistic, in which the study of the shape is not functional to the purpose of energy but a true art installation (**landart**). Or they can be common objects, repeated in space and/or stratified over the years, but that undeniably mark the landscape and its use (**landscape**).
The table below attempts to illustrate some case studies in these categories reading across the three categories of relationship with the landscape (landscape, landmark and landart).

Table 6: Landscape – landmark – landart. Systemic reading of peculiar cases[39].

		relationship with landscape		
		landmark	**landscape**	**landart**
analysed case		isolated system iconic element	widespread system / distributed	demonstrative installation or provocative or iconic, with declared artistic intentions
pylon in the Lombardy countryside [39]		-	X the pylons belong to the landscape in a widespread and the temporal stratification does not make them more visible	-
incinerator of Brescia		X it marks especially the arrival at Brescia in motorway	-	X for detailed studies of colour it is also partially in this category
Windstalk, Dario Nunez Ameni and Thomas Siegl, 2nd place LAGI contest 2010, Abu Dhabi (UAE). Piezoelectric installation.		-	-	X it is an art installation that also generates electricity
BIG Architects incinerator with ski track, Copenhagen, Denmark		X incinerator that will mark the entire area of Copenhagen and that will have the ski slopes and mountain bike trails	-	-

[39] Image source: www.flickrhivemind.net

		relationship with landscape		
		landmark	**landscape**	**landart**
analysed case		isolated system iconic element	widespread system / distributed	demonstrative installation or provocative or iconic, with declared artistic intentions
Friedensreich Hundertwasser, incinerator of Spittelau, Vienna		-	-	X the object of design and "branded" skin doers the Energy unction
Blackfriars Solar Bridge, Solarcentury, London, UK bridge / station with photovoltaic roof		X in the scenario of the course of the River Thames in the City, the huge station's coverage of the Blackfriars Bridge in London shows very clearly the will to signal a notable point in the city	-	-
photovoltaics guardrail on the Brenner motorway		-	X along this part of highway, the continued and time settled presence of this ES is not unlike the presence of the asphalt of the street or the mountains in the background	-

The study of the proposed method is not meant to be objective or aseptic: each category can be a meta-planning orientation for the ES. It can guide the choices also during the ES planning phase, pointing out the influence margins in addition to the expected performance. The identified categories can guide stakeholders for their planning choices and can help resolve the conflicts that arise when an innovation is proposed in the field of energy conversion and production.

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Concept and Practice of the Cultural Heritage Conservation under Flood Disaster: A Case Study of Ayutthaya, Thailand.

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Abstract
In this paper, the past flood in 2011, the historical monument sites of Ayutthaya were also affected and damaged, the threat posed to cultural heritage by flood disaster analysed for six zones in Ayutthaya, Thailand. The vulnerability of 84 historical monument sites has been evaluated through a conservation calculation based on the approach conducted is based on previous study and application of Geographic information system (GIS) techniques for identifying the disaster vulnerability areas and the priorities conservation. For the present study, this adapted approach was chosen because it allows the non-experts in the field of urban cultural heritage or architecture conservation, to perform survey on the step of conservation. Moreover, the results of GIS can be verified with the field survey to deliver priorities of intervention based on the vulnerability of the historical monument sites, physical factor that are considered important for the occurrence of flood disaster have been used to generate a susceptibility map. A qualitative risk assessment was carried out by combining susceptible area and historical monument sites. As there were very limited historical damage data available on the occurrence of flood disaster, a combination of local and expert knowledge has been used to extract information on both historical monument sites. Finally, some recommendations are given related to the analysis of the impact of natural hazards on historical monument sites and assets for evaluate the risk factors of integrating hazard risk aspects of cultural heritage sites into the conservation plans.

Keywords: community based, conservation, cultural heritage, damage, flood disaster, priority.

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Introduction

This study is based on cultural heritage conservation under flood disaster in Ayutthaya, 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 (Office of Fine Art Department, 1994). 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 (UNESCO, 2010).

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 (The World Bank, 2012).

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 (The World Bank, 2009). 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 (UNDP, 2004). The important cultural property of Ayutthaya were also affected and damaged.

Methodology

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 1.00-2.00 m. and the total area is approximately 3,000 rai (4.80 Sq.km.) (Office of Fine Art Department, 1994) (The World Bank, 2009).

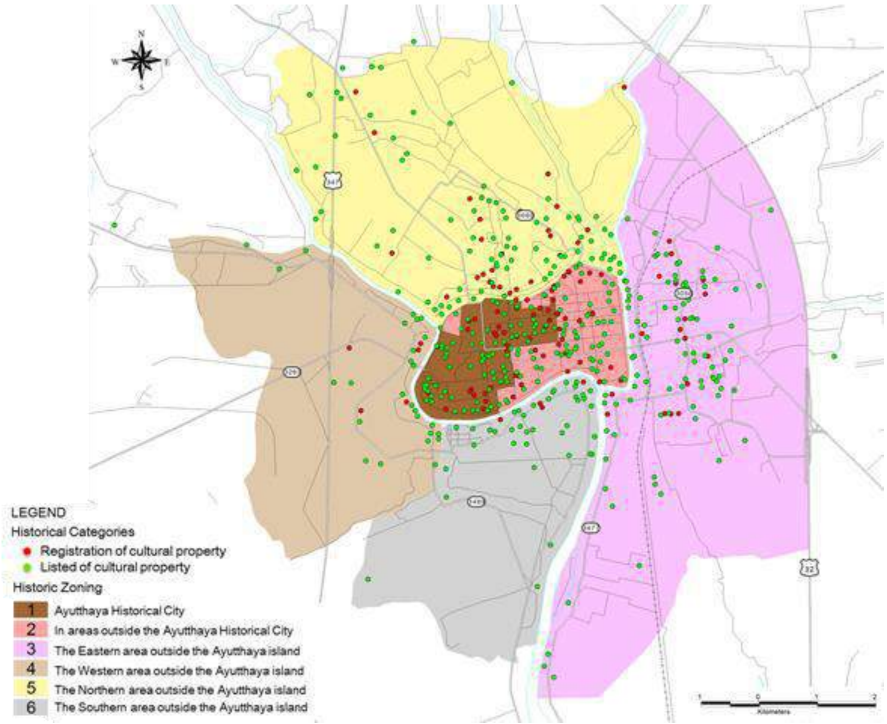

Figure 1: The Distribution of Cultural Heritage Sites around Ayutthaya Historical City Coordinated by the Global Positioning System.

Table 1. The Distribution of Cultural Heritage Sites in Ayutthaya.

Cultural Heritage	Registered	Listed	Grand total
Zone 1	30	75	105
Zone 2	30	64	94
Zone 3	18	90	108
Zone 4	5	26	31
Zone 5	27	79	106
Zone 6	5	40	45
Total	115	374	489

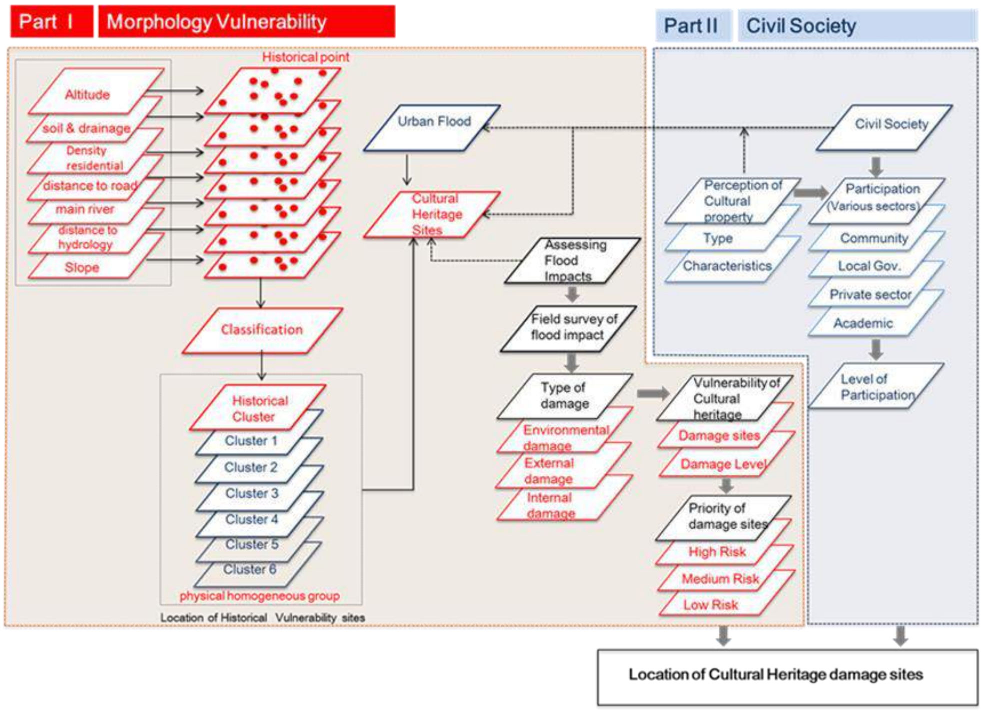

Figure.2: Methodological Framework for Urban Morphology Types.

Result and Discussion

Concept of assessing impact and value.
It is important to assess the damages in terms of environmental damage, external damage and internal damage. The levels of damage; high risk, medium risk and low risk respectively, are also assigned. Furthermore, the CHS values are ranked as high (Ayutthaya historical city), medium (registered) and low values (on the list) (Office of Fine Art Department, 2010). These two factors are employed as indicators for setting the priorities of CHS conservation.

GIS-mapping and analysis of disaster risk is in two layers: Layer 1 is a degree of risks at the site (high risk, medium risk, low risk) Layer 2 is the values of the site (high value, medium value, low value). Analysis is done in order to develop recommendations for management action which will put the high priority on historical sites of high value and high risk (Figure 3)

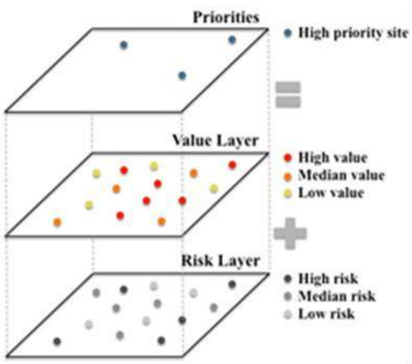

Figure 3: The Concept of Assessing Impact and Value
[Source: Wittya Daungthima and Kazunori Hokao, 2013].

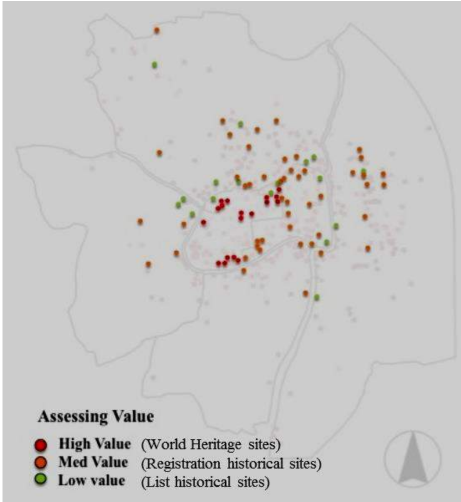

Figure.4: The Value of Cultural Heritage [Source: Wittya Daungthima and Kazunori Hokao, 2013].

Assessing the flood impacts.
CHS plays a significant role in the Ayutthaya historical city identity and is important to conserve. The 2011 floods have greatly affected a large number of CHS assets including museums, temples, archaeological sites, cultural landscapes, and historic landmarks within and around the Ayutthaya city. Assessing damage and losses to CHS assets is a site-specific exercise. Their diversity requires site-by-site assessments.

Type of damage.
The survey of CHS damage sites in Ayutthaya is based on the types of damage which are: 1) Environmental damage consists of areas at risk from flood, ground cracks, landscape damages, pit on ground or subsidence, surface water flow paths, vulnerable communities and critical infrastructure. 2) External damage which are light damage (wall or decorative aspects) and structural damage 3) Internal damage includes interior of affected building (wall, decoration and ceiling). From the surveys, it was found that, at present there are 3 groups in Ayutthaya CHS damage (Wittaya Daungthima, Kazunori Hokao, 2013).

Field survey and damage assessment.
The field survey on previous flood impacts studies. To studies the details of the data store to the field and the type of damage by the description of CHS include the Name of cultural heritage, Type of cultural heritage (registration historical sites and list historical sites), Coordinate by GIS and GPS, Address of cultural heritage, Zone of cultural heritage, Description compound size and construction, Photo number, Date and time for the operators to explore and records data corruption CHS. Type of damage include 1) Environmental damage: areas at risk from flood, ground cracks, landscape damage, ground of the pit or subsidence, surface water flow paths and critical infrastructure. 2) External damage: light damage (wall, decorative aspects), structural damage. 3) Internal damage: interior of building affected (wall, decoration, ceiling) to find characteristic of the damage sites and level of the damage.

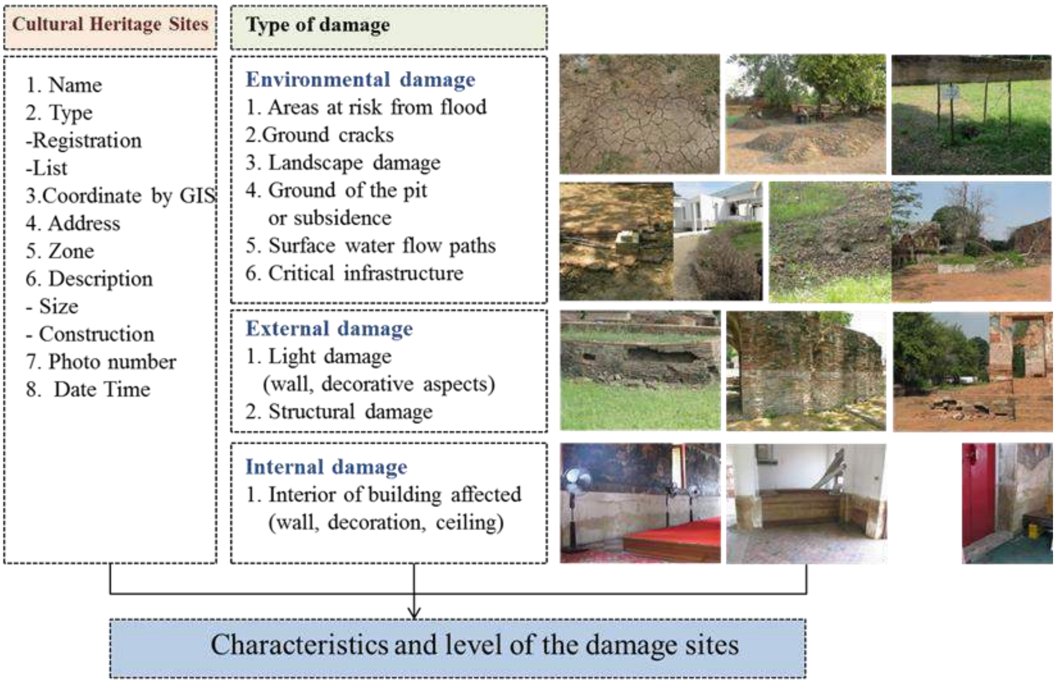

Figure 5: Characteristic and Level of the Damaged Sites [Source: Author, 2013].

The studies of field survey on April – May, 2012 the flood impacts and the CHS vulnerabilities the result show that the previous flood has damaged the CHS in Ayutthaya. To conserve those CHS, it is important to assess the damages in terms of environmental damage, external damage and internal damage. Environmental damage, high risk found 6 CHS, medium risk found 37 CHS and low risk found 41 CHS. In UMT 2 the most Environmental damage, UMT 3 and UMT 1 respective (see in Figure 6). External damage, high risk found 11 CHS, medium risk found 23 CHS and low risk found 50 CHS. In UMT 2 the most External damage, UMT 3 and UMT 1 respective (see in Figure 7). Internal damage, high risk found 10 CHS, medium risk found 18 CHS and low risk found 56 CHS. In UMT2 the most Internal damage, UMT 1 and UMT 3 respective (see in Figure 8).

The levels of damage; high risk, medium risk and low risk respectively, are also assigned. The results are shown in Table 5. Assessing impact of flood high risk found 11 CHS, medium risk found 30 CHS and low risk found 43 CHS. In this study found 84 CHS in study area were assessed as damage by flood in 2011 is shown in figure 9 for the remaining 405 HMS damage assessment was carried out considering due to limitations during the historic monument sites survey of the damage, some of HMS them begin for renovation. The field survey of flood impacts, water flood in Ayutthaya on October – December, 2011 and drainage of moisture in the soil need time to prevent damage to structure of the CHS (Wittaya Daungthima, Kazunori Hokao, 2013).

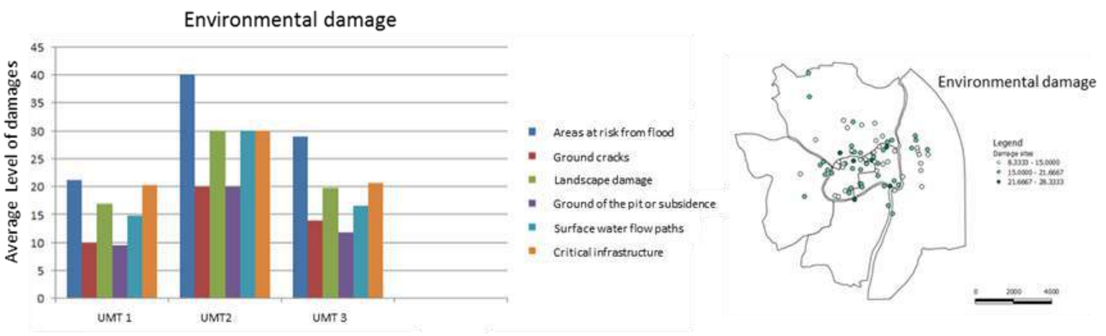

Figure 6: Types of Environmental Damage [Source: Author, 2013].

Table 2 Assessing Impacts of flood Environmental Damage.

Custer	High Risk 21.67- 28.33	Med Risk 15.01-21.66	Low Risk 8.33-15.00	Total
Damage site	6	37	41	84

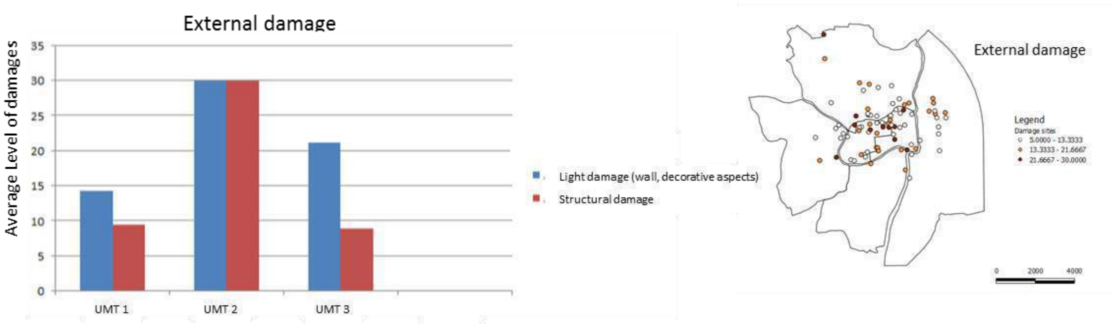

Figure 7: Types of External Damage [Source: Author, 2013].

Table 3 Assessing impacts of flood External Damage.

Custer	High Risk 21.67- 30.00	Med Risk 13.34-21.67	Low Risk 5.00-13.33	Total
Damage site	11	23	50	84

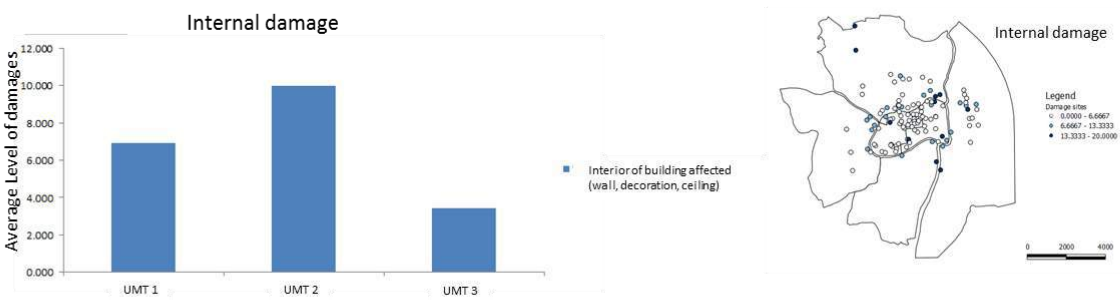

Figure 8: Types of Internal Damage [Source: Author, 2013].

Table 4 Assessing impacts of flood Internal damage.

Custer	High Risk 13.34- 20.00	Med Risk 6.67-13.33	Low Risk 0.00-6.66	Total
Damage site	10	18	56	84

Table 5 Assessing impacts of flood.

Custer score	High Risk (181-240) 17.04- 23.33(%)	Med Risk(121-180) 10.74 - 17.03 (%)	Low Risk(60-120) 4.44 -10.73(%)	Total
Damage site	11	30	43	84
Average	214.29	146.77	96.74	125
Min	190	130	60	60
Max	240	180	120	240

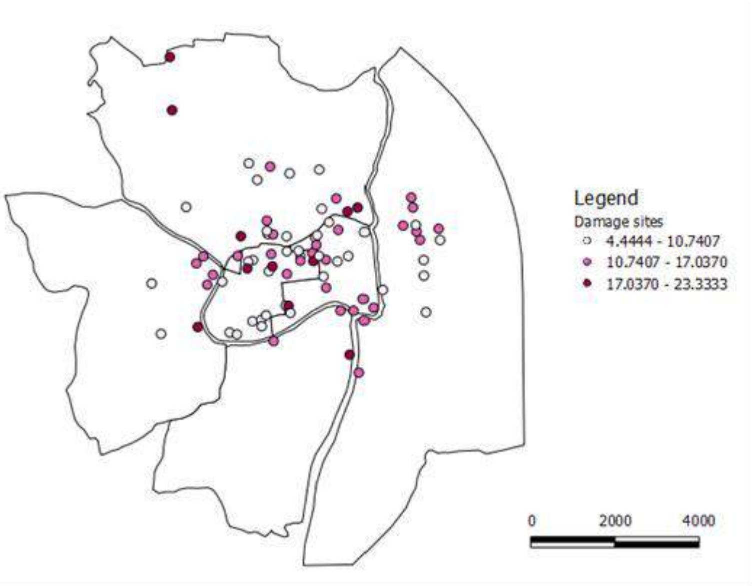

Figure 9: Assessing Impacts of Flood [Source: Author, 2013].

Integrated assessment to support urban scale and local neighborhood scale.

The scale and level of flood effects to urban area and cultural heritage had required to the will require local governments and civil society. Some cultural heritage sites are beginning to require local governments meet urban flood protection of cultural heritage sites. However, it is at the local level that most protection, the process made-by public officials, practitioners and citizens in cities. That process not included decisions process about flood protection and cultural heritage sites. City planners and local decision makers generally lack the tools and means needed to make informed choices about the flood risk and cultural heritage implications or to measure their effects. Policy makers and regulators at all urban scales, as well as their political constituents and stakeholders, need decision support tools that illustrate the flood protection and cultural heritage implications of urban morphology type so relevant land use, conservation areas decisions.

This research focuses on the presents and ideal tools or integrated with spatial information for support decision maker on urban flood and cultural heritage sites in the previous study. This integrated urban flood risk and cultural heritage sites to evaluate the relative urban morphology classification benefits of alternative development approaches in a city ranging from the building scale to the local neighborhood to city settlement level. It summarizes the relationship between morphology and flood risk, particularly in the flood mitigation arena and to presents a framework that illustrate how integrated tools are already being proposed in Ayutthaya Historical City (AHC) as part of the urban planning and urban design process. This study shall present an idea to overcome investigate safety and security of their local areas, and draw up the results in to map for decision making sharing of information transfer of powerful experience and architectural design measures to live safely from the current to the future.

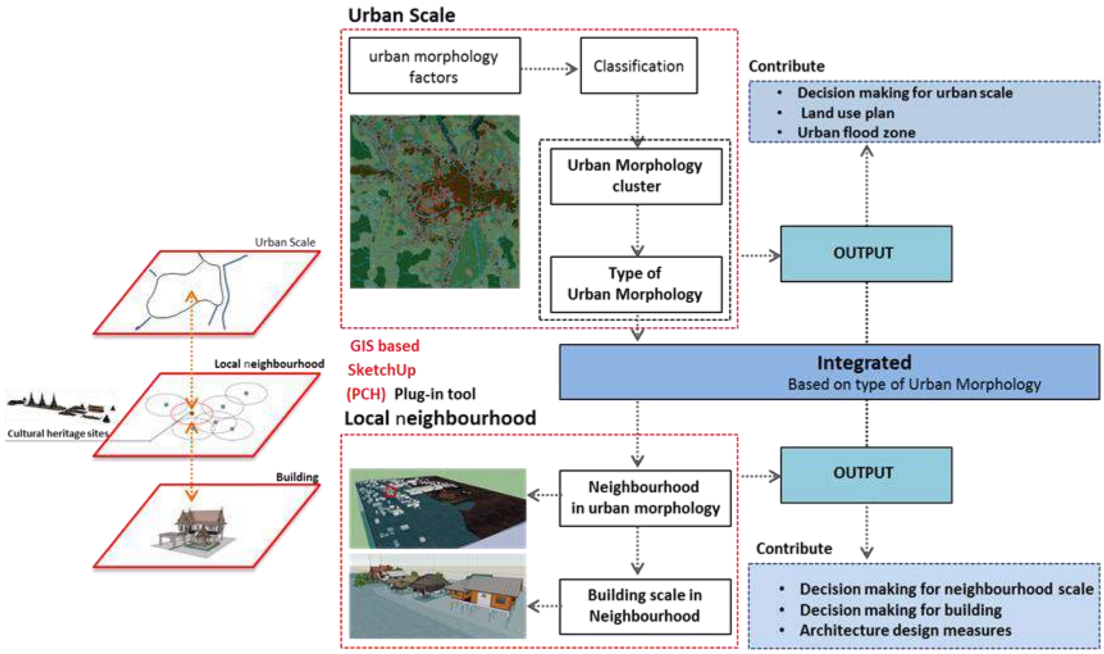

Figure10: Integration spatial Information for Support Decision Making.
[Source: Author, 2013].

Conclusions

The results of this study indicated that there are importance for both the composition and configuration of possible physical impact of flood disaster and field survey. The description of the quantitative relationships of seven the disaster vulnerability factors with the urban flood disaster, found seven factors that are most important to analysing the possible physical impact of flood, altitude or elevation, drainage system & soil, density of resident, distance to main river, distance to hydrology, slope and distance to road. This research expands our scientific understanding of the effects of flood disaster on urban cultural heritage and CHS. The possible physical flood impacts are quite similar to field survey of CHS.

These results have important theoretical and management implications. Urban planners and Urban Architects attempting to mitigate the impact of flood disaster on CHS can gain insights into the importance of the priorities of CHS conservation and renovation.

The results are consistent with those previous research assessing impact and value of CHS. It is important to assess the damages in terms of environmental damage, external damage and internal damage. The levels of damage; high risk, medium risk and low risk respectively, are also assigned. Furthermore, the cultural heritage values are ranked as high (Ayutthaya historical city), medium (registered) and low values (on the list).These two factors are employed as indicators for setting the priorities of CHS conservation.

The investigate safety and security of their local areas for two scale (urban and local neighborhood). Difference urban morphology types and neighborhood is difference for the investigation safety and security of local areas

Contributions in this study, to encourage greater interest in local safety and security, as well as sharing of information and to investigate the safety and security of their local areas, spatial information for support decision makers on cultural heritage distributions and hierarchical for cultural heritage conservation and management.

Acknowledgment

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Stakeholder's Engagement to Assess and Enhance Climate Change Adaptation Strategy for Water Resource Management

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Abstract
This research aims to explore the role of stakeholder engagement in ex-ante assessing and planning of climate change adaptation strategy. The research designs the participatory assessment process for engaging with stakeholders on issues of water resource management and adaptation for climate change.

More specifically, the research has to build a bottom-up information gathering mechanism for multi-stakeholders' opinions; furthermore, to plan an adaptation strategy from local knowledge for social acceptance and public consensus. A three-stage process," Participatory Assessment Process", is planned as the appropriate way. Stage 1 is "Resource Survey", which includes two steps: stakeholder's interview and identification. On Stage 1, conflicts that stakeholders really consider would be identified; and local communities and core groups of stakeholders would be connected.
Stage 2 is "Knowledge Extraction and Interpretation", and there are three steps on Stage 2: scanning of existing literature related to stakeholder engagement processes, holding "Core Group Workshop" of stakeholders, and then inviting core groups and local communities to engage co-learning activities. Through core groups' feedback from the workshop, the knowledge extraction and interpretation would be modified appropriately. The knowledge could be shared with core groups and local communities during co-learning activities.
Stage 3 is "From Conversation to Consensus" whereby the "Stakeholder Workshop" would be held. There are face-to-face conversations in the workshop to incorporate these opinions and knowledge to identify the key issues and feasible options of adaptation strategy. Through the three-stage process, it would suppot decision makers to take more different and comprehensive perspectives into consideration during the policy-making process.

Keywords: Stakeholder engagement, Participatory assessment process, Climate change adaptation, Water resource management

Introduction

Scientists observe a phenomenon of shifting seasons, temperature and precipitation are not the same as usual, for climate change has already begun to transform global weather. Global temperature naturally rises up and falls down from year to year. People cannot stop a warming trend of global changes, which average temperature is slowly increasing. Additionally, human activities, overusing fossil fuel and accelerating forest degradation, have increased the emission of greenhouse gases; therefore, scientists also project that if emissions of greenhouse gases are not reduced, average temperatures could increase. The effects of rising temperature and changing precipitation are intensifying the circulation of water on, above and below the surface of the Earth, thereby making drought and floods to be more frequent, severe and widespread. Climate change has already affected on water resources, such as water quantity and water quality. Summary for policymakers of The Fifth Assessment Report (AR5) of IPCC (Intergovernmental Panel on Climate Change) statements clear, new and scientific evidences relevant to climate change that affects water resource. According to the summary, "*Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions*" (IPCC, 2014).

In additionally, water demands will increase in many regions but water supplies will shrinks due of rising temperature. The balance of water quantity faces a challenge on simultaneously meeting water needs. If scientists provide a variety of adaptation technologies designed to better conserve water supplies and improve water recycling, water resource management will have a better response to climate change. But water resources management is such difficulty that government have to satisfy water demands of different usage. How to support decision makers to develop climate change adaptation strategies for water management to response climate change? How to connect climate change related scientific knowledge to policy-making process to support strategy planning? We argue that this research focus on mechanism building to connect science to policy, and to help decision makers take different perspectives into consideration. Furthermore, this research aims to explore the role of stakeholder engagement in ex-ante assessing and planning of climate change adaptation strategy, and designs the " Participatory Assessment Process" for engaging with stakeholders on issues of water resource management and adaptation for climate change.

What is stakeholder engagement for climate change adaptation strategy?

The term *stakeholder* typically refers individuals and groups, both/either of them involves an event. And *stakeholder* is also defined as (IFC, 2007):

"...persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively"

Depending on the event objectives, stakeholders are diverse for each team, section and division, and may adjust the difference to suit to the relationship between stakeholders and the event (IMMI, 2008).

Stakeholder engagement broadly refers to a continuous process between an event and these potentially impacted activities and approaches. Firstly in the business activities, decision makers increasingly understand the risks of operation that come from poor stakeholder relations, in contrast, good stakeholder relations benefit for good risk management. According to Commonwealth Scientific and Industrial Research Organisation (CSIRO) research report (Gardner et al., 2009):

"The term stakeholder engagement is used to describe any process that involves stakeholders in some form of collaborative effort directed towards a decision, which might involve future planning and/or behaviour change. The extent of this collaboration can vary from fairly brief and simple information provision, to more extensive and long-term relationships amongst participants"

For the response to climate change, mitigation and adaptation are both important actions. Mitigation, reducing emissions of greenhouse gases, is the main guidance of national strategy at first. Many mitigating actions decrease carbon dioxide emissions by advancing technology; the generating electricity power process of renewable energy produces a few, almost zero emissions of carbon dioxide. *Adaptation* gradually forms another important action in the past decade. *Adaptation* improves society's resilience to long-term climatic changes and reduces the society's risk of environmental changes. In order to plan climate change adaptation strategy appropriately, three main properties could be considering: interdisciplinary, multilevel governance and local knowledge. Researchers facilitate these data collected from different fields - the climate scientific data, natural environment data and social-economic data, and then use it in determining possible impacts of climate. Through improving research methods, researchers connect interdisciplinary science to policy, and these scientific research results support decision makers to undertake adaptation strategy and preventive actions.

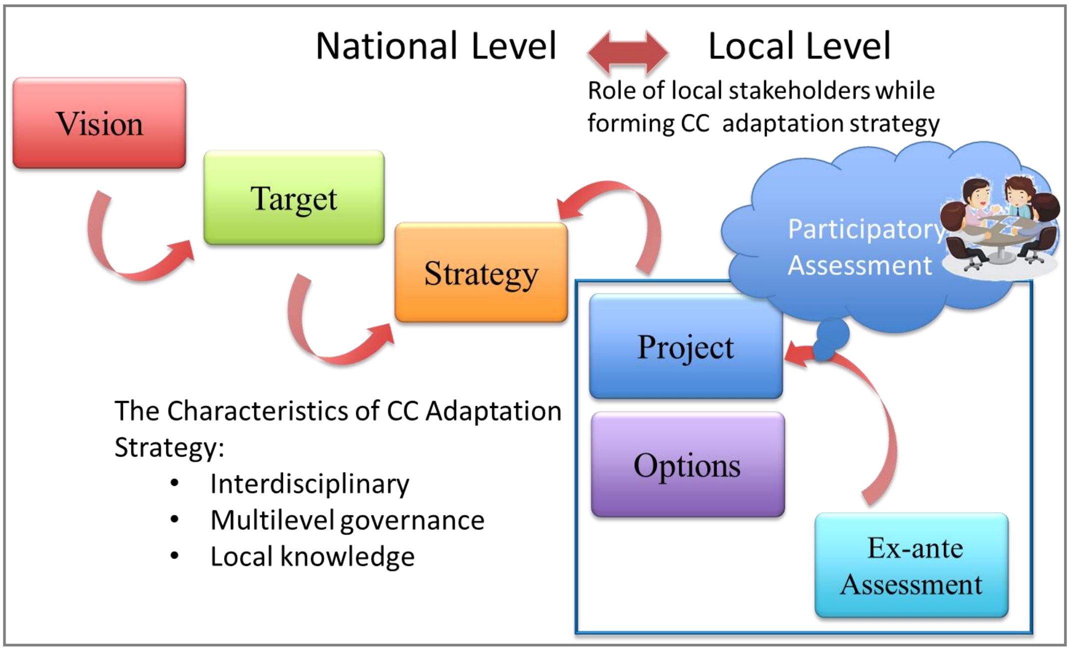

Figure 1: Bottom-up mechanism of adaptation strategy planning

As shown in figure 1, since impacts of climate change are from national to local area, scope, actions and actors of adaptation strategy should be distinguished from different governmental levels - from local to national. While decision makers focus on local adaptation strategy, national should be supporting role. Otherwise, considering about these properties of adaptation, functions and roles of stakeholders should be more active and aggressive while forming adaptation strategy. As far as local adaptation strategy is concerned, local stakeholders should be invited to join strategy planning process. Furthermore, a bottom-up assessment of local projects and options will modify strategy to be aligned with target and vision, and also build a well-formed linkage between local and national level.

Why is it important that stakeholders engage adaptation strategy?

Needs of stakeholder engagement in natural resource management is increasingly rising and has been also seen as a sufficient condition to improve justification of management. This is reflected in a steady increase in the number of projects of natural resource management over the past decade that stakeholder engagement is relevant to the topic of climate change adaptation (Wise, 2014; Yee, 2010).

If stakeholders, especially local stakeholders, could and would be informed, to join, and to negotiate, it believes that local projects and options under climate change adaptation strategy would be more acceptable and effective through stakeholders' knowledge, view, and opinions. However, stakeholder engagement includes many levels and types. Because the concept of stakeholder engagement has been implemented through citizen participation, most of the literature have been discussed and argued. Arnstein (1969) address a typology of eight levels of participation, and the eight types are arranged in a ladder pattern with each rung corresponding to the extent of citizens' power in determining the end product. According to "A Ladder of Citizen Participation", citizen participation ranges from non-participation where participants are "educated" or "cured" by power-holders; tokenism where participants are proffered by power-holders as the total extent of participation and they may indeed hear and be heard; to citizen power where participants increase degrees of decision-making influence and obtain the majority of decision-making seats or full managerial power (Arnstein, 1969). In this research, we indicate three functions in increasing effect of stakeholder engagement. As a contribution, as an organization and as empowered; all are an approach to realize stakeholder's engagement. While stakeholder as the contribution, it assumes a passive community that is given information. They are told what is going to happen, is happening or has happened. While stakeholder as the organization, they are given a voice, but no power to ensure their views are given attention. Their views have some influence, but traditional power-holders still make the decisions. While stakeholder as empowered, some power of stakeholder is delegated; furthermore, they have the full delegation of all decision-making and action (Warburton, 1997). Effective stakeholder engagement not only provides an individual opinion or local knowledge but also provides more opportunities to diagnosis adaptation strategy planning. The possibility of planning a good adaptation strategy will rise if stakeholder engagement is effective and appropriate.

Considering impacts of climate change, it not only effect in physical and ecological systems, but also in the socio-economic system. These impacts have brought opportunities and threats for issues that are defined by stakeholders to be appropriately responded and tackled. Tackling an environmental governance problem is a reflection of the strength of the interests and power of the actors who define the problem (Adger et al., 2005). For this reason, a good adaptation strategy will consist of stakeholder engagement as part of a strategy planning process. It means that stakeholder engagement will improve understanding of climate change adaptation related problem. Furthermore, supporting decision makers adopt strategies that keep options open, reduce potential regrets and account for new information over time. (Ranger et al., 2010) In order to face the uncertainty of climate change and reduce the risk of impact, decision makers can make a decision that avoids exposure to potentially costly maladaptation, is informed and robust through effective stakeholder engagement.

How to enhance and access?

Due to the research aims to explore the role of stakeholder engagement in climate change adaptation strategy planning, we have to find what stage of strategy planning process is appropriate phase for stakeholder engagement. At first, based on "The Process of Public Policy Formulation" (Anderson, 1978), the process consists of six stages: problem formation, policy agenda, policy formulation, policy adoption, policy adoption, and policy evaluation (as shown in figure 2).

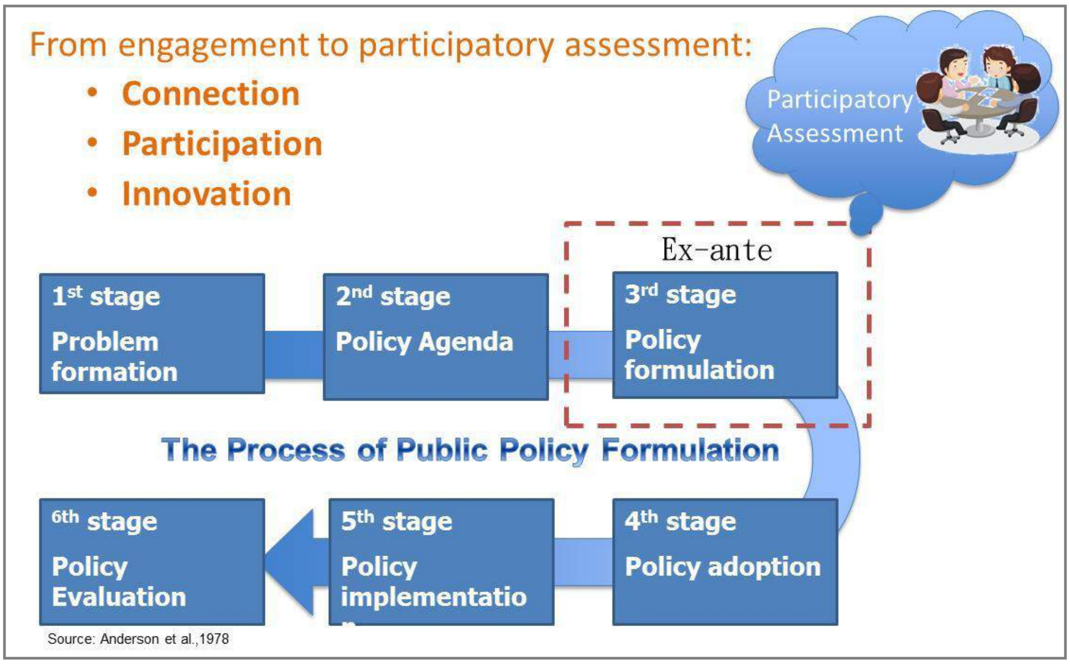

Figure 2: Early stakeholder engagement of the process of public policy formulation

In the 3rd stage "Policy formulation", the government proposes solutions to the problem. And thinking about benefits of stakeholder engagement, we argue that early stakeholder engagement, as applying to ex-ante assessment method, provides valuable opportunities to influence social acceptance and set a transparency policy-making process with stakeholders early on. While planning climate change adaptation strategy, there are still many uncertainties and unknown impacts. Use early interactions with stakeholders as a predictor of critical issues and potential risks, and help generate good/new ideas and alternative solutions on the early strategy planning process.

In addition, applying the principles to change types of stakeholder engagement and enhance participatory assessment. There are proposed three principles in this research: connection, participation, and innovation. The principle "connection" has connotations of connecting local people and local knowledge to adaptation strategy planning that local stakeholders could be identified. Another principle is "participation". As mentioned above, the 3rd stage "policy formulation", which development of appropriate and acceptable actions for dealing with problems, is the rationale stage for stakeholder's engagement. Due to enhancing participatory assessment, the third principle is "innovation" that embodies to encourage stakeholders to give some good/new idea of adaptation strategy. According to these principles, this research designs and proposes the "Participatory Assessment Process", and builds a bottom-up information gathering mechanism for opinions of multi-stakeholders, which to enhance and access stakeholder engagement for climate change adaptation strategy.

The "Participatory Assessment Process" for engaging with stakeholders consists of three stages, which are broken down into six steps (as shown in figure 3). Stage 1 is "Resource Survey", which includes two steps: stakeholder's interview and identification. Through two steps of stage 1, related issues that stakeholders really consider would be identified, and local communities and core groups would be connected. At beginning of the process, stakeholder's interview is an important step which understands and identifies a critical issue and relevant stakeholders. Stakeholders are diverse for interests, specialties and professions, and they can be defined or identified by one or more of categories. The relationship between an event and different categories of stakeholders should be established, and stakeholder's identification should base on event objectives to find out all relevant stakeholders, who constitute about individuals, groups and communities. If we concern the level and scope of issues of climate change, we should distinguish these individuals, groups and communities of stakeholders between local and national. According to the list of relevant stakeholders, we can find out the highest relevant individuals and groups, establish connections to them, and set up core groups.

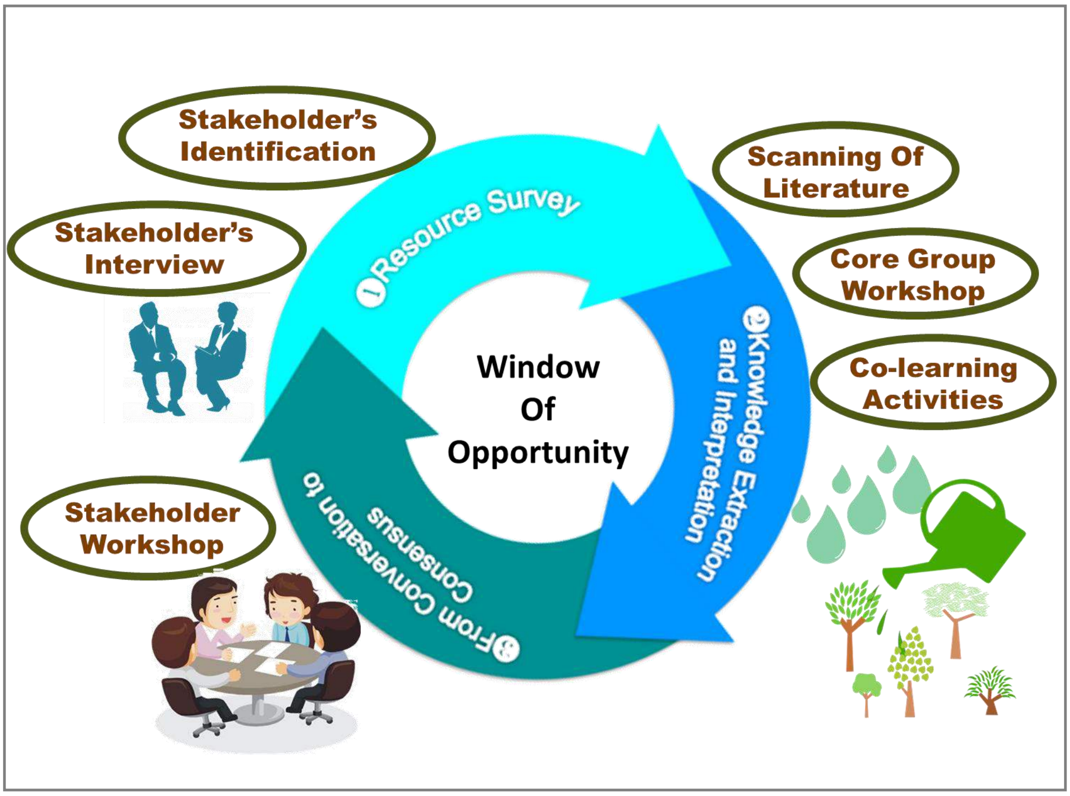

Figure 3: Participatory Assessment Process

Stage 2 is "Knowledge Extraction and Interpretation", and there are three steps on this stage: scanning of existing literature related to the critical issues, holding "Core Group Workshop" of stakeholders, and then inviting core groups and local communities to engage co-learning activities. Providing to the stakeholders with objective, balanced and multi-dimensional information, it assists them in understanding the issues, thinking about the opportunities and risks, and finding the solutions and options. However, these issues of climate change could be interdisciplinary knowledge, not just weather forecasting and environmental surveying, but also human activating and social developing. These core groups join the core group workshop and give their opinions on the workshop. The role of core groups is "trial tester". Through these core groups' feedbacks, the knowledge extraction and interpretation would be modified appropriately and be understood easily. The core groups could share extracted and interpreted knowledge with local communities during co-learning activities, and all of them understand the issues in advanced.

Stage 3 is "From Conversation to Consensus" whereby the "Stakeholder Workshop" would be held. There are face-to-face conversations in the workshop to incorporate these opinions and knowledge to identify the critical issues and feasible options of adaptation strategy.

In this research, we also development a tool for adaptation assessment, and we call it as "Water Diamond". As shown in fig 4, there is a parallelogram on the center, and the shape of the parallelogram is like the diamond, therefore, we call it as "Diamond". In the other way, this case study of the research is about water management. For these reasons, the tool for adaptation assessment is named as "Water Diamond". In the left slide of fig 4, it shows the integrated checklist which consists of eight WH questions of three levels. WH questions would guide stakeholders to assess adaptation options systematically and comprehensively. According the assessment principles, we transform some items of integrated checklist to the “Water Diamond” and display stakeholders’ opinions of multi-dimensions on the “Water Diamond”. Stakeholders would justify the options base on the answers of WH questions, and could negotiate with each other in each dimension of the opinions to identify feasible options, or to development better alternatives.

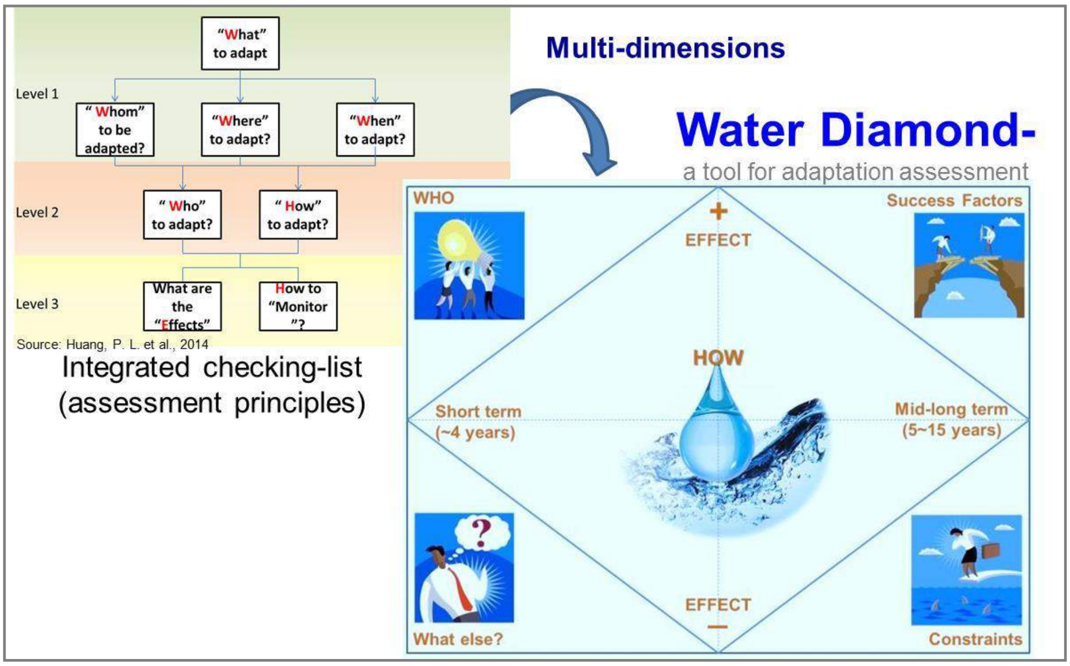

Figure 4: A tool for adaptation assessment – “Water Diamond”

Through the three-stage process, the bottom-up information gathering mechanism for opinions of multi-stakeholders would assist decision makers to take more different and comprehensive perspectives into consideration during the policy-making process. Simultaneously, the bottom-up mechanism would also assist decision makers to plan an adaptation strategy from local knowledge for social acceptance and public consensus.

Case study: water resource management

The subject of this case study of this research is “Water Resource Management in Southern Taiwan Science Park”. The Southern Taiwan Science Park (STSP) is an industrial park that consists of Tainan Science Park and Kaohsiung Science Park, and was established by the government of Republic of China (Taiwan) in 1995 (STSP, 2015). In this case, we focus on the Tainan Science Park of STSP, which includes key industries: integrated circuits, optoelectronics, green energy, and biotechnology.

Climate change also results in rising temperature and changing precipitation in Southern Taiwan. Additionally, heavy rain is frequently falling in wet seasons and rainfall is continuously decreasing in dry seasons. Less water likely will be available during the summer months, when demand is highest, since future projections for less total annual rainfall, less rainfall in dry seasons, and heavier rain in wet seasons. The amount of annual rainfall in these regions is already limited; if water demands rise, severity and length of droughts will increase continuously. If water supply is not enough, these industries will have the serious effect on their operation. But other sectors in the Southern Taiwan also need water to operate their work, like agriculture. With prediction of precipitation, the probability of drought happening will increase. We think that it is necessary to build a pathway of stakeholder engagement. All stakeholders discuss and negotiate what they need, and also think about that how to create “Win-Win” result for each other. We set the scene: first, focus on demand side of water resource management; second, assess water use of technology industry in Southern Taiwan Science Park; and third, forecast impacts of climate change: according to A1B scenario of IPCC to year 2030.

In the case study, we utilize the participatory assessment to explore the role of stakeholder engagement. As shown in fig 5, this is the flowchart of this case study, which consists of three stages and six steps. On stage 1”Resource Survey”, there are 18 people that are interviewed in 15 respondent interviews. After these interviews, we identify the stakeholders and divide them into 7 categories and 25 units. On stage 2 “Knowledge Extraction and Interpretation”, we scan literature related the subject of this case. Meanwhile, we hold one core group workshop and two co-learning activities. After joining these events, these stakeholders would have more argumentation and discussion. Not only be given information, but also have more direct influence. On the last stage “From Conversation to Consensus”, we hold a one-day stakeholder workshop. The workshop was designed with informing, discussing, voting, assessing and sharing on the agenda and almost 40 people joined the workshop. During the one-day stakeholder workshop, we have assessed these adaptive options on the tool for adaptation assessment –“Water Diamond”. Through “Water Diamond”, we organize all of the stakeholders’ view and opinions, and modify and update adaptation strategy according to structured stakeholders’ view and opinions.

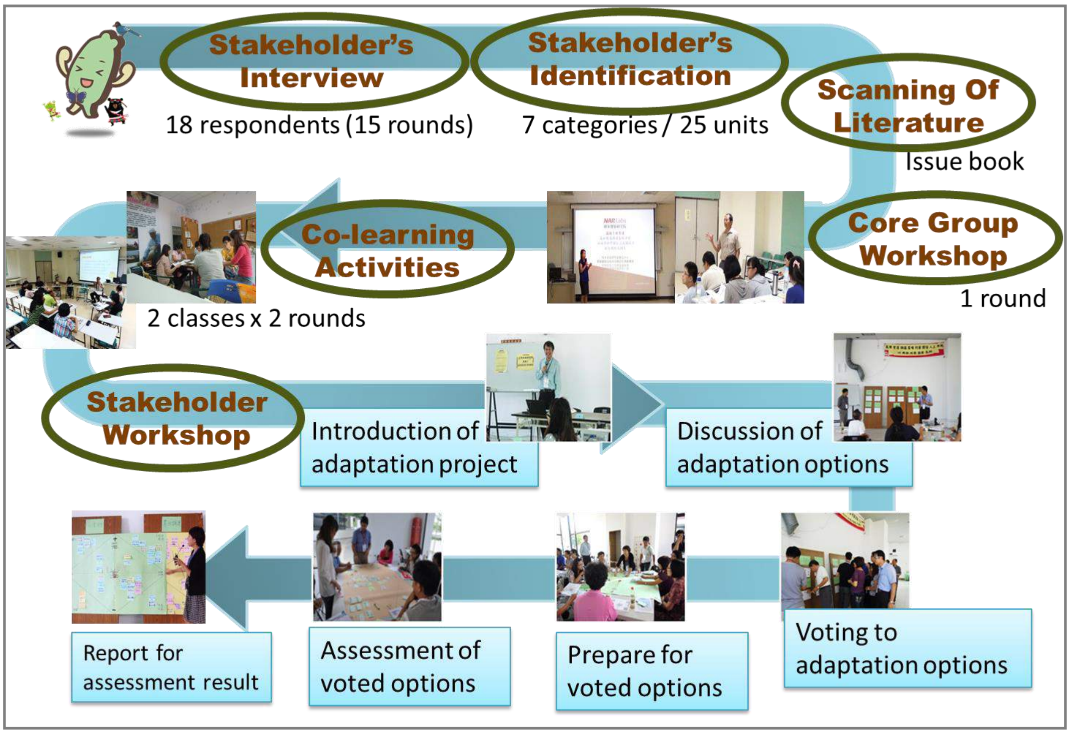

Figure 5: Flowchart of Participatory Assessment Process

Conclusion

To sum up, water resource under climate change affects many sectors of water consumption, including household, agriculture and industry. Therefore, water resources management is important to both ecosystems and society. Responding impacts of water resource under climate changes are two main approaches of adaptation strategies that the government might take: bottom-up and top-down. The government would respond and prevent these impacts of national level, while all citizens have faced the impacts—this is what top-down strategy does. In contrast, people should improve the resilience of local area to react these impacts of climate change—this is the meaning of bottom-up strategy. Both approaches of adaptation strategies have assessed stakeholder attitude and society's value. If adaptation strategies would be successfully implemented, stakeholder attitude and society's value are key factors. In this research, we design the participatory assessment process for engaging with stakeholders, simultaneously, we build a pathway of stakeholder engagement. The three-stage process of bottom-up mechanism would support decision makers to take more different and comprehensive perspectives into consideration during the policy-making process. And finally, enhance the robustness of policy-making process while planning climate change adaptation strategy.

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Thermochemical Energy Storage as A Way to Increase The Sustainability of Energy Generation

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Abstract
For the future of the energy sector it is necessary to increase the use of unused potentials by waste heat at low temperature (T < 350°C) by industrial processes under the focus of economic conditions.

Achieving this objective involves, taking full advantage of all the potential arising from the separation between generation und consumption of heat. On the basis of this request, it is necessary on the one hand to store heat over a long period of time and on the other hand to transport heat from A to B. These requirements would not be fulfilled through the technology of sensible or latent heat storage systems.

The storage of heat by the thermo chemical storage technology is one opportunity to reach these targets. The main advantage of this technology is that the storage density is a factor 10 higher by the TCS (MgO + H2O -> Mg(OH)2) in comparison to the sensible storage technology (water 60°C -> 90°C) and that the storage material can easily be transported by a truck. The storage and transport of heat without loss is the basic condition for an energy-, resource-, and cost-efficient future in the energy sector.

Through consideration of the TCS in energetic, exergetic and economic sight it is possible to formulate well-founded conclusions. For this purpose it was necessary to depict different process configurations in the process simulation tool “IpsePro”. On basis of these simulations it was possible to compare the different processes and to optimize the system configurations.

Keywords: Thermochemical heat storage, magnesium oxide, theoretical storage density, real storage density, economic, process integration

Introduction

Storage is one of the most important topics for the sustainability of energy generation in the world. But mostly we think about the storage of electricity. When we take a look to Figure 1 we see that also the energy in form of heat has a big share on the world energy consume.

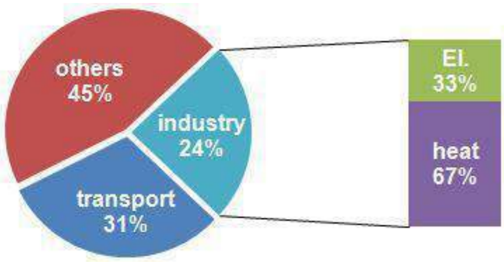

Figure 1: Energy demand of EU27 [1].

Sensible heat storage was for a long time the only available storing technology. Recently more sophisticated techniques are researched and developed, such as latent heat storage or storage through sorption. The techniques of heat storage by sensible and latent storages have a number of disadvantages for long-term heat storage. There are heat losses to the ambient over time and a relative low energy density (large storage volumes) [2]. The implementation of high efficient and compact TES systems will be the next innovation step in the future of heat storage [3]. As an alternative to the descript techniques, it is possible to store energy in a thermochemical storage material (TCSM). This system uses reversible chemical reactions A(s) + B(g) = C(s) + heat for the storage process. Reactants are interesting if they have the following characteristics: low cost, non-toxic, non-corrosive, sufficient energy storage density, cycle stability and reaction temperatures in the proper range with a fast kinetic. A large number of hydrates, hydroxides, carbonates and solvates can fulfill these requirements [4][5].

The technique of thermochemical energy storage is based on reversible chemical reactions. They use the binding energy of the molecules. The principle of the thermochemical heat storage can be seen in Figure 2 in the example of heterogeneous reaction of magnesiumoxide in a solid form plus water in gaseous form to magnesiumhydroxide in a solid form. The storage is done through the feeding of heat at a temperature level T_1 shown on the left side of the figure. Due that a chemical binding is separated in basic molecules MgO(s) and H_2O(g). If the basic bonding react together to molecule $Mg(OH)_2$(s) as before the splitting the enthalpy of reaction will be released at a temperature level of T_2.

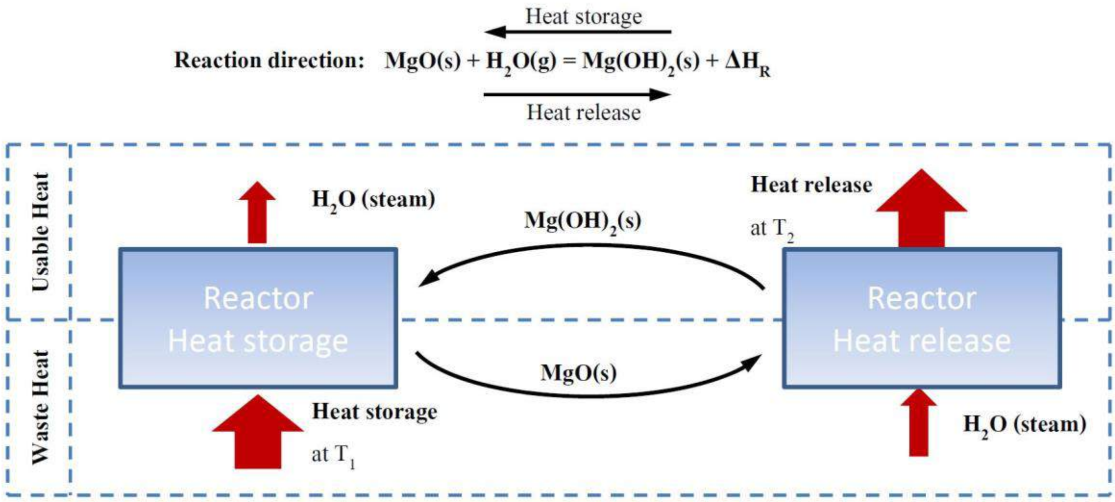

Figure 2: Thermochemical heat storage cycle related to Magnesium.

To control the reaction it is relevant to know the relation between the equilibrium temperature to the partial pressure of water p_{H2O}. Figure 3 shows the equilibrium curve. On the curve the reaction $MgO(s) + H_2O(g) = Mg(OH)_2$ has in both directions the same velocity. So the content of MgO and $Mg(OH)_2$ reaches after an infinity time the content 50:50%. For the partial pressure of 1 (log(1)=0) the connected equilibrium temperature over the curve is 265°C. If the temperature level is over this equilibrium temperature the system is in the storing mode and if it is under this temperature it´s in the releasing mode. All these parameters influence the kinetic of the reaction [6].

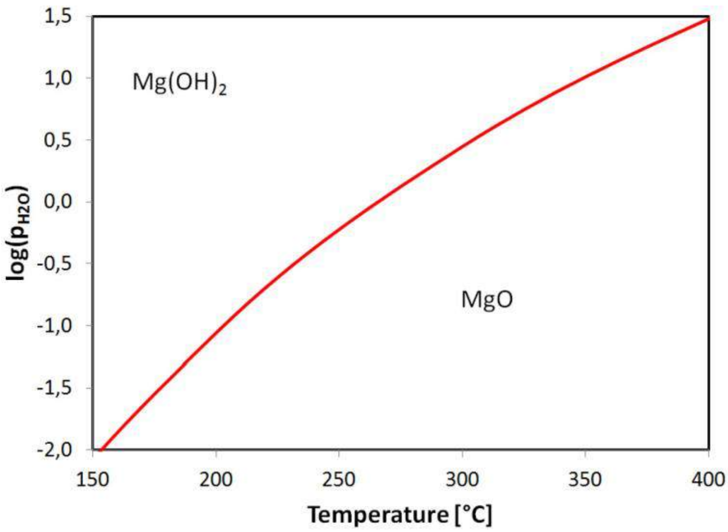

Figure 3: Equilibrium temperature over partial pressure of water.

This paper is focused on chemical reaction systems by using solid-gas reactions, but there are also other types as gas-gas and liquid-gas reactions available [7].

Theoretical heat storage

There are lots of reversible reactions, which could be used for heat storage. An important criterion for the right choice of the TCSM is the temperature for heat storage and heat release as seen in Figure 2 given by temperature T_1 and T_2. These two temperatures are connected by the equilibrium temperature and so it's necessary to consider them with respect to this temperature. Another important factor is the specific storage content or the specific storage density. Both of them are connected to the enthalpy of reaction, which can be calculated by the following equation:

$$\Delta H^0 = \sum \Delta H_B^0(products) - \sum \Delta H_B^0(educts)$$

Figure 4 and 5 show a certain choice of TCSM. For the considered application in this paper the temperature range is chosen from 100°C to 300 °C.

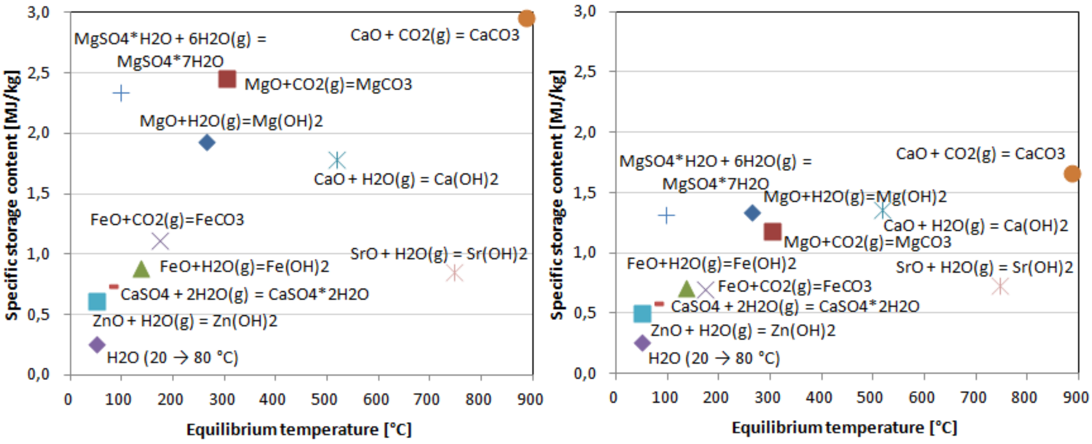

Figure 4: Specific storage content. Left: related to educts / right: related to product.

Figure 4 shows that the theoretical specific storage content from the reaction MgO(s) + H2O(g) = $Mg(OH)_2$(s) differs in relation to the reference material educts (MgO) or product ($Mg(OH)_2$). If the specific storage content is compared to sensible storage by water (heated up from 20 to 80 °C) it shows that the MgO reaction has related to the educts a 7 times higher storage content and if it is related to the product the storage content is 4 times higher. Another way to compare different thermal energy storage systems can be done over the volumetric value.

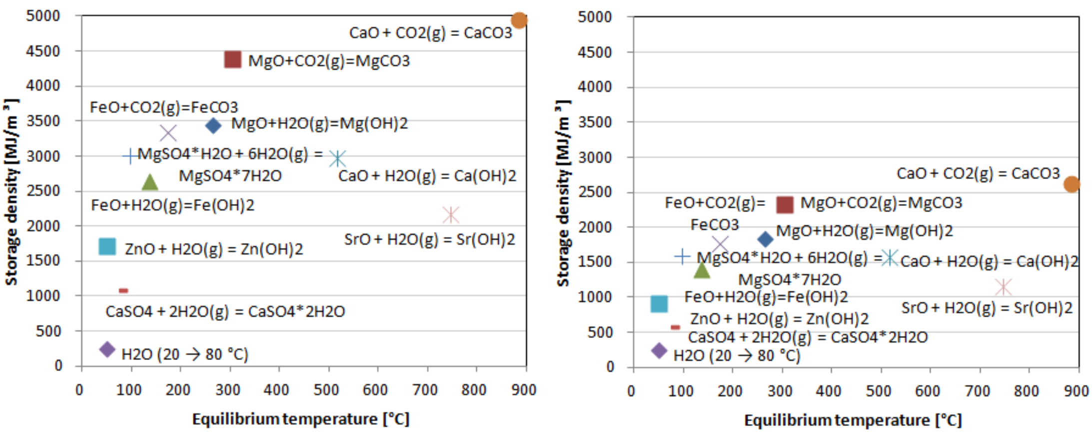

Figure 5: Storage density related to educts. Left: porosity = 0,5 / right: porosity = 0,7.

The storage density related to the educts for two different bulk porosities can be seen in the two diagrams of Figure 5. It can be seen that the bulk porosity has an important influence on the storage density. By considering the educts (MgO) of the MgO(s) + H_2O(g) = $Mg(OH)_2$(s) reaction with a bulk porosity of φ = 0,5 the storage density compared to sensible water is 13 times higher. By the use of a commercial available TCSM the bulk porosity is 0,7 and this decreases the storage density and compared to water it is 7 times higher. It can be seen that the relation of the TCSM is an important factor for the storage density. The further sheets of this paper considers only the reaction MgO(s) + H_2O(g) = $Mg(OH)_2$, because of the fact that this reaction has the highest storage density in a certain temperature range 100 – 300 °C with respect to the educt water. The used MgO is in a granular form with a mean particle diameter of 355 µm and a bulk porosity φ = 0,7.

Reactor system

For further research on the system it is necessary to choose the right reactor system for the right material. There are a certain amount of reactor systems with advantages and disadvantages [8]. There are common technologies listed:

- Fluidized bed reactor
- Free fall reactor
- Rotary kiln reactor
- Screw reactor

Screw reactors and rotary kiln reactors are complex to operate and to seal because of the rotating mechanical system. The heat transfer coefficients are lower than by the other two technologies. The free fall reactor cannot be used, because of the low residence time, which is usually between 1 and 10 s [9].

For further research a fluidized bed reactor was modeled in the process simulation program “IpsePro” from the company “Simtech” because of the following advantages:

- Flow able particles (behavior like liquid)
- High surface (Gas – particle)
- Particle mixing (Distribution particle species)
- Homogeneous temperature distribution (axial and radial)
- High heat transfer coefficient
- High mass transport

One of the limitations of the use of a fluidized bed reactor is the particle size over the density difference between particle and fluidization gas. The usage of the reactor for the chosen material can be checked with the “Geldart diagram”. The used material is in the group B and so there is no problem for the usage of this reactor for this application. For the heat transfer a bed heat exchanger is installed. First simulations by the “IpsePro” model show a heat transfer coefficient between 100 – 600 W/(m^2*K) [10]. Through the set of the bed height to a value of 0,85 m the pressure loss is always the same for the simulation and the diameter of the reactor is a result. It is also assumed that there is no complete conversion of the TCSM. The conversion rate is set to a value of 90% for the heat storage and release.

Processintegration

One of the most effective ways to deliver heat to areas with high heat demand densities is the usage of a district heating system [11]. In order to supply a district heating network cost effectively and energy efficiently with waste heat from industrial processes it is necessary to transport the thermal energy by mobilized thermal chemical storage (M-TCS) [12]. To consider a TCS system correctly and completely it is also necessary to choose an application and a system with all components. This paper considers a possible application, which is shown in figure 6. This figure illustrates a part of Austria with three district heating networks shown by the blue circuits and a waste heat source shown by the grey triangle in the middle of the map [13].

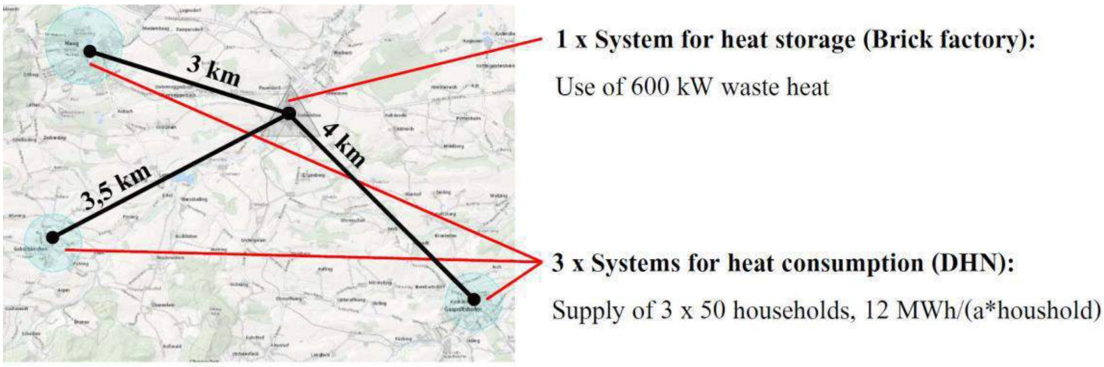

Figure 6: Process application. Store: brick factory / Release: district heating network

A conventional technique for heat storing could not be used through the fact that the heat must be stored and transported to different customers in a distance over 3 to 4 km. A connection from the waste heat source to the district heating network would also be a problem through the high investment costs of the piping and through the time offset between heat production and heat consumption. So it´s thinkable that the thermochemical heat storage is an opportunity to use this waste heat besides electricity production by a low efficiency of 12,8 % (Cement plant Lengfurt) [14].
One possible flow sheet of the storing and releasing process is shown in figure 7. Both systems are closed systems. This means, that the gas for the fluidization is in a cycle. The green color signs the fluidization gas of the system. The main content is nitrogen, which is mixed with water. The water content is related to the process application and the kinetic of reaction. Especially the heat release (hydration) application needs three stages for the injection of water. These stages are combined with an up heating of the fluidization gas. Through this the condensation of water in the carrier gas (nitrogen) is prevented.

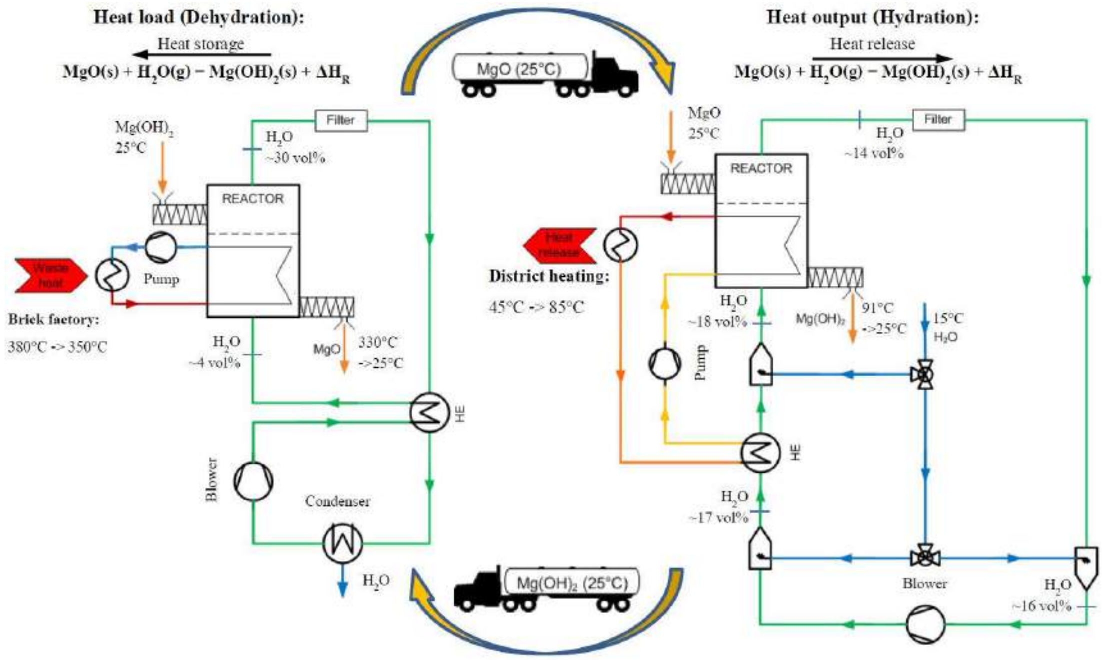

Figure 7: Flow sheet of the TCS-Application.

The following figure shows the simulation results of the system, which is shown in Figure 7. It can be seen that the storage density is decreasing compared to the theoretical storage density (see Figure 5). If the condenser heat could be used in a district heating network by the heat storage system the storage density can be increased crucial. To identify the losses of this system an energy and exergy analysis is done.

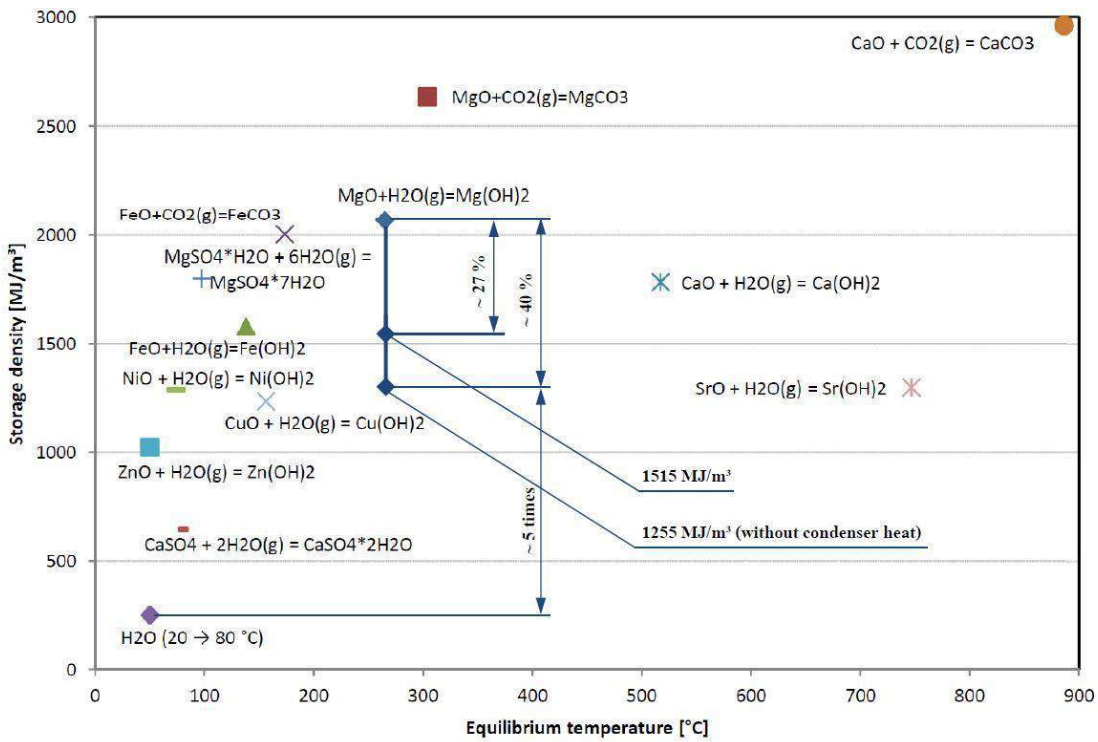

Figure 8: Calculation results for $MgO + H_2O = Mg(OH)_2$ shown in a Figure 5

Energy & exergy analysis

The shown process from Figure 7 is simulated and the results are used to implement an energy, exergy and economic analyze of the whole system. The thermochemical storage process is optimized to highest energy efficiencies. This is equal to a high storage density of the TCSM. Another optimization point is the residence time of the particle in the reactor. This parameter does not influence the efficiency of the whole process, but truly the investment costs for the economic analyze. This will be described clearly in the next section. The following two figures show the whole cycle of the TCS process in one glace from the view of energy and exergy. The two main boundary conditions for this process are the transport temperature of the TCSM, whit 25 °C and the conversation rate with a value of 90 %.

All shown percentage values in the sankey diagram of Figure 9 are related to the input energy of the storage reactor (625,3 kW = 100 %). The energy efficiency of the whole system is 35,87 % (without condenser heat). This value is not equal to the usable heat value of the heat output reactor with 33,6 %, because of the fact that the whole input energy of heat exchangers 80,2 %, blowers 13,5 % and injectors 0,9 % results only to 94,6 %. The values of the reactor losses are not shown through the low losses of the reactor itself. The other losses are from the filters 0,6 %, storage & transport 18,1 % and condenser 41,5 %. The energy analysis shows, that the fully or partially use of condenser heat increases the whole efficiency of the system up to 80,1%. The second big share of the losses is given by the storage & transport of the TCSM. It is assumed that the material is transported by only 25 °C. That means that the sensible losses especially by the heat storage system (330°C to 25°C) are enormous through the loss of sensible energy. It could be practicable to use special trucks and storage facilities to avoid the loss of sensible energy.

To compare the TCS application with electricity production an exergy analysis is done and can be seen in Figure 10. The shown percentage values in the sankey diagram are related to the input exergy of the storage reactor (299,7 kW = 100%). The exergy efficiency is calculated with 10,1 %, if the heat of the condenser can be used fully or partially the efficiency increases up to 18,5 %. An interesting point is that the exergy efficiency is very low in comparison to the energy efficiency. This is describable by the fact that the heat is converted from a temperature level of approximately 350°C to a level of approximately 85 °C. Compared to the electricity production of a similar process it is in a similar range [14]. The whole input exergy is delivered from one heat exchanger 88% and the blowers 28,4 %. In contrast to the energy analysis the losses in the exergy analysis are especially high in the reactors 59,7 % and the losses in the condenser has a low value 9,8 %. The other losses are placed in the other process components heat exchangers 3,7 % injectors 10,3 %, storage & transport 10 % and blowers 10,6 %.

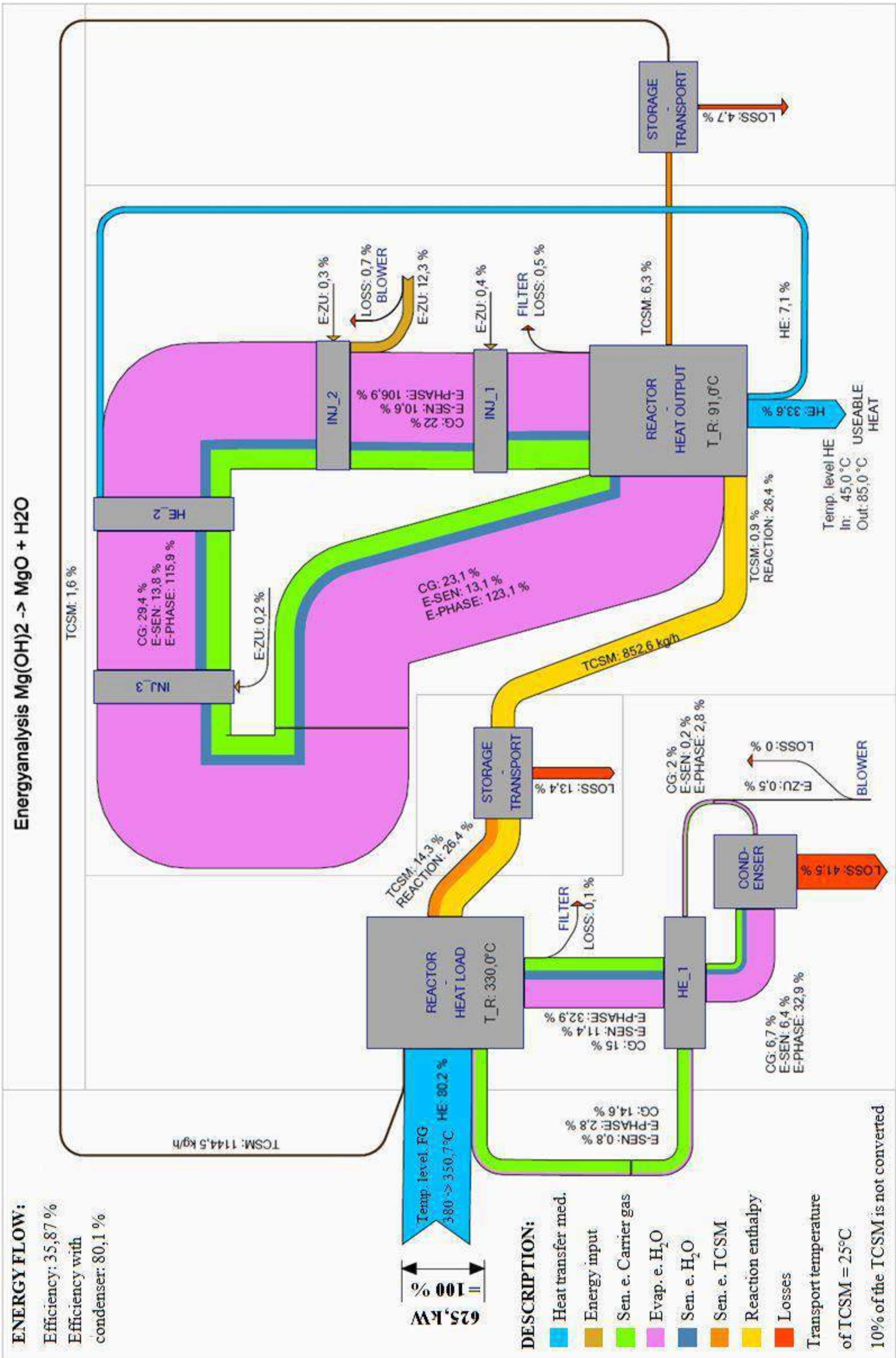

Figure 9: Sankey diagram of the energy analysis

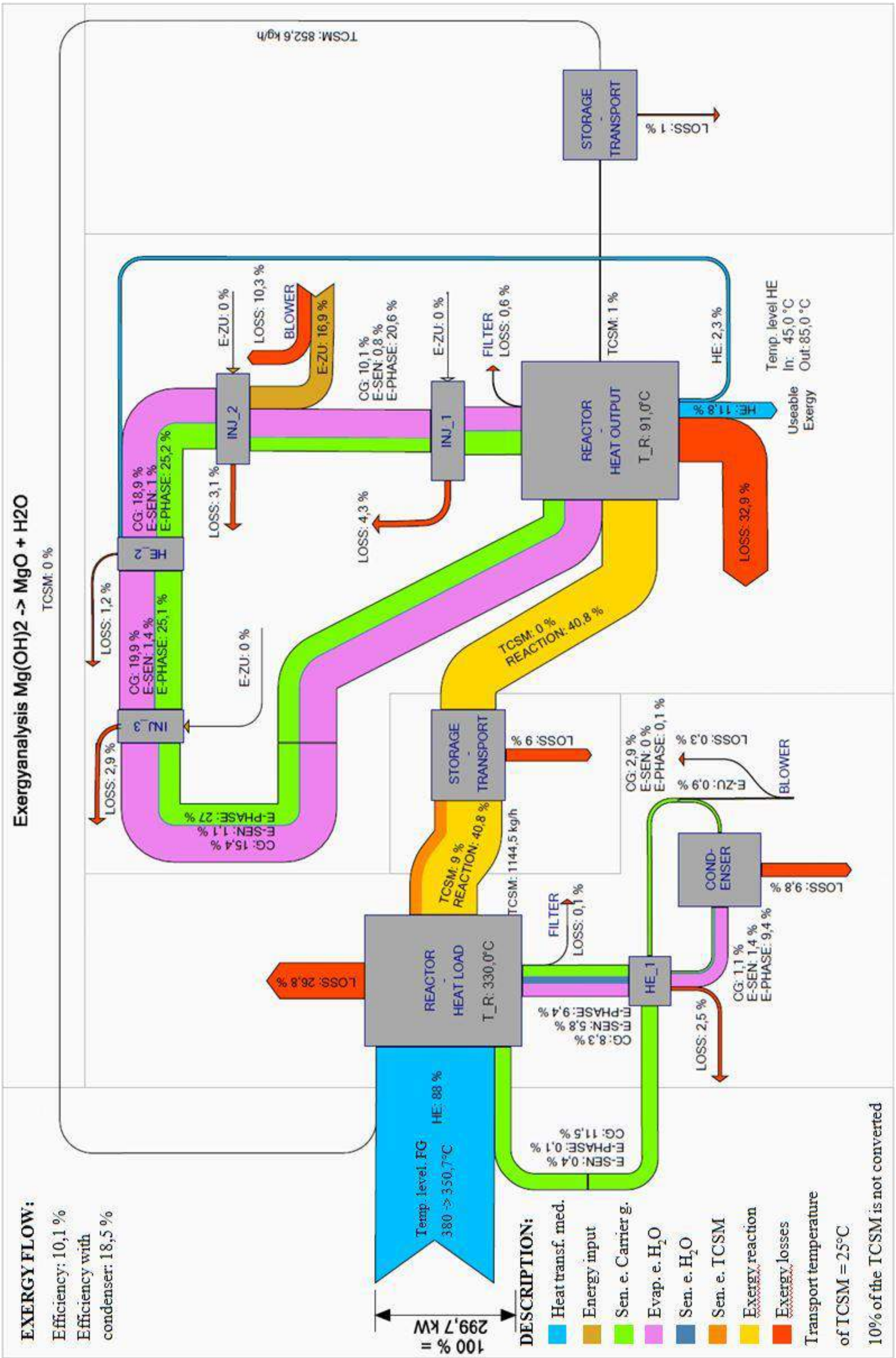

Figure 10: Sankey diagram of the exergy analysis

Economic analysis

There are several possibilities to evaluate the profitability of an investment for an industrial application. One of them is the investment calculation. The different methods of the investment calculation provide an opportunity to get significant results. The results of the investment calculation give a decision support for the usage of thermochemical energy storage application. To rate the quality of an investment a dynamic method of investment calculations is used in this paper. This method considers the date of incoming and outgoing payments [15][16].

Through the use of the net present value method the necessary “heat price per MWh” is calculated. There are three main parts of cost:

- direct investment costs
- fix costs (including: repair, maintenance and personal costs)
- variable costs (including: operation, TCSM, heat and transport costs)

The direct investment costs are calculated over the costs of the different components. The following components are used in the system:

- Reactor
- Filter
- Heat exchanger
- Blower
- Pumps
- Storage tank
- Injectors

The costs for pipe works, assembling and engineering are assumed with 20 % of the components costs. The whole sum of the components costs, pipe work costs and engineering costs amount to the direct investment costs. It is assumed that the investment costs are paid from the company`s own funds. The depreciation period is taken as equal to the systems lifetime and the average operation time of both systems (heat storage and heat release) is assumed 20 years. Other assumptions are:

- yearly maintenance costs are 2,5 % of the direct investment costs
- yearly repair costs are 2 % of the direct investment costs
- inflation and escalation rates are assumed to be zero
- no influence from the CO_2 price market
- energy transport capacity of a truck is 19,2 MWh_{th}/truck

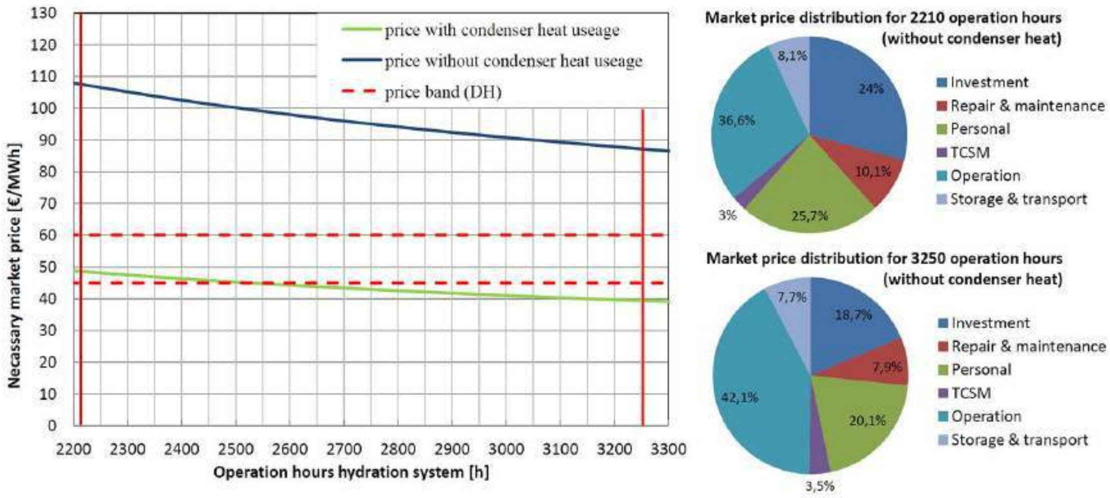

Figure 11: Results of the economic analyze.

Figure 11 shows the results of the economic analysis. Without using the condenser heat the heat price has a value of 87 – 108 €/MWh_{th} over the operation hours per year of the heat release systems. The both cake diagrams show the distribution of the costs for 2210 and 3250 operation hours of the heat release system. The transport costs have a small influence on the whole heat price. The operation costs represent the greatest value, but they are only changeable through the use of another reactor system. The energy analysis shows that it is a crucial advantage if the condenser heat can be used. Through this enormous influence the heat price can be decreased to 39 – 49 €/MWh_{th}.

The dashed red line shows the possible market price from today (45 – 60 €/MWh_{th})[17]. By the usage of the condenser heat we have a competitive system today. The system without condenser heat is not competitive against other technologies for the heat production. If the fuel costs of conventional heat production techniques are rising, the thermochemical storage technique could be more competitive in the future.

The influence of the CO_2 certificate costs is not considered, because of the running process to modify the consisting system by the European commission. The calculation of a system with heat production by natural gas 233,3 (kg CO_2)/MWh_{th} [18] and the market price 7,02 €/t_{CO2}[19] results in extra costs of 1,63 €/MWh_{th}. This means that the CO_2 certificate costs have no important influence on the market price of heat.

Conclusion

A brickyard factory as heat storage location and three district heating networks as heat release locations are considered. A conceptual mobilized thermal energy storage system was evaluated in a technical way (energy and exergy analysis) and economic way. According to these analyses, the following conclusions are made:

- By the comparison of different TCSM it is on the one hand important that the values are related to the form of the storage material (educts or products, bulk density) and at the other hand that the whole system is considered.
- The M-TCS system can raise the global amount of heat without using fuels, through the increasing of heat production by waste heat sources.
- Cost of heat could be in a range from 88 to 108 €/MWh_{th} and could be decreased if the condenser heat could be used from 39 to 49 €/MWh_{th}. Certain applications which use condenser heat have potential for realization.
- The transport costs with approximately 8 % have no important influence on the whole system.
- The costs of CO_2 certificates have no important influence on the economic feasibility.

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Comparison of Photometric Quantities and Photon Quantities of Light Sources For Interior Green Wall Illumination

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Abstract
Interior green walls which are vertical greenery systems inside buildings are gaining popularity due to their environmental, economic and social benefits. Different from exterior green facades, interior green walls usually receive limited natural light, resulting in relatively low photosynthesis rate and thus hindering the plant growth. Without violating the basic principle of sustainability, an energy efficient supplementary lighting system is required to provide the interior green wall with necessary quantity of light. Most light sources are however developed for human applications while plants have an entirely different response to light from human eyes. Light quantity for plant growth should be evaluated by photon efficiency, which is highly related to the rate of photosynthesis. This paper investigates the relationship between photometric quantities and photon quantities of various light sources with the aid of a calibrated spectrophotocolorimeter. LED lamps are recommended to be used in the supplementary lighting system for interior green walls due to their good performance in both luminous efficacy and photon efficiency.

Keywords: Interior green wall, lux, photon, photosynthesis, supplementary lighting system

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Introduction

With the rapid growth of urbanization around the world, more and more areas of the human habitat have evolved from natural vegetation to concrete jungles. Building blocks are increasingly taller and densely packed to cope with the rising demand of land. After decades of urbanization, many modern cities are confronted with various environmental problems like air and noise pollutions, lack of vegetation, urban heat island effect and global warming. Many efforts are being made in a bid to mitigate the problems. The rise of environmental consciousness calls for new building designs that can provide environmentally friendly functions, e.g. reducing building energy consumption, lowering indoor ambient temperature and improving indoor environmental quality. For this purpose, various innovative solutions such as constructing greenery systems in buildings have emerged (European Commission, 2012).

Building integrated greenery systems have many benefits. With respect to the environment, plants absorb carbon dioxide and release oxygen via photosynthesis. They freshen up the air and reduce carbon emission to the atmosphere (Darlington, Dat, & Dixon, 2001). Plants also absorb short-wave radiation and reduce solar re-radiation from building surfaces (Kleerekoper, van Esch, & Salcedo, T.B. 2012). As the building surface temperature decreases, urban heat island effect is mitigated. Moreover, the ability of plants to reduce noise disturbance allows the environment to be more aurally acceptable (Wong, Kwang, Tan, Chiang, & Wong, 2010). Greenery also provides buildings with economic advantages. As plants can reduce carbon dioxide concentration and decrease the temperatures inside and outside buildings, greenery systems are particularly suitable for reducing the energy demand for ventilation and air conditioning, thus improving the energy efficiency of buildings (Perez, Coma, Martorell, & Cabeza, 2014). As for the social aspect, plants are also desirable. Since the human civilization, plants have been used to create places for recreation and rest (White & Gatersleben, 2011). Evidence shows that consistent contact with the nature has positive psychological impact, reducing stress and increasing human health and well-being (Nielsen & Hansen, 2007). Furthermore, growing plants on building structures enhances people to be aware of the importance of developing a built environment in a sustainable manner (Yuen & Hien, 2005). Whereas green roof is a useful building integrated greenery system (Wong, Cheong, Yan, Soh, Ong, & Sia, 2003), integrating vertical greenery systems into building design is another promising idea to promote sustainability, especially in the case of a densely built environment where the horizontal roof surface areas are limited.

A vertical greenery system allows plants to be grown on the wall of a building. This system can be classified into two major groups: external green facades and internal green walls (Kontoleon & Eumorfopoulou, 2010). The former consists of a vegetation covered by climbing or cascading plants rooted either at the base in the ground or in plant boxes on the outer wall of a building. An internal green wall is generally more complex. It is a layer containing a variety of plant species attached to an independent waterproof vertical structure isolated from the building inner wall. This arrangement can avoid humidity problems (Loh, 2008). There are several types of green walls; the module type is one among them. For this type of green walls, plants are filled in pockets and directly rooted in the vertical structure using a porous material that provides physical support for the plant growth and serves as a means of water distribution and irrigation uniformity (Francis & Lorimer, 2011).

Apart from air and water, light is another essential element for green plants to grow well. Chlorophyll in green plants initiates photosynthesis by capturing light energy and converting it into chemical energy. In this way, plants transform water and carbon dioxide into primary nutrients. Photosynthesis does not necessarily take place in continuous light (Sysoeva, Markovshaya, & Shibaeva, 2010). An accumulated period of time with specific lighting level would similarly trigger photosynthesis. Naturally, daylight is the best light source for plants to grow. It is capable of providing plants with a high lighting level and a continuous spectrum throughout the daytime. Plants on green roofs or green facades exposed outdoors normally do not have any problem in obtaining sufficient light. Green walls in interiors, however, usually receive less or no daylight. A supplementary lighting system should then be provided for healthy plant growth. However, if the lighting system consumes too much energy, it would violate the principle of sustainability. An energy efficient supplementary lighting system which provides appropriate light quality, photoperiod and, more importantly, light quantity for the indoor plant growth (Goto, 2003) should be installed (Fernandex-Canero, Perez-Urrestarazu, & Franco-Salas, 2012). Light quality refers to the spectral composition of the light source. Not all wavelengths are equally effective for photosynthesis. Red and blue light drives photosynthetic metabolism the best as chlorophyll absorbs red and blue wavelengths most efficiently while almost all green and yellow counterparts are reflected or transmitted (Pinho, Jokinen, & Halonen, 2012). Light of the same energy but at different wavelengths emits different numbers of photons. Photoperiod is defined as the duration of plants' daily exposure to light (Mattson & Erwin, 2005). Plants can be classified into short-day and long-day in this way, where short-day plants grow well when the night length exceeds their critical photoperiod and long-day plants grow well when the night length falls below their critical photoperiod. In this paper, the light quantity in terms of the benefits to both human perception and plant growth would be studied. Common light sources used for illuminating green walls are investigated.

Photometric quantities

Light quantity is considered to be very important to the supplementary lighting system of an interior green wall. It can be evaluated using the parameter, luminous flux (Φ_v), which is defined as the total amount of light emitted in all directions from a light source. The SI unit of luminous flux is lumen (lm). Luminous flux is a photometric parameter that quantifies the light within the visible spectrum, which means the part of electromagnetic radiation visible to a human eye and ranging from 380 to 780 nm. Therefore, it gives no indication to the level of other parts of electromagnetic radiation like ultraviolet or infrared. Unlike radiation power unit, measurement of light quantity is dependent on human factors. Different wavelengths of visible electromagnetic waves of the same radiation power and beam angle do not look the same to the human eye. The parameter of light quantity has to be adjusted to reflect the varying sensitivity of the human eye to different wavelengths of light. As a result, when radiant power is converted into luminous flux, a correction factor which is spectral luminous efficiency $V(\lambda)$ for photopic vision or $V'(\lambda)$ for scotopic vision should be added. The luminous flux output of a light source is defined by Equation (1),

$$\Phi_v = K_m \int_{380}^{780} \Phi_e(\lambda) V(\lambda) d\lambda \tag{1}$$

where $\Phi_e(\lambda)$ is the spectral radiant power in W/nm and K_m is the maximum spectral luminous efficacy which equals 683 lm/W.

Light quantity can also be further regarded as the luminous flux incident on a surface per unit area (m^2), which is characterized by another lighting parameter, called illuminance (I). The unit of illuminance is lux (lx). This is the parameter commonly used to specify the lighting level on a reference plane in many international and local lighting codes and standards. The illuminance at a point on a surface is defined by Equation (2),

$$I = \frac{d\Phi_v}{dA} \tag{2}$$

The light quantity received by the plants on an interior green wall decreases with the distance from the light source. The required illuminance differs among plant species as some with a high degree of shade tolerance can grow under lower illuminance than others (Niinemets, 2006). The recommended illuminance level on the typical plants growing indoors ranges from 750 to 2,000 lux (IESNA, 2011). For the purpose of defining the efficiency of a light source to convert electrical energy into lighting energy, the parameter luminous efficacy would be used. It is defined as the ratio of luminous flux output to electrical power input. The unit of is lm/W.

Electric light sources

For the supplementary lighting system of interior green walls, standard incandescent lamps, tungsten halogen lamps, metal halide lamps and LED lamps are commonly used.

Incandescent lamps are one of the oldest electric lighting technologies. By heating a tungsten filament inside a standard incandescent lamp, the atoms within the filament become excited and light energy is radiated in a full and continuous spectrum. A standard incandescent lamp is cheap in price and its disposal causes little environmental problems. However, it has the drawbacks. Most of the radiation output of a standard incandescent lamp falls in the infrared region that is not visible, resulting in that it is the least energy efficient light source with a high heat output and a low luminous efficacy (7 – 14 lm/W). Besides, with use, the tungsten slowly evaporates, eventually causing the filament to break, which leads the standard incandescent lamp to have a relatively short life, typically nominated as 1,000 hours. Due to the high energy use of standard incandescent lamps, some governments are now in the process of phasing out the use of these lamps in favour of more energy efficient lighting.

Another type of incandescent lamps is the tungsten halogen lamp, in which a small quartz capsule contains the filament and a halogen gas. The small capsule size allows the filament to operate at a higher temperature such that the full spectrum light is produced at a higher energy efficiency than the standard incandescent lamp. The luminous efficacy of tungsten halogen lamps can reach 23 lm/W. These lamps take the benefits of the halogen cycle such that the halogen gas combines with the evaporated tungsten redepositing it on the filament extends the life of the filament, keeps the lamp wall from blackening and reducing luminous output. The rated lifetime of tungsten halogen lamps can be as long as 5,000 hours. Those of reduced voltage can be smaller in size and thus allow greater accuracy of light beam control than the standard incandescent lamps.

The most common supplementary lighting system for interior green walls uses metal halide lamps, which belong to high intensity discharge lamps. They have several advantages (Egea, Perez-Urrestarazu, Gonzalez-Perez, Franco-Salas, & Fernandez-Canero, 2014). They are full spectrum light sources which produce an intense white light with blue being dominant. They have a high luminous efficacy of 60 – 98 lm/W and a long lifespan ranging from 2,000 to 10,000 hours (CIBSE, 2009). However, they have the drawbacks. A “cold” metal halide lamp cannot immediately start producing its full luminous output because the temperature and pressure in the lamp have not yet reached the full operation level. The warm-up process usually takes several minutes. The energy used during the warm-up time is therefore wasted.

Rapid advances in lighting technology provide an increasing number of options for the supplementary lighting system of an interior green wall. The use of LED lamps as a lighting system for horticulture is rapidly expanding (Morrow, 2008, Massa, Kim, Wheeler, & Mitchell, 2008, Olle & Virsile, 2013). Compared with metal halide lamps, high quality LED lamps have an even higher luminous efficacy (approaching 100 lm/W) and release less radiant heat. They have a longer lifetime of 15,000 – 60,000 hours such that they can maintain useful luminous output for years (CIBSE, 2009). Their abilities to allow luminous output adjustment and to emit a controlled spectral composition, e.g. red and blue wavelengths, for plants to undergo effective photosynthesis allow them to imitate the changes of daylight quantity and quality during the day (Yeh & Chung, 2009), which is what metal halide lamps cannot achieve.

The aforementioned four types of electric light sources can be used in indoor spaces to replace daylight or partially supplement it during the periods of low daylight availability. However, they were originally developed for human applications while plants have an entirely different response to light from the human eye. The appropriateness of the light sources for plant growth should be evaluated by photon efficiency, which is highly related to the rate of photosynthesis.

Photon quantities

For the calculation of photon efficiency, spectral radiant power is measured. Radiometric units are for measurement of electromagnetic radiation. It is different from photometric units which characterize the interaction between light and a human eye. The energy emitted from one photon can be calculated from the Planck’s constant (*h*). Equation (3) gives the energy of one photon (unit: J) in terms of the photon’s frequency (*f*) and therefore speed (*c*) and wavelength of light (λ).

$$E(\lambda) = h \times f = \frac{h \times c}{\lambda} \tag{3}$$

where h is the Planck's constant (6.63×10^{-34} Js).

Using a calibrated spectrophotocolorimeter, the spectral radiant power ($\Phi_e(\lambda)$) (unit: W) emitted by a light source can be measured. The number of photons (N_λ) emitted at a particular wavelength per unit time can then be calculated by dividing the spectral radiant power by $E(\lambda)$, as expressed in Equation (4),

$$N_\lambda = \frac{\Phi_e(\lambda)}{E(\lambda)} = \frac{\Phi_e(\lambda) \times \lambda}{h \times c} \quad (4)$$

The total number of photons emitted per unit time from the light source can be calculated by integration over the visible spectrum. The unit for the number of photons can be changed to moles using the Avogadro's number (6.02×10^{23}). As a result, photon efficiency can be found by dividing the rate of photon emission with electrical power input (P). Equation (5) shows the calculation,

$$\text{Photon efficiency (mol/J)} = \frac{\sum_{\lambda=380}^{780} N_\lambda}{6.02 \times 10^{23} \times P} \quad (5)$$

The fundamental objective of an interior green wall is to promote sustainability in buildings. The supplementary lighting system should be designed in a way that the light sources would not consume excessive energy but give high photon efficiency for facilitating the photosynthesis process of the plants. However, few lamp manufacturers provide this technical information. This paper investigates the relationship between photometric quantities and photon quantities of various light sources that are commonly found being used for interior green wall illumination with the aid of a calibrated spectrophotocolorimeter.

Experimental results

A total of 13 different types of light sources were purchased from the market and investigated in this study. They included one standard incandescent lamp, one tungsten halogen lamp, two metal halide lamps, three LED bulbs, two LED MR16 lamps, two LED floodlights and two LED strip lights. Measurements were conducted for their electrical and photometric characteristics in a calibrated spectrophotocolorimeter. The integrating sphere of the meter is located in the lighting laboratory of Department of Building Services Engineering, The Hong Kong Polytechnic University. The basic properties of these light sources are tabulated in Table 1.

Table 1: Basic properties of the light sources being investigated in this study

Lamp type	Brand	Electrical power input (W)	Correlated colour temperature (K)	Luminous output (lm)	Luminous efficacy (lm/W)
Standard incandescent	A	52.3	2580	366.2	7.00
Tungsten halogen	A	48.1	2825	560.1	11.64
Metal halide 1	A	152.5	5085	10348.1	67.86
Metal halide 2	A	277.7	5891	20034.1	72.14
LED bulb 1	A	6.9	6402	593.4	86.00
LED bulb 2	A	7.3	3059	637.7	87.36
LED bulb 3	A	9.9	6759	998.6	100.87
LED MR16 1	A	7.7	2720	341.1	44.30
LED MR16 2	A	7.9	4026	423.2	53.57
LED floodlight 1	B	12.0	3061	822.6	68.55
LED floodlight 2	B	11.9	4371	666.0	55.97
LED strip light 1	A	5.4	3359	185.0	34.26
LED strip light 2	A	5.0	4499	151.5	30.30

A standard incandescent lamp, due to its operating principle, approximates an ideal blackbody radiator. The colour temperature of the standard incandescent lamp investigated in this study was measured to be about 2,600K. This lamp had the nominal rating of 60W, which echoed the measured electrical power consumption of 52.3W. Among the 13 light sources studied, despite consuming a moderate amount of power, the measured luminous output of the standard incandescent lamp was not high. Its lighting performance was the worst and its measured luminous efficacy was the lowest which was only 7 lm/W.

The electrical and photometric characteristics of the tungsten halogen lamp investigated in this study were in general similar to those of the standard incandescent lamp previously discussed. The colour temperature of the tungsten halogen lamp was measured to be about 2,800K. The nominal rating of the lamp was 50W while the measured electrical power consumption was 48.1W. Despite similar amount of power consumption, the luminous output of the tungsten halogen lamp was measured to be 560 lm, about 50% more than that of the standard incandescent lamp, leading its measured luminous efficacy to reach 11 lm/W.

Two metal halide lamps were purchased for investigation in this study. The brand of these two lamps was the same, but their nominal ratings were respectively 150W and 250W, which were consistent with the electrical power input measured (i.e. 152.5W and 277.7W). The correlated colour temperatures of the two metal halide lamps were high towards bluish white, between 5,000K and 6,000K. Although it required a large amount of power for these metal halide lamps to give full luminous outputs, because their luminous outputs were also high, their luminous efficacies were abundantly higher than those of the incandescent lamps, reaching about 70 lm/W.

Since LED lamps were reported to become popular light sources for growing plants, 10 LED lamps of four types were examined for their electrical and photometric properties. In general, LED lamps have a higher luminous efficacy than the other types of lamps investigated in this study, but the value of this parameter varies a lot among the 10 LED lamps. The 3 LED bulbs of three different nominal ratings (7W, 7.5W and 10.5W) and two different levels of correlated colour temperatures (about 3,000K and about 6,500K) had the highest luminous efficacy ranging from 86 lm/W to over 100 lm/W. For the LED MR16 lamps of the same nominal rating (6.5W) but having different correlated colour temperatures (about 2,700K and about 4,000K), their measured luminous efficacies were only around 50 lm/W.

Although manufacturers claim that LED floodlights usually have a very high luminous efficacy (over 80 lm/W), the two LED floodlights that were purchased for this study could only have the measured luminous efficacies of about 60 lm/W, regardless of their correlated colour temperatures. These LED floodlights produced exceptionally low luminous efficacies probably because they almost demanded the least electrical power input among the similar types of lighting products in the market. It is believed that LED floodlights of a higher nominal rating would have a luminous efficacy approaching 100 lm/W.

LED strip lights are rather new lighting products. Their applications range from decoration to general illumination. LED strip lights have the advantage that their length is adjustable allowing them to be convenient in use. The two LED strip lights (with length of 0.5 m) that were investigated in this study demanded about 5W similarly, but had different correlated colour temperatures, which were about 3,000K and 4,500K respectively. Both of these lights had a measured luminous efficacy of about 30 lm/W. Despite a low value at present, the photometric characteristics of LED strip lights are undergoing development. It is believed that they could have a much higher luminous efficacy in the near future.

Among the above mentioned four types of light sources measured by the calibrated spectrophotocolorimeter, LED lamps were found to be the most energy efficient light sources with the higher value of luminous efficacy in general. However, this parameter was derived with the basis on human perception such that the rate of photosynthesis promoted by the light sources was not implied. Photon efficiency was therefore calculated using Equation (5), which is reported to be the most suitable parameter to quantify the efficiency for plant growth due to light (Nelson & Bugbee, 2014). The calculated photon efficiency of the 13 types of light sources investigated in this study was tabulated in Table 2.

Table 2: Calculated photon efficiency of the light sources (from best to worst)

Lamp type	Photon efficiency (μmol/J)
LED bulb 3	1.51
LED bulb 1	1.31
LED bulb 2	1.24
Metal halide 1	1.23
LED floodlight 1	1.03
Metal halide 2	0.99
LED floodlight 2	0.81
MR16 LED 2	0.78
MR16 LED 1	0.70
LED strip light 1	0.52
LED strip light 2	0.48
Tungsten halogen 1	0.48
Incandescent 1	0.31

Comparing Table 1 and Table 2, it could be found that although for most of the light sources investigated in this study, the higher the luminous efficacy, it was likely that the photon efficiency would usually be higher as well, there were exceptional cases. Metal halide 1 had a lower luminous efficacy than metal halide 2, but it had a higher photon efficiency. Similarly, LED bulb 1 had a lower luminous efficacy than LED bulb 2, but it had a higher photon efficiency. The findings therefore mean that luminous efficacy has no direct relationship with photon efficiency, which is affected by the spectrum of the light emitted from the light source.

With the advanced development of lighting technology, LED lamps are now dimmable. Apart from their relatively high luminous efficacy, more lighting energy could potentially be saved by the dimmable function. Hence, there is a need to study how the reduced luminous output of dimmable LED lamps would influence the photon efficiency. Consequently, a dimmable LED lamp was purchased for the experiment.

The nominal rating of the dimmable LED lamp was 12W. The spectral radiation was measured by the calibrated spectrophotocolorimeter at its full luminous output as well as five different dimming levels, each of which consumed power at 2.1W, 4.0W, 6.1W, 8.4W and 10.1W. Figure 1 shows the values of photon efficiency at different electrical power input values of the dimmable LED lamp.

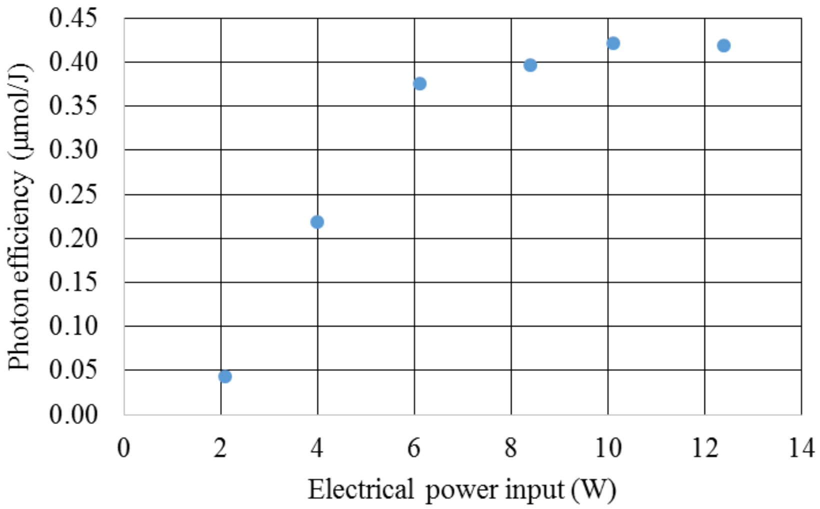

Figure 1: Relationship between photon efficiency and electrical power input of the dimmable LED lamp investigated in this study

Figure 1 reveals that the relationship between the photon efficiency and the electrical power input of the dimmable LED lamp was nonlinear. Nevertheless, the trend was unlike that of the metal halide lamps whose photon efficiency was reported in other researches to drop significantly when they are dimmed (Bubenheim, Sargis, & Wilson, 1995). For the LED lamp, the photon efficiency remained almost constant with the power reduced to half value. Therefore, with the advantages of high luminous efficacy and high photon efficiency despite half-dimmed, it is recommended to use dimmable LED as the light source of the supplementary lighting system of interior green walls.

Discussion

There are a few remarks for this study. First, it is technically required for LED lamps to be physically attached to the luminaires which allow heat dissipation by the heat sink. The reflectors, diffusers and other parts of the luminaire would absorb both the light and photon output. Meanwhile, for the other light sources, the lamps can be separated from the luminaires, so that the luminous output and photon output are correctly measured. Second, the number of tested lighting products was not adequate. There were two major reasons: (i) it was not an easy task to purchase various types of high output LED lamps; and (ii) even if a high output LED lamp was obtained, it was difficult to measure its electrical and photometric characteristics using the standard integrating sphere of the spectrophotocolorimeter due to its large physical size. For the latter reason, it was a difficult task to accurately measure the spectrum radiation output of large LED lamps as significant errors would arise.

Conclusion

Plants and greenery provide numerous benefits for urban areas and environment. Interior green walls enable the distribution of vegetation across the interior wall surfaces of a building. Due to the difficulty to obtain sufficient daylight energy for producing nutrients, an interior green wall usually requires a supplementary lighting system that is both energy efficient for not violating the basic principle of sustainability and can provide adequate light quantity for maintaining plant growth in a healthy manner. Since most lighting products were developed for human applications, light quantity was expressed in the photometric unit based on the luminous sensitivity of a human eye. Plants however have an entirely different response to light from the human eye. For the study of plant growth, light should be quantified by the number of photons which is highly related to the rate of photosynthesis. However, few lamp manufacturers provide sufficient technical information in this aspect.

Various light sources are commonly found being used for interior green wall illumination. They are namely standard incandescent lamps, tungsten halogen lamps, metal halides and LED lamps. Experiments in a controlled laboratory environment were conducted to investigate the relationship between the photometric quantities and photon quantities of 13 types of these light sources with the use of a calibrated spectrophotocolorimeter. Electrical and photometric characteristics of the light sources were measured. Luminous efficacy were obtained and photon efficiency was calculated for all the light sources under investigation. The findings of this study indicated that there is no direct relationship between luminous efficacy and photon efficiency of a light source. Photon efficiency is influenced by the spectrum of the light emitted from the light source and separate calculation for photon efficiency is required for choosing the appropriate light source for plant growth. Besides, since LED lamps are now dimmable, the change of photon efficiency due to the dimming function was examined. It was found that the photon efficiency decreased in a limited way when the electrical power input was reduced. In view of the merits of high luminous efficacy and high photon efficiency, this study therefore recommends to use dimmable LED lamps as the light sources for interior green wall illumination.

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The Dynamism of Old Wooden Houses within Chiang Mai City Wall

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Abstract
Cultural sustainability is one of the key factors for sustainable development apart from economic growth, environmental stewardship, and social inclusion. It is also associated with protecting, preserving and conserving tangible and intangible heritage. Architectural conservation gives a sense of identity, spiritual and symbolic as well as functional and economic values. It plays an important part for a cultural continuum leading to cultural sustainability. The main concept of this paper is to promote cultural sustainability through urban historic landscape and architectural conservation. The main concept of this paper is to promote cultural sustainability through urban historic landscape and architectural conservation.

Dwelling is about a 'place' for people, it is '*both a process and artifact: it is the experience of living at a specific location and it is the physical expression of doing so*'. They generally adapt or develop over times as needs and circumstances change. The dwelling is more than the structure transcending over the physical frame of their habitation. However, looking into how manifestations and adaptations of their dwellings will help to promote understanding people of any culture that is prime to cultural sustainability.

During the past decades Chiang Mai, the second city of Thailand, has confronted an astonishingly rapid growth bringing many problems to local citizens, including the decrease of old wooden houses within the city wall.

Within the above mention approach, this paper will investigate how 191 old wooden houses, surveyed during 1985, within Chiang Mai City Wall habituate to changes through over 30 years of times. It gives the over all picture of those houses through numbers, locations and other details. Moreover, a brief comparison between the wooden houses within the city wall and the traditional styles to see the adaptations of physical structures as needs and circumstances change. It ends with inside observations and suggestions.

Keywords: old wooden houses, dynamism, conservation, Chiang Mai city wall

Introduction

Cultural sustainability is one of the key factors for sustainable development apart from economic growth, environmental stewardship, and social inclusion. It is also associated with protecting, preserving and conserving tangible and intangible heritage. Architectural conservation gives a sense of identity, spiritual and symbolic as well as functional and economic values. It plays an important part for a cultural continuum leading to cultural sustainability. The main concept of this paper is to promote cultural sustainability through urban historic landscape and architectural conservation.

During late the 20th century, for many scholars, the high communication technology and the so-called 'informational city' gives rise to 'space of flow' prevailing over 'space of place' (Castells, 1989: 348, see also Allen and Hamnett eds. 1995 and Harvey, 1989). This also brings global cities all around the world the 'sameness'. The differences, exclusions or marginalization turn out to be subservient. The multinational cooperation and international architectural styles take over physical appearance of the world cities. One of the most interesting questions is how this situation afflicted with urban historic landscape and cultural continuum.

David Harvey (1990) argues that, rather than insignificant, place bounded identity is more important in the post-modern capitalism era than before because of the following reasons: 1) the greater challenges over the 'sameness' within similar function cities around the world, 2) the uncomplicated location selection due to cheap transportation cost makes differences between places are more important than the opposite, 3) social, political and cultural differences make each location more attractive than the others for the multinational cooperation and 4) many of the surplus capitals during these two decades are invested in place constructions which is 'wiser' than going to savings, over scale real estate or tourist resort developments. In this sense, conserving physical or tangible, as well as intangible heritage is still important and cultural continuum could possibly extend far into the future.

Dwelling is about a 'place' for people, it is '*both a process and artifact: it is the experience of living at a specific location and it is the physical expression of doing so*' (Oliver, 2003). Dwellings are generally adapted or developed over times as needs and circumstances change. The dwelling is more than the structure transcending over the physical frame of their habitation. Thus, looking into how manifestations and adaptations of their dwellings will help to promote understanding people of any culture that is prime to cultural sustainability.

This paper aims at investigation to how 191 old wooden houses, surveyed during 1985, within Chiang Mai city wall habituate to changes through times. It starts with a brief history of Chiang Mai and the area within the city wall. Then the paper gives the over all picture of old wooden houses in Chiang Mai city wall through locations, ages and other details. Moreover, a brief comparison between the wooden houses within the city wall and the traditional Lanna[1] styles of 'wooden and Ruen Ka Lae[2] houses'

[1] ***Lanna*** is the name of a conglomerate of northern Siam principalities, mostly under the leadership of Chiang Mai. It covered the area of modern north Thailand and extended its influence far into the neighbouring regions. Its golden period was over two and a half centuries from the late thirteenth to the mid sixteenth century AD.

[2] ***Ruen Ka Lae***: noble traditional house with two pieces of crafted cross wood at the top of the gable roofs.

are described to see the adaptations of physical structures as needs and circumstances change. It ends with the inside observations and suggestions.

Chiang Mai

Chiang Mai, a living historic city, is renowned for its natural beauty and cultural assets. It is in the north of Thailand and the inland Chiang Mai-Lampoon Basin (as shown in Figure 1). It was founded in 1296 by King Mungrai and became the centre of Lanna Kingdom, a united northern principality, since. After over two hundred years of self governed Lanna was then ruled by the Burmese for over two hundred years. Siam[3] and Lanna conquered the Burmese in the liberation war in 1782. Chiang Mai then became a vassal of Bangkok. Later, the country turned into totally centralized and Chiang Mai which was once a unique and flourishing culture, is now developing into a mere province within a Thai nation-state. (Thongchai, 1994: 102-103).

Figure 1 Location of Chiang Mai
(Source: googlemap.com)

At present, Chiang Mai is known as the second city of the country after only Bangkok. It is the centre of administration, economic, education, communication and also health services of the north. The Chiang Mai municipality - *thesaban nakhon* -area covers about 40 square kilometres with a population of 132,635 (Chiang Mai Municipality, 2014) in that it gradually reduces during the past decades. However, the urban sprawl of the city now extends into several neighbouring districts. The Metropolitan Area has a population of almost 700,000, nearly half the total of Chiang Mai Province, and the area covers 529 square kilometres - over 10 times of the municipal area. Chiang Mai is one of the major tourist attractions and becoming more and more global, bustling with Thai and foreign tourists from all over the world. There are also long term residents, i.e. Europeans, Americans, Japanese, etc. and foreign labours, especially the Tai from Myanmar, which said to be several 100,000s in Chiang Mai.

During the past decades, Chiang Mai has confronted an astonishingly rapid growth from both governmental and non-governmental capitals. Mega projects, new developments, shopping malls, and high rises sprang up all over the cities. This situation was peek during 2011-2013, before the Chiang Mai comprehensive plan has been introduced in May 2014 after a vacuum[4] of law for almost 7 years (see Figure 3).

[3] ***Siam:*** the former name of Thailand, before 24 June 1939 and again from 8 September 1945 to 20 July 1949.
[4] Vacuum of law: the update process took almost 7 years, making there's no comprehensive plan during that time

Chiang Mai University, at the foot of Suthep Mountain, is one of the major magnets in this area, affecting much of the city structures and land-use patterns of the surrounding (see Figure 2).

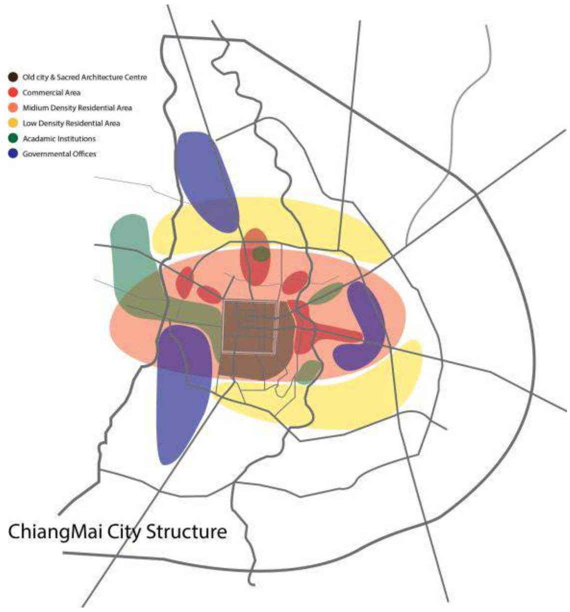

Figure 2 Chiang Mai City Structure

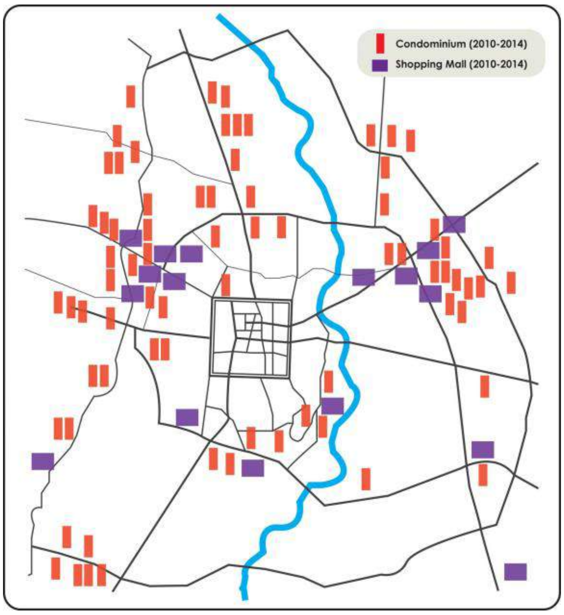

Figure 3 Chiang Mai city new projects during the 'no comprehensive plan' period

Though bringing economic benefit, the situation of the global Chiang Mai has also created many problems to the local citizens. The problems are traffic jams, air pollutions, insufficient supplies of public facilities and utilities, i.e. green open space, electricity, water supply, garbage disposal and the deterioration of urban historic landscape and buildings. The city has becoming 'ugly'. Chiang Mai city itself could be stated as an *over use* living historic city. Figure 4 shows locations of historical and archaeological significant ancient monuments within and beyond Chiang Mai city wall.

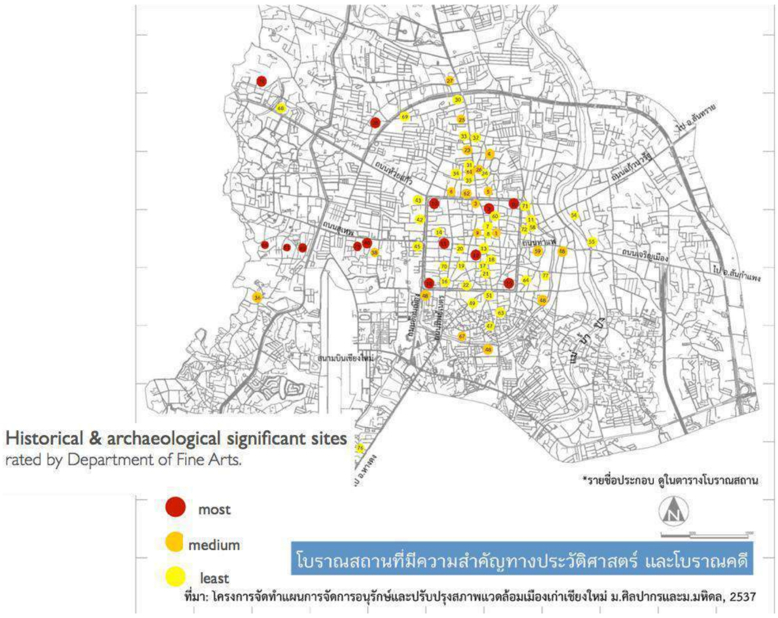

Figure 4 Locations of historical and archaeological significant ancient monuments in Chiang Mai

Chiang Mai City Wall Then and Now

Chiang Mai old city is located to the west of the Ping River and to the east of the Suthep Mountain. King Mungrai named Chiang Mai after its meaning – the new city. After moving to many sites previously, the location was perfect for his new city. Suthep Mountain acted as a natural boundary to the west and as a water resource for the city. The remnant, in the present Chiang Mai University at the foot of Suthep Mountain, suggests the water reservoir was to collect water from the mountain and channel it to the city (Sarassawadee and Pichit, 1996). Two metres higher than and over a kilometre's distance from the riverbank, it was safe enough to protect the city from flooding.

Chiang Mai, like many other ancient cities, has ritual traces attached to its founding. As it is a highly ethnically diverse area, it has traces of different cultures and ideologies on the city plan. It seems true that the reason King Mungrai moving again to the present site of Chiang Mai was to find a new symbolic centre.

The city was laid out probably following a combination of animist traditions, Indic Theravada Buddhist and Chinese Mahayana Buddhist precedents, as a result a square city allied with the cardinal directions (Aasen, 1998: 66) The city wall was very formal rather than informal like Mungrai's previous towns. The walled city was a special domain containing the royal palace, houses of the nobility and a number of temples. The design of the square city wall inherited from the allied kingdom, Sukhothai. (see Figure 5)

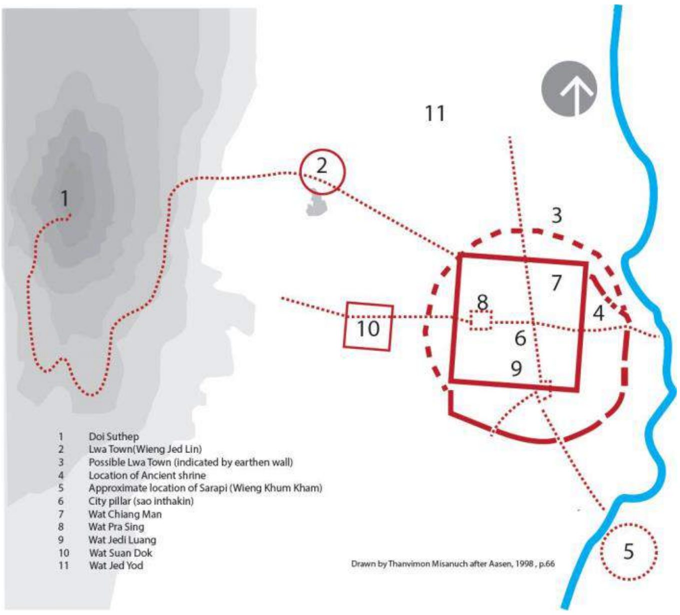

Figure 5 Old remnants and natural features of Chiang Mai City

Nowadays the old city appears in two distinctive forms. The inner wall is a cardinal oriented square with its 1.5 kilometres east-west width, and 1.6 kilometres north-south length (Pranom, 1987). The outer wall is semi-circular form to the east of the square connects to the northeast and southwest corners of the square city wall. (See Figure 5)

There is no clear conclusion about the building date of both city walls of Chiang Mai. One of the most stimulating hypotheses is that the square city wall was built when Chiang Mai was formally founded, on top of the circular Lwa[5] City wall of which only its eastern part is now left. The supportive evidence for this hypothesis are: the width and the length of the city that was stated in the chronicle match with the outline of the two forms together not just the square city itself and the guardian pillar (soa lak muang or soa inthakin) which is at the centre of the circular form not the square (see Sumet, 1989; Nuansri, 1985; Aasen, 1998). Moreover, according to the chronicle, on the site of Chiang Mai was a Lwa town which was beset by demons (Wijeyewardene, 1986: 82). Another version of the chronicle also mentions that King Mungrai asked the Lwa king when he found the old pillar and he was advised to keep it at the original place for the good of the people (Sarassawadee, 1994).

The social organization of small and tightly knitted communities and the long history built up through ethnic complexity and diversity of Lanna, has its marked on Chiang Mai's characteristics and vicinity. Looking at a map, clearly Chiang Mai consists of several old remnants: Wieng Chiang Mai, Wieng Suan Dok, Wieng Jed Lin, as well as Wieng Khum Kham to the south of Chiang Mai (see Figure 4). This represents a group of interrelated walled cities with their different roles (Somchot, 1996: 387). It truly expresses the meaning of *muang* of which Mungrai was its *choa muang*[6].

At present it is still occupied by worship places and civil institutions to a great extent. There are 38 Buddhist temples plus 7 abandoned sacred sites as well as other listed

[5] An Austroasiatic-speaking group, who originally occupied lowland areas of Lanna, Northern Laos, and Shan states of Myanmar (Department of the US Army, 1970. Cited from Aasen, 1998: 17).
[6] Head of principalities.

archaeological sites, i.e. the city walls. Moreover, at least 2 vocational colleges, 8 primary and secondary schools, a number of nurseries and language and tuition schools are located within the city wall. It could be stated that the area is still one of the good residential areas in town enjoying a low-rise environment surrounded by natural beauty and historical sites. Nevertheless, Figure 5 shows that the area also incorporate with many tourist facilities; hotels and guesthouses, pubs and bars, restaurants, banks, coffee shops, markets and super markets. It is the truly mixed of the old and new in the old city of Chiang Mai.

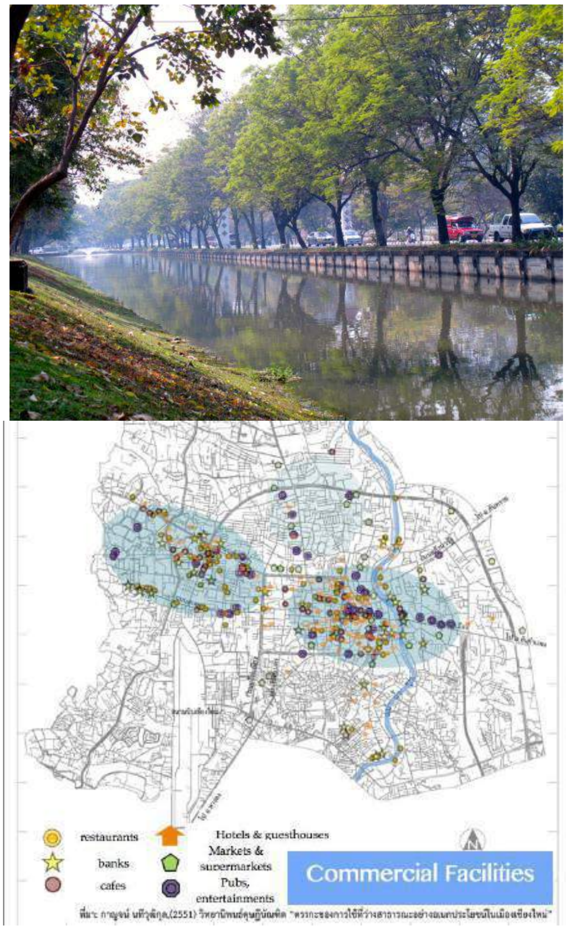

Figure 6 The Beauty of the City Moat and the Locations of tourist facilities in the three zones of Chiang Mai

The city wall area has been designated as the ‘Conservation Area for the Thai Art and Culture Promotion’ through several Chiang Mai Comprehensive Plans since 1982 including the present plan announced on the 26 May 2014 (see Figure 7). In addition, since 1988 the Chiang Mai Municipality law also regulated the architecture style and height of buildings in the conservation areas of Chiang Mai old city. However, Suebsak (2002) found out that the regulation of building construction has not efficiently encouraged physical development and incorporated physical characteristics of the area. There were buildings in different modern architectural styles. Many buildings had their locations and heights that block the view of ancient monuments, religious, and old buildings (see Figure 8).

Realizing the problem, the municipality set a team of experts reviewing the law and introduced a new law in February 2015 giving more details of how the new structures should be constructed in the city wall, including building masses and forms, roof styles, colours, textures as well as the sizes of signs and billboards. Hopefully, this will enable the more harmonious historical landscape of the old city. We then move to the next section investigating the situation of the old wooden houses within the inner city wall.

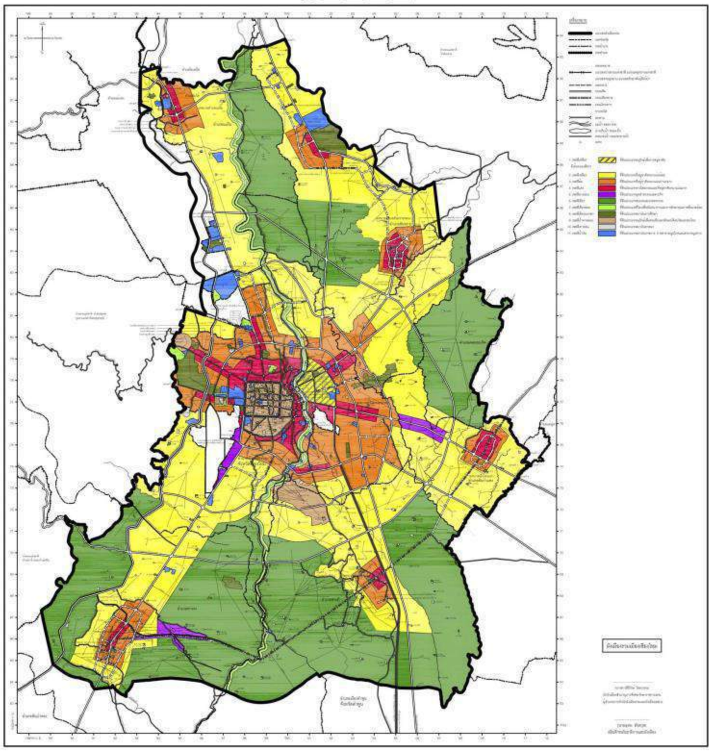

Figure 7 The Chiang Mai comprehensive plan 2014

Figure 8 A high-rise hotel adjacent to the city moat destroys urban historic skyline

The Declining of Old Houses in Chiang Mai City Wall

In 1987 a thesis submitted for a master degree in Urban Planning at Chulalongkorn University, by Pranom Tansukanun, entitled 'A Study for Conservation Planning of the Area within Chiang Mai City Wall' surveyed and rated religious and domestic architecture through their significance in age, history, special architectural characteristics, architectural aesthetic, townscape values, locations, and touristic values. It marked 191 old houses as 'valuable' for conservation.

The basic criteria for the house selection in the 1987 visual survey are traditional style and age over only 20 years, realizing the rapid house demolition rate. The majority of the houses surveyed that time were 31-40 years old (37.4%), 41-50 years old (27%) 21-30 years old (14%) and 51-60 years old (14%) respectively. The fewest were houses age over 60 years old (8%), while very rare cases were over 70 years old. Figure 9 shows the ratio of house age groups.

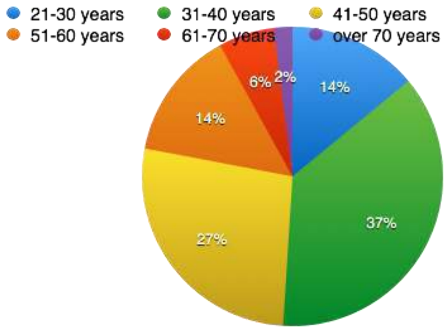

Figure 9 Old House Ages in Chiang Mai City Wall from the 1987 Survey

Most of the houses were situated at the centre, to the east and the south side of the city wall where economic functions have been higher than the west (Figure 17 shows the locations of houses surveyed in 1987 and 2013). This was also true for the 'highest values' architecture of which were mostly located to the east and the south side of the city wall. Figure 10 shows the significance of houses in the city wall rated through all criteria. Among the 4 significance groups; the highest, very high, high and moderate, the biggest group was the high values (55%). The highest value group shared 7%, the very high values shared 20% while the moderate values shared 18%.

Interestingly, not very many of these houses were located on the main roads, but along small winding alleys that has always been one of the major characteristics of the old Chiang Mai.

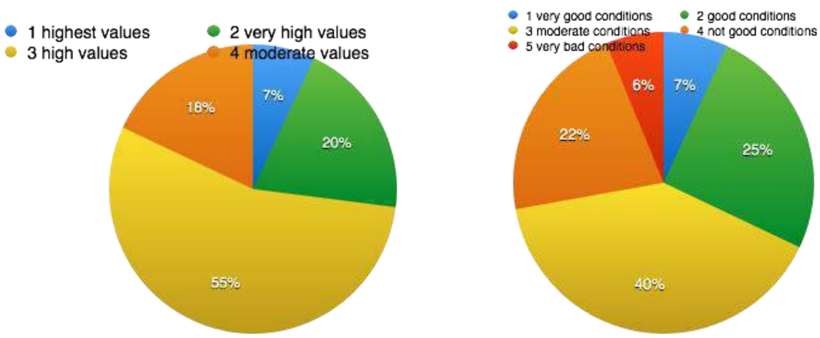

Figure 10 Values and Conditions of Old Houses from the 1987 Survey

The conditions of these houses were generally in the moderate group (40%), good (25%) not good (22%), very good (7%) and very bad conditions (6%) repectively.

In 1992, another survey by Pranom for a small research on ‘Changes of Old Buildings in Chiang Mai City Wall Between 1987-1992’ sponsored by Klang Foundation found out that only about 19% of the houses were in better conditions. While about a half had already been demolished (27%) and were going to be demolished (23%). Moreover, and the rest of the houses (31%) were in uncertain stage (see Figure 10). It could have been said that, apart from about one fourth of the houses that were demolished, the old houses up to a half were in risk. It was also clear that the most vulnerable houses were the old age owners who loved and stayed in the houses but the ancestors were reluctantly keeping the houses.

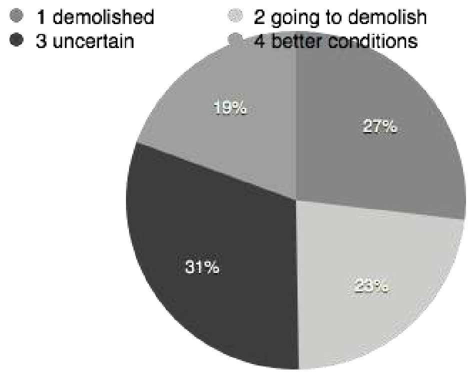

Figure 11 Conditions of Old Houses Comparing Between Year 1987 and 1992

The 1992 survey also found out that the majority of houses, 28 out of 33 houses, were demolished when changing use from residential to guesthouses, dormitories, commercial buildings and others. Only a few could use the same physical spaces for the new functions. This came to a universal problem for historic cities - ‘form and function dilemma’ as stated by Ashworth (1991) – when needs and uses change much more rapid than physical attributes in most historic cities. However, Ashworth also argues that conservation could be a tool for management of urban change. The next section we will investigate how wooden houses adapt physical attributes from traditional Lanna style to fit with the changes through times.

The Adaptation to New Needs

In 2013, another survey by Pranom, in cooperated with a team from the Compass Magazine, conducted for writing an article to raise the public awareness of old house conservation. The article gives a summary for the old building types in Chiang Mai city wall associated with ages into 5 categories ordering from new to old, details as follow:

1. The modern buildings - 50 years
2. The modern wooden houses 50-60 years
3. The adaptive traditional wooden houses 60-70 years
4. The traditional wooden houses 70-80 years
5. The large traditional-colonial buildings over 80 years

First – the concrete modern buildings, age about 50 years, the starting time of Chiang Mai University that brought many modern buildings to Chiang Mai. The low roof slope with concrete and cement elements are the significant characters of the buildings in this period (see Figure 12). There are not very many buildings of this type the old city with only a few single and shop houses. However, this type of building is still significant to the total picture of architectural development of Chiang Mai. For this reason, the further study on the adaptation of old houses within the city wall will cover this type of houses.

Figure 12 An example of a Modern House Converting to be a Hotel
(Source Left Photo: http://www.yourchiangmai.com/blog/wp-content/uploads/2014/06/hom10.jpg)

Second – modern wooden houses coexist in the modern time, age between 50-60 years. The house also has low roof slope but mainly made of wood, and the more western style planning than the adaptive Lanna traditional style previously built (see Figure 13). In the 1987 survey, this type of house was not included since they were quite young.

Figure 13 An Example of a Modern Wooden House in the City Wall.
(Source: The Compass Magazine, Vol.10 No.124 September 2013)

Third – adaptive traditional wooden houses that design before the modern wooden house period, age between 60-70 years. The characters of houses in this period are still in harmony with the traditional Lanna style but the design and planning began to pick up some elements in the western style, for example; more separated rooms rather than the fluid inner-outer spaces and less open spaces within the houses (see Figure 14).

Figure 14 Examples of Adaptive Traditional Wooden Houses
(Source of left photo: The Compass Magazine, Vol.10 No.124 September 2013)

Fourth – post traditional wooden houses, age between 70-80 years, with some influences from the large traditional-colonial[9] buildings in the previous period and adapt some of the Lanna traditional style, bringing wonderful houses with characters of Lanna style.

Figure 15 Post Traditional Wooden Houses

Fifth – large traditional-colonial buildings, age over 80 years. Many buildings smartly used some of the colonial style elements to express Lanna style and hot humid climate buildings by keeping the open or fluid inner-outer spaces. These are one of the good examples of the adaptive design from originally Lanna style houses. The first sub-type in this group were made of cement and woods, while the second sub-type were mainly made of woods (see Figure 16 and 17).

[9] Colonial is a western influential style, though Thailand has never been formally colonized, but the term is being used to specify the time or period of the influence.

Figure 16 Large Traditional-Colonial Buildings: Cement and Wood Sub-type (Source: The Compass Magazine, Vol.10 No.124 September 2013)

Figure 17 Large Traditional-Colonial Building: Wooden Sub-type with Cement Fence Posts.

Lastly, the 'wooden and Ruen Ka Lae' or the original Lanna style houses will be described here for the comparison of the physical attributes, though none is exist in the city wall at present. The typical Lanna wooden house plan in Figure 18 shows that the stairs lead to the front deck or 'Jan Na' (1) and the elevated multi-purposed area or 'Teun' (2) where guests are accepted in this area. Connecting to the 'Jan Na' is a small passage (Hom Lin-7) between two bedrooms (Hong Non Yai-3 and Hong Non Noi-4) that leads to a dinning area (Jan Lang-6) where the water pots (Han Nam-8) are normally located and a cooking area (Heuan Kheau-5).

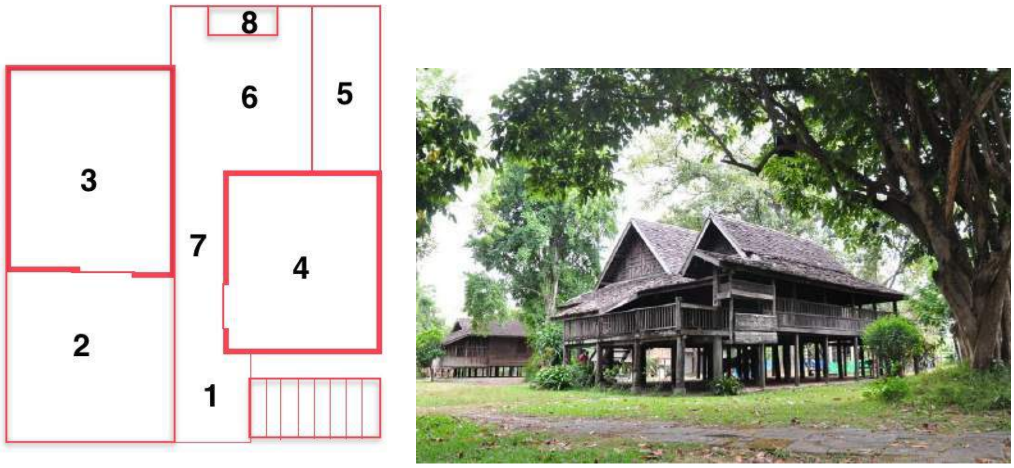

Figure 18 Typical Floor Plan of a Wooden Traditional Lanna House
(Source: Drawn after Anuvit and Wiwat, 1978,
photo: http://202.28.248.175/57/u57265/wordpress/?page_id=294)

1 'Jan Na'- Front Deck 2 'Teun'- Multi-purposed Area 3 'Hong Non Yai'- Master Bedroom 4 'Hong Non Noi'- Bed room 5 'Heuan Kheua'- Kitchen 6 'Jan Lang'- Back Deck 7 'Hom Lin'- Passage 8 'Han Nam'- Water Pot

We can see that the fifth group of 'large traditional-colonial building' is the one that splendidly mixed traditional and western influence with different planning but the similar high-pitch roof style and the fluid of spaces around the building. The fourth group of 'traditional wooden house' also with the form follow tradition, appears to have more traditional elements than the fifth group for example the 'Fa-Lai' or moving partitions and the lath partitions (Figure 19).

Figure 19 'Fa-Lai' (left) and Lath Partitions (middle) with a 'Han Nam' (right) in Traditional Lanna Houses

The third group of the 'adaptive traditional wooden houses', though having the same high pitch roof styles, the planning and spatial organization is different. Moreover, spatial fluidity is lesser than the traditional Lanna house.

The second group of the 'modern wooden houses' was the starting point of being 'different' from the traditional Lanna. The most distinctive feature was perhaps a much lower pitch roof as bigger roof materials allowed to do so. The planning and spatial organization was also influence from a new way of design. However, woods were still the main material throughout the house.

When times change, the first group of the 'modern house' that was not included in the first survey has been more and more important as one of the significant development period. It reflects the social and technical context of the time with low pitch roof and mainly masonry and concrete works. The void system and vertical and horizontal solar fins are also unique and create a sense of aesthetic of its own.

The Spirit of a Living Historic City

The latest survey reveals that only 59 houses from the 1987 survey still exist (see Figure 20). Within these numbers, only 54 houses could be count as 'valuable' that is 28% or lower than one-third of the houses. The majority of the 54 houses are in the third and fourth groups, ageing about 60-70 and 70-80 years old. There are very rare houses in the fifth group and most of them are very large houses. (See Figure 21)

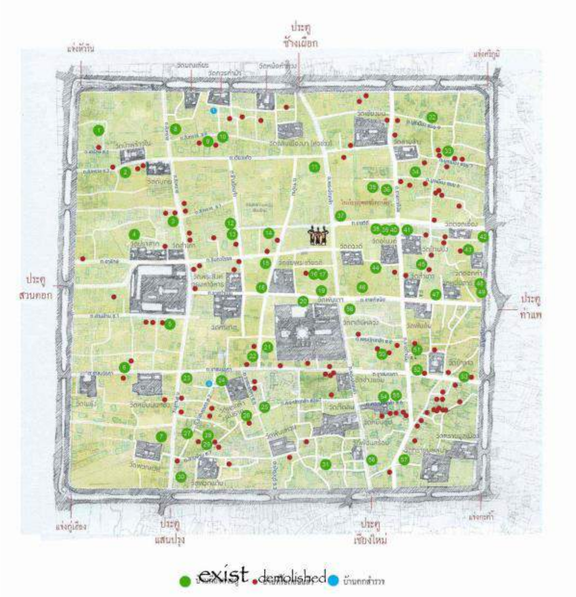

Figure 20 The Locations of Houses Surveyed in 1987 and 2013
(Source: Compass Magazine, September 2013)

Figure 21 A Very Large House Still Exist in the City Wall
(Source: Compass Magazine, September 2013)

Though the latest survey shows many problems of urban conservation, especially the rapid rate of old house demolition, surprisingly the team was not depressed but was very happy indeed. This seems to be true because the inner city wall is still a place of greenery with lots of trees and shrubs, and a tranquil place in some sense. It still is a place of 'spirit' of a living historic city with lots of neighborhoods, people and activities of its daily and sacred lives. (see Figure 22)

Figure 22 The Spirit of the Place: Small Alleys with Lots of Trees and Shrubs (Source: Compass Magazine, September, 2013)

Conclusion

As mentioned earlier, looking into the manifestation and adaptation of dwellings helps to promote understanding people. These are at the center of identity and spirit of their dwellers that could strengthen cultural sustainability. It could be summarized that the dynamism of old wooden houses concerns a global and a local levels. At the city level, the more global factors, such as socio-economic, play an important part. These factors drive the city into the more global network. Thus, new needs, especially from tourists, have come to light. As the historic landscape of old Chiang Mai was low rise among open spaces filled with shrubs and trees, not packed with buildings as many European cities, the 'infill' has become extremely significant. The infill architecture should be well taken care of together with regulations and codes for a livable city, protecting good lives for its people and good views for its visitors.

At the house level, the three interconnected issues: dwellers, process and dwellings as artefacts, are concerned. These issues are contextual and have been also change in accord with socio-economic factors through times. The adaptations of old houses within Chiang Mai city wall are varied during the past decades. Though some are demolished, others are reshaped, reorganized or change to new uses. Many cases still show the conformity with traditional style. These various types of manifestation and adaptation should be safeguard in place.

However, in some cases, dwellings are transformed into a new 'out look' with similar spatial organization. These cases, not at a glance, show the compatibility but could fit in and add the continuum of traditional architecture that still exists today. A question may arise here that why rather 'new' buildings should be included in the conservation list of Chiang Mai. The answer may point out to 'groups of buildings' values and the overall landscape of the old city. In addition, the replacement by newer buildings would decrease the values of urban historic landscape.

A closer look into details of these adaptations would give more knowledge and a better decision on how to conserve these dwellings. With its variety, the area within Chiang Mai city wall could act as a living museum for the pride of its local people and a learning center for its visitors. The most important thing is to manage to achieve this goal.

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Abstract
Yogyakarta is one of the provinces in Indonesia that has no fossil energy potential. All activities of the community in Yogyakarta Province is highly dependent on the stability of energy supplies from other regions, where almost all energy needs in Yogyakarta, such as fuel oil and Liquid Petrolium Gas (LPG) supplied from the outside area with the use of energy increasing each year. Electrical energy was supplied from the inter connection network of Java-Madura-Bali (JAMALI). Energy plan in order to secure supply of energy is an important agenda for energy policy in Yogyakarta, so that energy usage can be optimized. For the purpose of this research we tried to use accounting models by using LEAP (Long-range Energy Alternative Planning) software, where firstly analyzes the current situation of Yogyakarta's energy consumption.

Applying LEAP model to simulate primary energy and final energy demand in the periode time 2011-2030 under different scenario composition that is Bussines As Usual (BAU), Moderate (MOD), and Optimistic (OPT) scenario. The results show that: energy demand grew an average of 3.43% per year and the overall final energy demand are 9792.11 thousand BOE in 2030. Demand for fuel oil in 2030 was 6.861.35 thousand BOE, 6,782.24 thousand BOE, and 6,651.82 thousand BOE respectively for BAU scenario, MOD, and OPT scenario. While the demand for electricity is 2417.11 thousand BOE, 1994.96 thousand BOE, and 1807.06 thousand BOE respectively for BAU scenario, MOD, and OPT scenario. For all the three scenarios, 8,09-12,5% carbon emission intensity reduction target can be realized, and energy elasticity smaller than 1, this suggests that energy is efficent.

Keywords : Yogyakarta, Energy Eficiency, Plan, LEAP

Background

Yogyakarta (DIY) is one of the provinces in Indonesia that has no fossil energy potential, where almost all energy needs in Yogyakarta, such as fuel oil and *Liquid Petrolium Gas* (LPG) supplied from outside the area with the use of energy increasing each year. Electrical energy was supplied from the inter connection network of Java-Madura-Bali (JAMALI) because there are no power stations to fulfill the electricity demand of Yogyakarta. This means that all activities of the community in Yogyakarta province is highly dependent on the stability of energy supplies from other regions. As an icon City of Culture, Education City, and the second tourist destination after Bali, Yogayakrta then become one of the destinations educational and tourist potential for residents from outside the region. This condition will clearly have implications for the increasing number of economic and human activity that uses both fuel and electrical energy in the region.

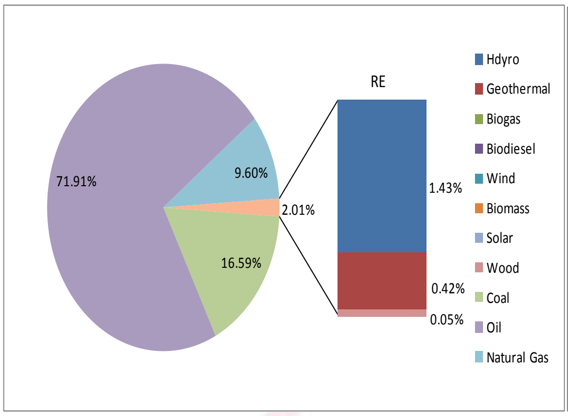
In the other hand the pattern of energy consumption is the consumptive of energy consumption. Energy majority have not been used to support economic growth. This can be seen from most existing energy used in household and transportation sectors, which reached 19.98% and 71.86% of the total energy used in 2011, the rest is the energy used in commercial and industrial sectors. The composition of the type of energy used in DIY is still dominated by energy type of fuel that reaches 74.66% of total energy consumption in 2011 (Department of Energy and Mineral Resources DIY). While the growth elasticity of energy use to GDP growth in the same period reached 1.37. This suggests that the elasticity of energy use in DIY is wasteful or inefficient due to run sectors of economic activity with growth of 1% per year needed energy with a growth of 1.37% per year.

By this phenomenon, the Government of Yogyakarta Province, as the opinion of Cai, et.al (2008) and Connolly, Lund, Mathiesen, and Leahy (2009) was supposed to do the proper planning on energy supply in order to build the strong energy security to fulfill the energy needs of society. Energy planning in order to secure supply of energy is an important agenda for energy policy in Yogyakarta (Stern, 2011), if not Yogyakarta will have serious energy issues that will affect to the economy and environment in the future.

Energy Condition of Yogya Province

As we see in Figure.1 below, primary energy mix is seen that the use of petroleum is very dominating, about 71.91% of all kind of energy, and coal used in electricity generation has a percentage of 16.59%. Besides being used in the generation of electricity, a small fraction of coal is also used in the industrial sector activity. Natural gas is used in the generation of electric energy has a percentage of 9.60%. In 2010, the use of new and renewable energy only has a percentage of 1.90%. Renewable energy consists of hydropower and geothermal energy used in the generation of electricity through the JAMALI interconection system and firewood used for cooking activity in the household sector.

The pattern of energy consumption in the Yogyakarta Province is the consumptive patterns of energy consumption. The energy that has been used is largely not yet used to support the economic growth. This can be seen from most existing energy used in household and transportation sectors, that reached 28.52% and 59.45% of the total energy used in 2010, the rest is the energy used in commercial and industrial sectors (Figure.2). While elasticity of energy used growth to GDP growth in the same period amounted to 1.37. This suggests that the elasticity of energy use in Yogyakarta Province is wasteful because to run the activity sector with growth of 1% per year, need 1.37% energy growth per year.



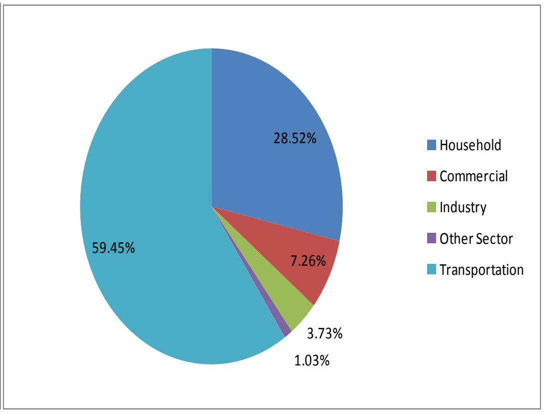


Figure 1: Primary energy mix *2010* **Figure 2 : *Energy Usage by Sector 2010***

Metodology

Basic assumptions of Research

The main focus of this research is to analyze the energy efficiency plan which is basically an estimate of the energy demand. Energy demand compiled by the year 2010 as the base year and 2030 as the year-end projection. Energy demand compiled using energy intensity methode and using LEAP software as a tool for calculating the energy demand forecasts. The intensity of energy is the energy usage parameters for each activity. Driving variables in this study are growing share of the economic, demographic variables consisting of the total population, number of households, population growth, and the composition of rural and urban populations.

Activity in the household represented by the number of households, so the energy intensity is the amount of energy consumption used in each household. Activity of commercial sector, industry, and other sectors represented by the value-added GDP for each sector. For these three sectors, energy intensity parameter specifies the number of energy used for each value-added generated by these sectors. The transport sector consists of modes of highway and non-highway modes. Modes of highway transport activity consisting of passenger cars, freight cars, motorcycles, and buses that represented by the number of vehicles. For highway transportation, energy intensity is the amount of energy used by each unit of the vehicle. As for the transportation of non-highway modes consisting of trains and aircraft, the activity represented by the distance. The intensity of energy for the transport sector non-highway modes is the amount of energy that is used for every kilometer mileage.

Furthermore, calculating of the energy demand is based on two scenarios, namely the business as usual scenario (BAU), and Energy Efficiency (EE) which consists of a moderate efficiency scenario (MOD), and optimistic (OPT). In BAU scenario, the calculation of the energy forecasts are based on the same pattern of energy use as happened in the base year. In this scenario, there is no new policy interventions regarding energy consumption such as energy conservation and use of renewable energy. Energy Efficiency scenario both the Moderate (MOD) and optimistic (OPT) was developed based on the BAU scenario with energy policy interventions based on energy efficiency potential and renewable energy implementation.

Energy Efficiency scenario based on energy efficiency potential derived from previous research. Potential energy efficiency can be seen in Tabel.1.

Table 1 Energy Efficiency Potential in Yogyakarta

No.	**Sector**	**Energy Efficiency Potential**
1	Industrial	15 – 20%
2	Household	10 – 25%
3	Commercial	25 – 30%
4	Others	25 - 30%

Source : Energy Office of Yogyakarta, 2010

For transport sector, energy efficiency is done by shifting modes to optimize the use of public transport. The target of transfer mode from personal to of public transportation modes is to increase the load factor of the bus modes from 24.34% to 60% in 2030. The transfer motorcycles and private passenger cars are respectively 14% and 11% in 2030.

Renewable energy scenario is based on the potential of renewable energy. Types of renewable energy such as solar energy, wind energy, hydropower, and biomass developed as primary energy in the electricity production. Biogas and biodiesel used to replace the demand of LPG, firewood, coal and briquettes in the household sector.

Table.2 Development of renewable energy for Energy Efficiency scenario (MOD)

No.	**Type of RE**	Target of Development				
		2010	**2015**	**2020**	**2025**	**2030**
1.	Solar	25 kWp	250 kWp	2.000 kWp	2.500 kW	3.000 kWp
2.	Hydro	25 kW	50 kW	600 kW	650 kW	750 kW
3.	Wind	20 kW	40 kW	80 kW	120 kW	160 kW
4.	Biogass	300 unit	1.000 unit	2.500 unit	4.000 unit	5.000 unit
5	Biodisel	0	0,5% M. Solar	1% M. Solar	1,5% mM. Solar	2% M. Solar
6	Biomassa	0	100 kW	500 kW	750 kW	2 MW

Tabel.3. Development of renewable energy for Energy Efficiency scenario (OPT).

No.	Type of RE	Target of Development				
		2010	2015	2020	2025	2030
1.	Solar	25 kWp	2 MWp	5 MWp	7,5 MW	10 MWp
2.	Hydro	25 kW	600 kW	750 kW	1.300 kW	1.800 kW
3.	Wind	20 kW	50 MWp	50 MW	75 MW	100 MW
4.	Biogass	300 unit	1.000 unit	2.500 unit	4.000 unit	5.000 unit
5	Biodisel	0	2,5% M. Solar	5% M. Solar	7,5% M. Solar	10% M. Solar
6	Biomassa	0	10 MW	15 MW	17,5 MW	20 MW

Data Analysis

Refers to the IEA (International Energy Assosiation) provision, energy demand model in this research using final energy approach (final used), where the final energy demand is modeled by sector, and energy end users in detail, namely: (1) industrial sector separated into five sub-sectors, (2) energy demand in the household sector (residential) were separated into four groups according to income, (3) commercial sectors based on the share of sub-sector to the formation of value added to GDP, (4) other sectors based on sub-sector share to the formation of value added to GDP, and (5) energy demand in the transport sector is modeled in detail according to the mode of transport.

This study used secondary data, namely: the demographics that consists of the total population, number of households, population growth, and the composition of the villages and towns, as well as data of economic growth and inflation. Supporting data include data on energy supply,can be obtained from the PLN and Pertamina, data of potential for renewable energy in the Yogyakarta province which obtained from field survey. Energy demand modeling in this study using energy final used approach where final energy demand by sector is expressed as follows. Aggregate energy intensity (et) can be written as a function of energy use sector (EIT) and sector activity (ait):

$$et = \frac{Et}{Yt} = \sum \left(\frac{\mathrm{Eit}}{\mathrm{Yit}}\right) \left(\frac{Yit}{Yt}\right) = \sum eit \, . \, ait$$

where Et is the aggregate energy consumption in year t, Eit is the energy consumption in sector i in year t, Yt is GDP in year t, and YIT is a measure of economic activity in the sector i in year t. In the end-use approach, aggregate energy demand is obtained by summing the energy demand in the sector level. Thus, the energy demand by sector was designed as follows:

a. Household Energy Demand : $Ed_h = \sum_1^4 Ih \; x \; (H_{t-1} \; x \; g) \; x \; A_{Ih} \; x \; K_h$
b. Transport Energy Demand : $Ed_T = \sum_{h=1}^6 IT x \; (T_{t-1} \; x \; g) \; x \; A_i \; x \; K_h$
c. Industrial Energy Demand : $Ed_I = \sum_{h=1}^8 ID x \; (T_{t-1} \; x \; g) \; x \; A_i \; x \; K_h$
d. Commercial Energy Demand : $Ed_I = \sum_{h=1}^6 IK \; x \; (T_{t-1} \; x \; g) \; x \; A_i \; x \; K_h$
e. Others Energy Demand : $Ed_I = \sum_{h=1}^3 IL \; x \; (T_{t-1} \; x \; g) \; x \; A_i \; x \; K_h$

Planning and energy models are designed with software tools, LEAP (*Long Range Energy Alternative Planning*). LEAP software will be generated an energy model based on energy scenarios that have been designed before, that is BAU scenario, Moderate (MOD), and Optimictic (MOD) scenario. The timeframe used for projecting the supply and demand for energy in Yogyakarta Province is for 20 years (2011-2030) by the year 2010 as the base year. Energy conservation scenario described in more detail for each activity energy consumption, based on the energy saving potential in every sector. Energy intensity in each sector is reduced interpolated according to the potential energy savings to the end of the projection. As for the diversification of energy scenario, energy intensity will be substituted by Renewable Energy (RE) lowered depending on the targeted use of RE

Result and discussion

Energy Demand Projection

Calculation of energy demand is based on three scenarios, that is Business as Usual (BAU), Moderate (MOD), and Optimistic (OPT). In the BAU scenario, the calculation of energy forecasts are based on the pattern of energy used as they did in the base year. OPT and MOD scenario was developed based on the energy policy of intervention, in terms of energy conservation and renewable energy. Based on that scenario, projection of energy demand of Yogyakarta Province shown in the Figure.1. Based on Figure 3, we can see that implementation of energy efficiency scenario resulted in diminishing energy use.

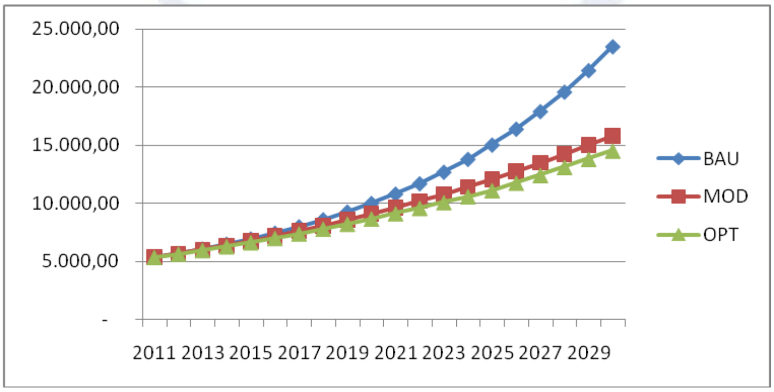


Figure 3. Energy final use projection

Overall, demand for fuel oil in 2030 was 6,861.35 thousand BOE, 6,782.24 thousand BOE, and 6,651.82 thousand BOE respectively for BAU scenario, MOD, and OPT. At the same period the demand for electricity is at 2,417.11 thousand BOE, 1994.96 thousand BOE, and 1,807.06 thousand BOE respectively for BAU, MOD, and OPT scenarios. Demand for LPG in 2030 was 1,156.29 thousand BOE for the BAU and the MOD scenarios, and 1,151.49 thousand BOE for OPT scenarios. Demand for energy-dense types consisting of coal, coal briquettes and firewood in 2030 amounted to 31.01 thousand BOE, 25.04 thousand BOE and 25.65 thousand BOE respectively for BAU, MOD, and OPT scenarios. Until the end of the projection, transport sector still dominates energy use (63%) and the household sector is the second largest sector of energy use in Yogyakarta Province (19%).

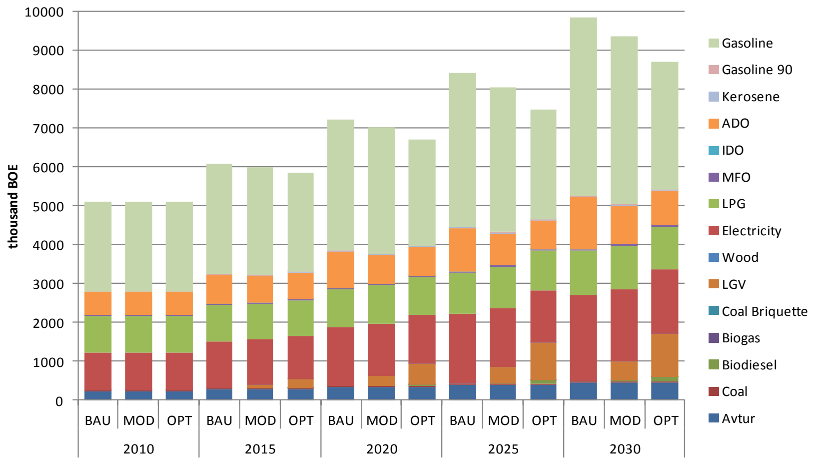


Figure 4 : Final energy demand by type of energy

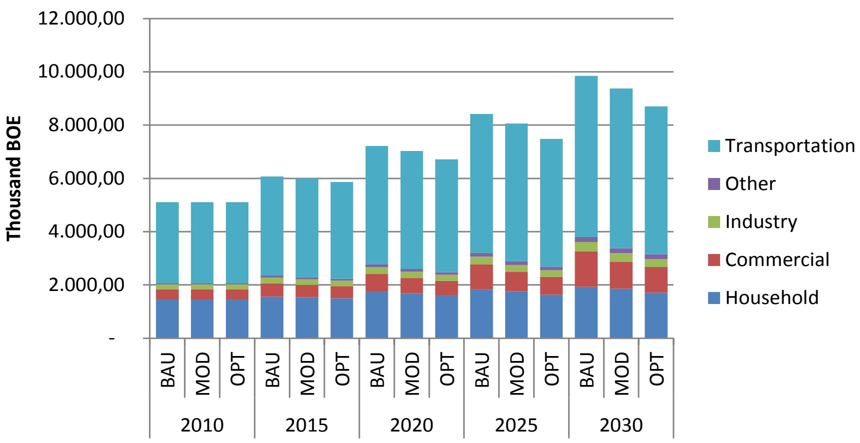


Figure 5 : Final Energy Demand by Sectors

Demand for gasoline is greatest during the forecast period, 46% of the total final energy demand for all scenarios. While the demand for electricity and gas (LPG) is the next largest, for all scenarios.

Energy Supply Projection

Energy supply in Yogyakarta Province is also compiled by the year 2010 as the base year and the year 2030 as the year of the end of the projection. Energy supply calculation is based on three scenarios, that is bussines as usual (BAU), moderate (MOD), and optimistic (OPT). Based on MOD and OPT scenarios, the primary energy mix in 2030 is shown in Figure.5 and Figure.6. From Figure.5, the primary energy used of oil just 66.69% be lowered by increasing the percentage of natural gas (14.11%) and renewable energy (3.35%). From Figure.6 oil and coal's role in providing energy in Yogyakarta can be further reduced through the implementation of programs within the OPT scenario. Meanwhile, increased use of renewable energy compared with the MOD scenario. The implication is the supply of oil energy will decrease.

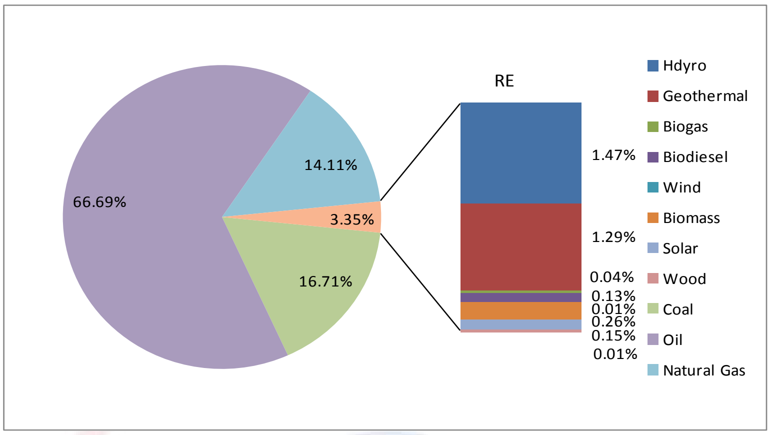


Figure. 6: Primary energy mix by MOD scenario

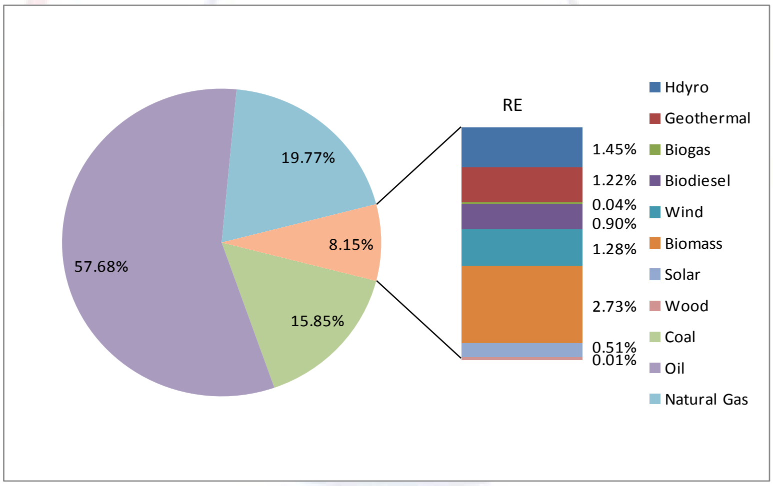


Figure. 7: Primary energy mix by OPT scenario

Carbon Emission

Environmental impact of energy used on the demand side can be represented by the emission of greenhouse gases (GHG) produced as air pollution. GHG emissions based on the scenarios that have been prepared, showing that the impact of the implementation of energy efficiency and renewable energy can reduce greenhouse gas emissions, generated by the use of energy to run the activity sectors. In 2030, the overall GHG emissions generated by the BAU scenario is by 6.56 million tons of CO2 equivalents. Based on the MOD and pest scenario, GHG emissions in 2030 respectively amounted to 6.03 million tonnes of CO2 equivalents and 5.75 million tons of CO2 equivalents. With the implementation of programs that can support the pest scenario, GHG emissions can be reduced to 12.5% when compared to the GHG emissions generated by the BAU scenario. These condition can be seen in Table.4 below:

Table.4 Total GHG Emissions In 2030

No	Scenarios	Total Emission
1	BAU	6.56 Million Tons of CO2 Equivalent
2	Moderat (MOD)	6.03 Million Tons of CO2 Equivalent
3	Optimis (OPT)	5.75 Million Tons of CO2 Equivalent

Energy Elasticity

The index used to measure the energy needs for economic development of a country is the energy elasticity, which describes the growing energy needs required to achieve the certain level of economic growth (GDP). Based on a series of analyzes that have been conducted, energy elasticity of Yogya Province can be seen in Figure 7 below. From the figure it appears that Energy Elasticity using BAU scenario until the end of the projection is greater than 1 (e> 1). This condition illustrates that the energy consumption in the Yogya province have not been efficient or wasteful, due to increase of 1% economic growth requires energy in larger quantities. Meanwhile, based on Moderate and Optimistic scenario by including aspects of energy conservation policy as outlined above, energy elasticity of Yogyakarta Province until the end of the projection record numbers smaller than 1 (e <1), This shows that with the implementation of conservation programs Yogyakarta Province can optimize energy used becomes more efficient.

Energy efficiency achieved by the Moderate scenario began in 2024 until the end of the projection, while based on Optimistic scenario, energy efficiency has been achieved by the year 2019. This shows that the implementation of the energy conservation programs, DIY can optimize energy use becomes more efficient. The implication is that in order to increase the economic growth of 1% will only require the use of less energy, and the energy that is available to be used productively. Lower energy use relative to the rate of economic growth will be achieved social welfare and better of environmental quality due to reduced exhaust emissions (negative externalities) on energy consumption.

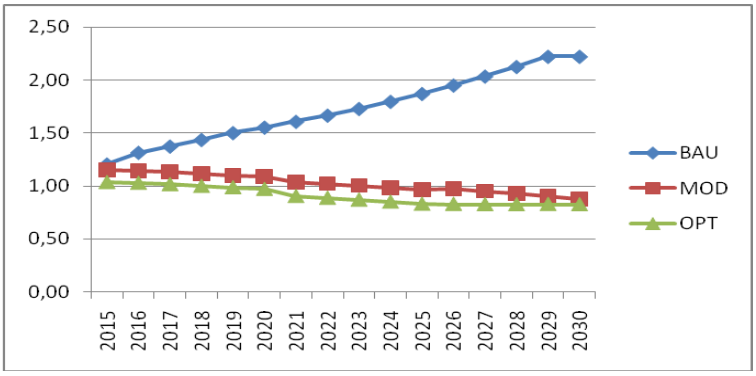


Figure 8. Energy Elasticity for all the three scenarios

Conclusion

The total primary energy demand will reach 9,848.17 thousand BOE, 9,374.99 thousand BOE, and 8,706.95 thousand BOE respectively for BAU scenario, MOD, and OPT scenario. In the next 20 years, Yogyakarta primary energy consumption will be still dominated by oil, but the proportion will decrease, while the share of non-fossil energy will rise. By sector energy consumption, transport sectors will occupy the dominant position in final energy consumption, with the percentage of more than 60% of the overall final energy demand. The average growth of final energy demand in the transport sector over the forecast period of 3.5% per year. The household sector is the second largest consumer of the percentage 19,5%.

Based on the pattern of energy final use per type of energy, gasoline is a type of energy use is dominated at 46% of overall energy use. While the electrical energy is the second largest amounting to 22:55% of overall energy use. For all the three scenarios, 8.09-12.5% carbon intensity reduction targets can be realized. Energy use in Yogyakarta Province still not efficient under the BAU scenario, but with a variety of energy conservation programs, until the end of the projection (2030) energy use shows the efficiency. This is evident from the Figure 7 that the elasticity of energy use is less than 1.

Energy efficiency by the Moderate scenario achieved in 2024 until the end of the projection, while based on Optimistic scenario energy efficiency has been achieved in 2019. This shows that the implementation of the various conservation programs Yogyakarta can optimize energy use becomes more efficient. The implication is in order to increase economic growth of 1% will only require the use of less energy, and energy can be utilized productively. Lower energy use relative to the rate of economic growth will be achieved social wefare and the better quality of the environment due to reduced exhaust emissions on energy consumption.

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The Distributional and Welfare Effects of the Emission Trading Scheme on Australian Households

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Abstract
An Emission Trading Scheme (ETS) is considered as an effective cost instrument to achieve the emissions reduction target. The Australian Labor Government intended to implement the ETS from 1st July 2015, instead the carbon tax to meet the Kyoto emissions reduction target of 5% below 2000 levels by the year 2020. This paper examines the effects of a domestic ETS on the Australian economy, and mainly focuses on these effects on Australian households. A single country, static CGE model is employed with an environmental extended social accounting matrix (SAM). Households are disaggregated into 20 household groups and household data is collected from the Household Expenditure Survey, 2009-2010. The results show that the carbon price is around \$20/tCO2, and the permits revenue is over \$10 billion. The electricity price is estimated to increase over 13 percent and the brown coal price decreases over 30 percent. All households experience a reduction in income and expenditure in various degrees. The welfare impact is calculated in terms of the Equivalent Variation. The results show that all household groups experience absolute welfare loss of nearly \$8 million for the poorest and \$200 million for the richest. If the permit revenue is returned to household groups in the form of an equal lump-sum transfer per capita this creates benefits to the highest number of household groups.

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1. Introduction

In order to achieve the Kyoto emissions reduction target of 5% below the 2000 levels by the year 2020, the Australian Labor Government introduced a carbon pricing scheme that commenced with a fixed carbon price of $23 per tonne of CO2-e in 1 July 2012, then would switch to an Emissions Trading Scheme(ETS) on 1July 2015. The imposition of a price on carbon emissions induced an increase in the cost of production, especially for emissions intensive industries such as electricity generation and transportation. However, as facing with the increased production costs caused by the carbon price producers would pass forward these costs to the final consumers in the form of higher commodity prices, or backward to laborers and investors in the form of lower wages and lower rentals of capital and land. Therefore this affects household expenditure, and income, as well as welfare.

This paper examines the effects of an ETS designed to achieve the Kyoto target (equivalent to emissions reduction of 11 percent of the base year 2009) on the income distribution and welfare of Australian households. To do this, the single, static computable general equilibrium (CGE) model is employed to analyze these effects. Household data was collected from the Household Expenditure Survey, 2009-2010. In this paper, the costs caused by an ETS are assumed to pass fully to consumers in the form of higher commodity prices. An ETS is estimated to be regressive. In order to mitigate the degree of regressivity, half of the permit revenue raised from the permit auctions is used to recycle to households. The author compares the effects of three scenarios of the revenue recycling on prices, household income and welfare. These scenarios include the lump-sum transfer based on per-capita; the lump-sum transfer to low and middle income household groups (12 poorest groups); and increasing government payment to all household groups based in the Government pensions and allowance ratios.

The remainder of this paper is organized as follows: Section 2 presents previous research which has examined the impacts of an ETS on an economy, distributional income and welfare. Section 3 describes the model structure and database for the simulations. Section 4 analyzes the effects of an ETS on prices, as well as distributional income and welfare to Australian households. Section 5 concludes the paper.

2. Literature Review

There have been several studies conducted to investigate the distributional and welfare effects of a carbon tax in both developed and developing countries. It seems that the carbon tax is regressive in developed countries (Poterba, 1991; Symons, Proops, & Gay, 1994) and progressive in developing countries (Yusuf & Resosudarmo, 2007). The degree of regressivity depends on the methodological choices such as type of measurement of distributional effects and the inclusions of behavioural responses. (Büchs, Bardsley, & Duwe, 2011). Distributional effects were measured by the annual income that were shown to have greater regressive effects than those measured by the lifetime income (or current consumption) (Grainger; & D.Kolstad, 2010). When the behavioural responses are added into the model, it seems that high income households respond less to price changes than low income households (Cornwell & Creedy, 1998). Many studies examined the incidence of the emissions trading scheme (or cap-and-trade) in recent years. These studies have analyzed the impacts on households in different income groups with auctioned revenue returned in a direct way of lump-sum transfer or an indirect way of reductions income tax and other taxes.

Dinan and Rogers (2002) examined the distributional effects of cap-and-trade program aimed to achieve a emissions reduction of 15 percent. The allowance is allocated by either giving away or auctioning. The revenue is distributed by the ways of decreasing corporate taxes, reducing payroll taxes, and providing a lump-sum rebate to households. The results indicated that the lowest quintile bore the largest share of the policy cost if the government gave the allowances away. However, in the case of auctioning, households in the lowest income quintile would obtain the largest benefits from the lump-sum rebate, while households in the highest income quintile gain more benefits as the government decreases corporate taxes.

Parry (2004) compared grandfathered emissions permits with other environmental policies to control power plant emissions of CO2, SO2, and NOx by employing an analytical model with household income proxied by consumption. The results showed that low income households were worse off under grandfathered permits than under an emissions tax. The author found that grandfathered permits were highly regressive for all pollutants for emissions reductions, with the top income quintile better off while the bottom income quintile was much worse off. However, if an emission tax or the auctioned permits revenue were recycled proportionally to households, the policy looked much less regressive. If revenue was recycled in a progressive manner as in equal lump-sum transfers, the policy became progressive in the case of CO2 and NOx.

Beznoska et al. (2012) examined the effects of an EU-ETS with the emissions reduction target by 20 percent below 1990 levels until 2020 on the prices of goods and the household welfare in Germany, in both cases with and without behavioural responses of consumers to price changes. The carbon price of €25 per carbon permit induced the highest increase in the electricity price of 14 percent. The average German household had the additional cost of €16 per month in the case of no behavioural responses. Household consumption was reduced by about 6 percent in the case of adding behavioural responses, compared to the case of no behavioural responses. The effects were regressive in both cases. To offset the negative effects in both cases, the research analyzed the effects of the EU-ETS on household welfare in the case of using auctioned permit revenue return to households via lump-sum rebates and a reduction on social security contributions. The results indicated that the effects would be progressive in the form of the lump-sum rebates and was still regressive in the case of a lower on social security contributions. However, the revenue recycling in the form of lower social security contributions had a better positive impact on inequality than the other form. So, there was a trade-off between efficiency and equity of the two forms of the revenue recycling.

In Australia, the carbon tax had been implemented from 1st July 2012 to 1st July 2014. Thus, there are a number of studies that focused on analyzing the effects of the carbon tax on the Australian economy as well as on distributional income and welfare. Notable research includes (Cornwell & Creedy, 1998; Creedy & Martin, 2000; Dougall, 1993b; Meng, Siriwardana, & McNeill, 2014)

An Emission Trading Scheme was used by the former Australian Government under its proposed Carbon Pollution Reduction Scheme (CPRS), but it was not passed by the Australian Parliament. The Centre of Policy Studies (COPS) developed the MMRF-Green model based on the Monash Multi-Regional Forecasting (MMRF) model. The MMRF-Green model is a dynamic, multi-sectoral, multi-regional CGE model of the Australian economy, including 8 states/territories (or 57 sub-states), 52 industry sectors and 56 commodities. Each state has a single representative household and a regional government. The price revenue incidence simulation model and the distribution model (PRISMOD.DIST) are used to examine the distributional implication of carbon pricing to households. Buddelmeyer et al. (2012) linked between the CGE model, the MMRF-Green and the MS model, MITTS (Melbourne Institute Tax and Transfer Simulator) to assess the effects of climate change mitigation on income and inequality in Australia for the period from 2005 to 2030. A reweighting procedure is used to transmit employment change from the CGE model to the MS model. The CGE results are used as exogenous and given inputs for the MS model to produce estimated effects on income distribution. An (ETS) was assumed to implemented on July 2013 and aimed to get the emission target of 80 % below 2000 level by the year 2050 (scenario 1) and of 90 % below 2000 level by the year 2050 (scenario 2). The results indicated that income growth is expected to be slow down between 2010 and 2015, and inequality is estimated to increase. There were two types of lump-sum transfers aimed at offsetting the increased inequality. The returned permit revenue had a positive impact on low income households, but real net income growth was the highest for the top quintile and was very limited for the bottom quintile.

3. Model structure and Database

3.1 Model structure

In order to gauge the distributional and welfare effects of an ETS on Australian households, this study applied a single country and a static CGE model, based on ORANI – G (Horridge, 2003), There are some assumptions in the model, for example, the agents are assumed to be price-takers (a perfect competition), zero profit conditions are assumed to all industries, and demand and supply equations for private-sector agents are derived from the solutions to the optimization problems (cost minimization, profit maximization and utility maximization). In the model, the Australian economy is represented by 35 sectors which produce 35 goods and services, one representative investor, 20 household groups, one government and ten occupation groups. There are modifications in the production function in this model compared with the ORANI-G model.

The production function has a five layer nested Leontief-CES function, the same as in the ORANI-G model, the top level is nested by a Leontief function describing the demand for intermediate inputs, composite primary factors and other costs. The other levels are nested by various CES functions. However, there is a different treatment in electricity generation and energy sectors in the production function. The model allows for the substitution between electricity generated by different sources through substitution elasticity, and the energy sectors are combined with capital in the primary factor part.

The final demands are represented the same as those in the ORANI-G model. In particular, investment demand is a nest Leontief-CES function, the household demand function is formed by a Klein-Rubin on the top, instead of a Leontief function in the intermediate and investment demands, but by CES function on the lower level, the same as the intermediate and investment demands. Export demand depends on the price of these commodities with the assumption of a constant elasticity of export demand. Government consumption is exogenously determined. In order to analyze the effects of an ETS, the model incorporates the carbon emission accounts. Carbon emission in the model is treated as proportional to energy inputs used to the level of activity.

3.2. Database

The Social Accounting Matrix (SAM) table, that is a core database of the CGE model, is constructed using the Input-Output tables, 2008-2009, published in 2012 by the Australian Bureau Statistics. There are 111 sectors corresponding with an equal number of commodities in the original I-O tables. In this model, four energy sectors are disaggregated into 24 sub-energy sectors then aggregated into 14 sub-energy sectors. The author disaggregated energy sectors and then aggregated them to form 35 sectors (corresponding to 35 commodities) in the economy. The household income and consumption data are disaggregated into 20 household groups based on income level and labour is disaggregated into 10 occupation groups according to the Household Expenditure Survey (HES), 2009-2010.

The carbon emission data was collected from the National Greenhouse Gas Inventory in the year 2009. This emission data is expressed in metric tonne of carbon dioxide equivalent (CO2-e). The emission in the database was classified into three categories, in which, the emission that was generated from the fuel combustion was attributed to the input emission; the emission generated from the residential sector was for the household consumption or the consumption emission; and the emissions related to activities including from fugitive emission from fuels, industrial processes, agriculture, waste and land use, land-use change and forestry (LULUCF) was attributed to output emissions. The emissions from fuels combustion or from activity were put in the I-O emission tables. The emissions that were generated from household consumption were disaggregated into 20 household groups based on the consumption shares of each household group. The emission intensity is based on the GTAP database.

The behavioral responses of economic agents are explained by the elasticity parameters. The elasticity parameters that include the Armington elasticity, substitution elasticity between primary factors, among different types of labour, substitution of elasticity between electricity generated from different sources, and among energy inputs that were obtained from ORANI-G. The elasticity of substitution between energy and capital is small (Okagawa & Ban, 2008; Truong, Kemfert, & Burniaux, 2007). Burniaux et al. (1992) indicated that energy and capital are complementary in the short to medium term, and substitutable in the long term. So the substitution elasticity between composite energy and capital is assigned the value of 0.25 in the model. In order to calculate expenditure elasticity for each household group and each commodity in the model of 20 household groups and 35 commodities, the model is based on Australian household demand elasticity by 30 household groups and 14 commodities estimated by (Cornwell & Creedy, 1997), in which, 14 commodities are mapping into 35 commodities in the model, and 30 household groups mapping into 20 household groups. These elasticity values are adjusted to satisfy the unity of Engel aggregation by dividing to the total share-weighted average elasticity of each household.

4. Results

Australian Government (2013) reported that in order to achieve the emissions reduction target of 5 percent below the 2000 levels, the emissions in 2020 will be 555Mt-CO2. It is assumed that the average emissions growth rate was the same as for the period 2000-2012 of 0.71 percent that was calculated from the emissions data provided by the National Greenhouse Gas Inventory. To meet the emissions target by 2020, the emissions from the baseline year must be reduced by 11 percent. This paper examines the effects of an ETS designed to achieve the emissions reduction of 11 percent on the Australian economy, and focuses mainly on distributional income and welfare of Australian households.

4.1. Price effects

The price on emissions permits is ultimately passed forward on to consumers in the form of higher prices or passed backward on to workers and investors in the form of lower wages and lower return of production factors such as capital or land. This section analyzes the effects of an ETS on consumer prices, production factors' prices, and other prices in the cases of with or without compensation.

4.1.1 Impacts on consumer prices

As shown in Table 1, it is clear that, without compensation, most prices of goods and services are estimated to experience an increase to various degrees, in which, electricity price increases at the highest rate of 13 percent. This is explained by the fact that nearly 70 percent of electricity production in Australia is sourced from coal (World Bank, 2012). As estimated in the model, the price of black coal in the black coal-produced electricity increases 112.2 percent and the price of brown coal in the brown coal-produced electricity increased by 132.5 percent, thus leading to a higher electricity price. The price of road transportation increased by 1.81 percent, while a rise in prices of other goods and services is quite small, being less than 1 percent. In contrast, there is a reduction in black and brown coal prices, in which, the price of brown coal is estimated to decrease at the highest percentage of over 30 percent. This decrease results from the fall in demand for brown coal of more than 14 percent. Overall, the consumption price index raises 0.411 percent.

As the permits revenue is recycled to household groups, the prices of most commodities increase at various degrees. As seen in Table 1, the increased prices in the per-capita lump-sum transfer policy is higher than in other two scenarios of revenue recycling. The increased price of most goods and services in the lump-sum transfer to low and middle income household and in the increasing government payments are not too much different, except food, beverage, tobacco and textile, clothing, footwear. The prices of these products increase more in the latter than in the former. This is one reason that the middle income groups receive more compensation in the case of increasing government payments than of lump-sum transfer to the 12 poorest household groups, which will then increase their consumption as they have more income.

In contrast, the price of brown coal is reduced by 30.37 percent in the case of no revenue recycling, and continue to decrease in the cases of revenue recycling. Meanwhile, a reduction in the price of black coal still keep unchanged in all scenarios. These products are of energy-intensive. Overall, consumption price index increases at 0.504 percent in the lump-sum transfer per capita, and in both cases of increasing government payments and providing lump-sum transfer to 12 poorest groups, the consumption price index increases 0.473 percent

Table 1: The effects of an ETS on prices of goods and services (percentage change)

Commodities	**No revenue recycling**	**Lump sum transfer (12HH)**	**Lump sum transfer (per capita)**	**Increasing Government payments**
Agriculture, forestry & fishing	0.544	0.602	0.633	0.603
Black coal	-0.104	-0.103	-0.103	-0.103
Brown coal	-30.375	-30.408	-30.422	-30.407
Gas	0.027	0.042	0.048	0.042
Mining	0.822	0.841	0.850	0.841
Food, beverages & tobacco	0.289	0.345	0.374	0.346
Textile, clothing & footwear	0.228	0.303	0.345	0.306
Wood, paper & print	0.297	0.365	0.402	0.367
Automotive petrol	0.175	0.220	0.227	0.219
Kerosene	0.113	0.118	0.120	0.118
Gas oil or fuel oil	0.076	0.090	0.094	0.090
Liquefied petroleum gas	0.181	0.198	0.204	0.198
Other petroleum and coal products	0.560	0.605	0.629	0.606
Chemical	0.223	0.272	0.299	0.274
Other metal	0.198	0.242	0.266	0.243
Furniture and equipment	0.216	0.269	0.297	0.270
Other manufacturing	0.264	0.322	0.353	0.323
Electricity	13.396	13.480	13.516	13.478
Construction	0.506	0.555	0.580	0.555
Whole trade	0.013	0.053	0.073	0.053
Road transport	1.813	1.848	1.863	1.848
Air transport	0.142	0.152	0.157	0.152
Other transports	0.077	0.104	0.116	0.104
Finance and Insurance	0.024	0.112	0.169	0.114
Education and training	0.309	0.363	0.388	0.362
Health Services	0.364	0.428	0.458	0.428
Other services	0.196	0.261	0.291	0.260
Consumption Price Index	**0.411**	**0.473**	**0.504**	**0.473**

Source: Simulations from the model

4.1.2. Impact on the price of primary factors

With the target of minimizing production cost, producers adjust their usage of primary factors, thus affecting primary factors' prices. Primary factors include capital, land, and labour. In this study, the nominal wage is fully indexed to the consumer price index (CPI), thus it is as the same as the CPI. The real wage is assumed to be rigid, so its percentage change is set to be zero. In the short-run period, it is assumed that the producers' demand for capital and land are fixed, and their percentage changes are set to be zero.

Table 2: The effects of an ETS on prices of primary factors (percentage change)

Variables	**No revenue recycling**	**Lump sum transfer (12HH)**	**Lump sum transfer (per capita)**	**Increasing Government Payments**
Capital rental	-1.652	-1.594	-1.565	-1.594
Land rental	-0.963	-0.903	-0.875	-0.904
Nominal wage	0.411	0.473	0.504	0.473
Real wage	0	0	0	0
Aggregate primary factor price	**-0.562**	**-0.502**	**-0.472**	**-0.502**

Source: Simulations from the model

As seen in Table 2, in the no revenue recycling, the emissions price results in a reduction in the prices of capital and land of 1.652 percent and 0.963 percent, respectively. Meanwhile the nominal wage increases at 0.411 percent. The reduction in prices of capital and land rentals is explained by a contraction in the Australian economy because of increased prices of most goods and services as shown in Table 1. When the revenue is returned to household groups, the economy recovers mildly, thus leading to a slight increase in the prices of capital and land, but the percentage changes of capital and land rentals are still negative, which means that the recycling is not sufficient to offset the negative effects caused by the permit price. The decreased prices of capital and land in the lump-sum transfer per capita are smallest, while the changes in these prices in the cases of equal lump-sum transfer to 12 poorest household groups and of increasing Government payments are nearly the same. By contrast, a rise in nominal wages, reflecting the CPI is seen in all scenarios. Overall, aggregate primary factor price reduces in all scenarios

4.1.3 Impacts on other prices

In order to achieve the emission reduction of 11 percent, the permit price is estimated at $20.455 per tonne of CO2-e in the case of without compensation. The permit price increases slightly in the revenue recycling scenarios because of the higher demand for energy commodities that creates more emissions generated into atmosphere, thus leading to an increase in a permit price.

Table 3: The effects of an ETS on other prices (percentage change)

Variables	No revenue recycling	Lump sum transfer (12HH)	Lump sum transfer (per capita)	Increasing Government Payments
Permit price ($ per tonne)	20.455	20.471	20.476	20.47
GNI price index	0.369	0.425	0.453	0.425
GDP price index	0.399	0.458	0.487	0.458
Export prices	0.147	0.164	0.172	0.164
Import prices	0	0	0	0
Terms of trade	0.147	0.164	0.172	0.164

Source: Simulations from the model

The GDP price index and the GNI price index are estimated to increase at 0.399 percent and 0.369 percent, respectively in the no revenue recycling. As households receive the rebate, they increase their consumption, thus leading these indices continue to rise. In the lump-sum transfer per capita both indices raise at the highest percentage of 0.487 percent and 0.453 percent. These increases result in the highest increase in nominal GDP of 0.202 percent and the smallest decrease in real GDP of 0.283 percent, compared with the other compensation scenarios. With the closure assumption of fixed import prices, the terms of trade are reflected by the change in export prices. The permit price results in the highest increases in export price of 0.172 percent in the lump-sum transfer per capita.

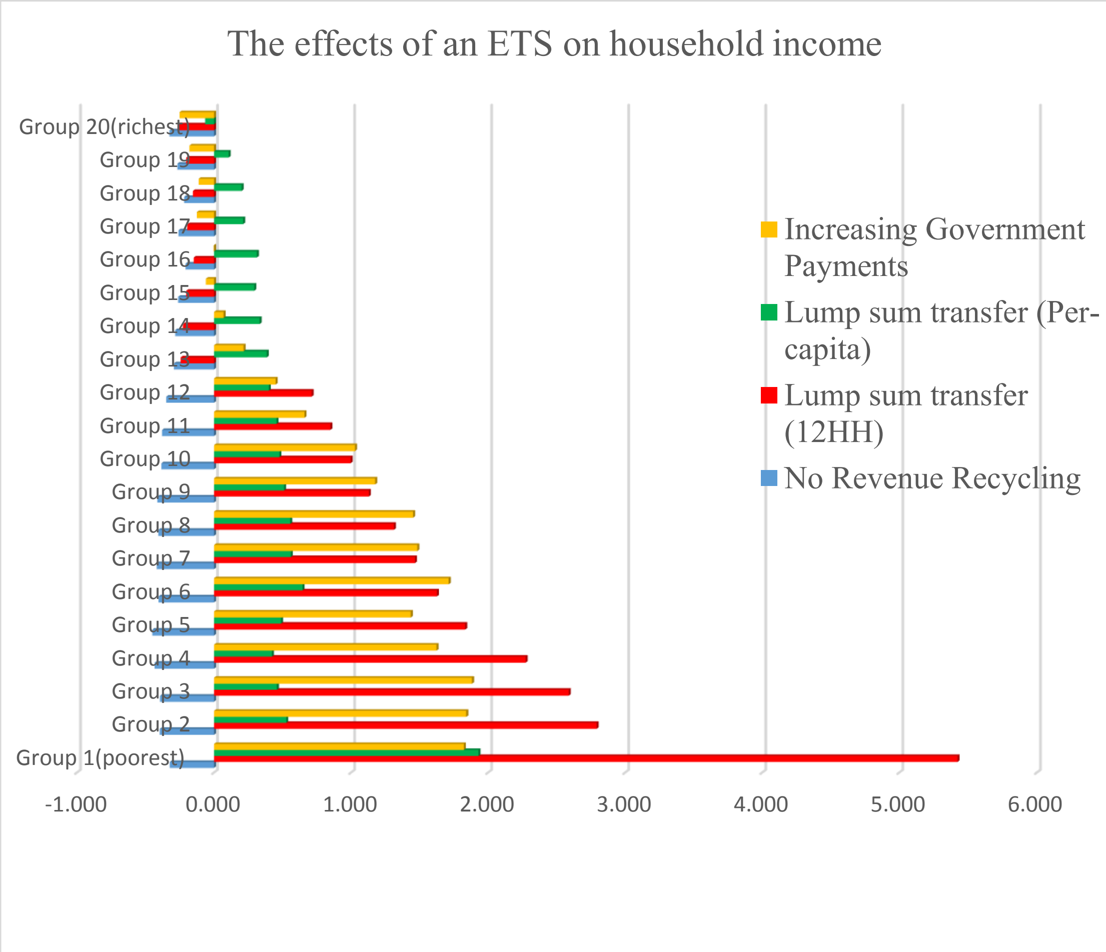
4.2. Impacts of an ETS on households

In this study, it is assumed that producers pass the full costs caused by the permit price to customers, therefore household groups would suffer from increased prices of goods and services. An increase in commodity prices may result in a reduction in household consumption. Moreover, a rise in the percentage of labour wages is smaller than the reduction in percentage of prices of capital and land rentals that produces a reduction of the income of all household groups. The following sections present more detail about the effects of ETS on the household income, expenditure and welfare in each scenario.

4.2.1. Impact of ETS on household income

Based on the Household Expenditure Survey, 2009-2010, the proportion of income sourced from labour, capital and land was 11 percent of the total income for the poorest household group and over 80 percent of the total income for the richest household group. The imposition of a permit price results in a decrease in capital and land rentals, and an increase in nominal wage in all scenarios that results in the income of all household groups change in various degrees.

Figure 1: The impacts of the ETS on income of household groups



Source: Simulations from the model

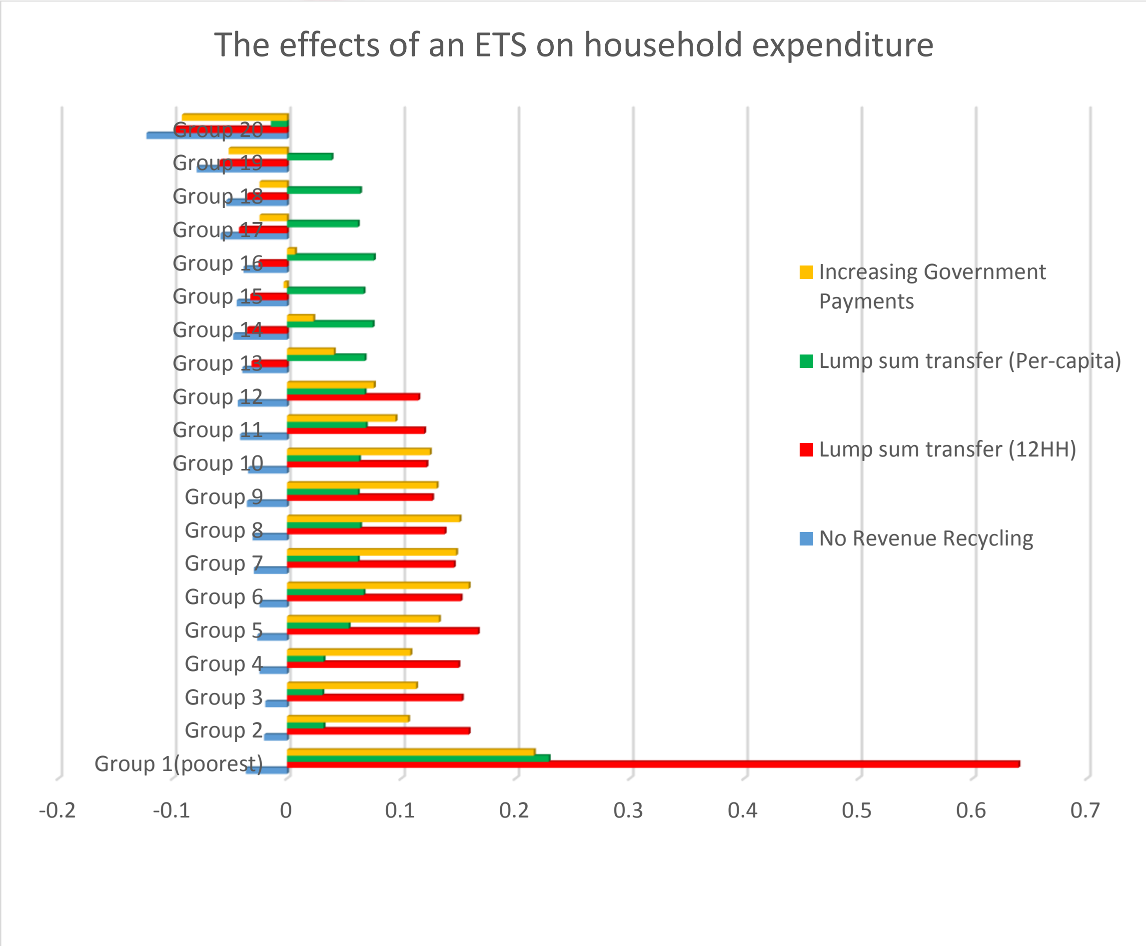
As seen in Figure 1, the income of all household groups is estimated to decline at varying degrees in the no revenue recycling. As the percentage change, the percentage reduction in income among household groups is not much different, but low income households experience a higher percentage reduction in income than rich households. As the dollar change, the wealthy household groups suffer a higher reduction than the poor groups, nearly $8 million for the latter and $200 million for the former. This income reduction across household groups is due to the decreases in the returns of capital and land, as expressed in Table 2.

When the permits revenue is returned the income of most household groups is improved. However, low income household groups receive more benefits than the rich household groups. When the revenue is returned to low and middle household groups, there are only 12 poor groups who receive a positive percentage change in their income, however when compared to an increase of Government payments 14 poor household groups experience a positive percentage change in their income. When the Government implements an equal lump-sum transfer per capita the lowest 19 groups show a positive change in their income. It means that the revenue is sufficient to offset the negative changes caused by the permit price to these household groups. For the rest of the household groups, the percentage changes in their income remain negative, but they are less than in the no compensation. The richest household group suffers an income reduction of 0.064 percent in the lump-sum transfer per capita, compared to 0.325 percent in the no revenue recycling. These reductions are explained by the smaller reductions in the returns of capital and land in the recycling scenarios, as shown in Table 2.

4.2.2. Impact of the ETS on household expenditure

Figure 2 shows the effects of an ETS on household expenditure in both with and without revenue recycling. It is clear that the permit price results in a reduction in expenditure of all household groups in a variety of degree in the no revenue recycling scenario. Rich household groups experience the higher reductions in both a dollar level and a percentage level than low household groups. As the percentage change, the poorest household group decrease by 0.036 percent, compared to 0.123 percent for the richest group. The decline in expenditure of all household groups is explained by the reduction in their income and the increased price of most goods and services.

Figure 2: Effects of the ETS on household expenditure (%)



Source: Simulation from the model

In order to mitigate these undesirable effects, the permit revenue is used to compensate to the vulnerable household groups. It is obvious that the lump-sum transfer per capita benefits equally all household groups, compared to other two revenue recycling. As the revenue is sufficient to offset the negative effects caused by the permit price to 19 out of 20 household groups, the richest household group still bears the negative change of 0.014 percent in expenditure, but it is a very small percentage compared to 0.098 percent in the lump-sum transfer to the 12 poorest groups and 0.092 percent in the increase of government payments. The revenue returned in the form of increasing government payment benefits to 15 out of 20 household groups, compared to 12 out of 20 household groups in the lump-sum transfer to 12 poorest groups. The sixteenth poorest household group in the increasing government payment improve their expenditure with a positive percentage change, this is due to the smallest percentage reduction compared with other rich household groups in the no compensation.

4.2.3. Impact of the ETS on the household welfare

The price on emissions permit induces the changes in the prices of goods and services, thus affecting the welfare of household groups. Equivalent variation (EV) is a monetary measure of welfare effect of the price change. EV measures the change in utility in terms of dollar value, in particular, the amount of money needed to achieve a new level of utility at the initial price level. The negative values of EV shows the welfare loss and the positive values represents welfare gain. As the results illustrated in Table 4, all household groups face welfare loss in varying degrees, in which the higher income household groups are estimated to have a greater welfare loss than the poorer income household groups, nearly \$197 million of the richest household group compared to nearly \$8 million of the poorest household group in the no revenue-recycling and the total welfare loss is \$548.41 million.

If the permit revenue is recycled to household groups in the form of the lump-sum transfer per capita 19 out of 20 household groups obtain the welfare gain, with only the richest household group suffering a welfare loss of \$23.08 million. The second, third and fourth poorest household groups derive the welfare gain of between \$ 4 million or \$5 million. This occurs because the average person in each household in these household groups is more or less than 1.1 persons, compared to 1.5 persons in the poorest household group and more than 3 persons in the four richest household groups. For the poorest group, they are not traditionally poor in the reality, because they are lost in their investment, they become the poorest household group. When the revenue is returned to households based on per-capita, due to the higher membership of people in the household they receive an increased rebate. Therefore, the rebate creates more welfare gain to the poorest household group than other poor groups.

If the permit revenue is compensated to low and middle income household groups 12 out or 20 groups obtain welfare gain, while 15 out of 20 household groups experience welfare gain with an increase in Government payments. Richest household groups still face welfare loss, except the fifth richest household group in the case of increasing government payment, they derive welfare gain. Overall, in all recycling scenarios, the Australian economy generally experience welfare gain

Table 4: The effects of an ETS on household welfare

Groups	No Revenue Recycling	Lump sum transfer (12HH)	Lump sum transfer (Per-capita)	Increasing Government Payments
Group 1(poorest)	-7.87	140.41	50.28	47.50
Group 2	-3.27	26.25	5.29	17.45
Group 3	-2.72	22.15	4.42	16.27
Group 4	-3.62	23.06	4.85	16.66
Group 5	-5.44	34.94	11.22	27.92
Group 6	-5.20	32.91	14.54	34.51
Group 7	-6.69	33.68	14.30	34.04
Group 8	-7.48	34.89	16.30	38.31
Group 9	-8.81	31.50	15.38	32.68
Group 10	-9.97	35.20	18.25	36.23
Group 11	-13.84	40.69	23.30	32.30
Group 12	-16.51	44.25	26.43	29.18
Group 13	-16.58	-13.17	29.23	17.79
Group 14	-25.06	-18.99	40.29	12.44
Group 15	-25.11	-18.29	38.02	-1.98
Group 16	-24.44	-16.04	48.99	4.49
Group 17	-44.20	-31.80	47.21	-18.13
Group 18	-45.47	-30.29	54.89	-20.20
Group 19	-79.45	-59.18	39.45	-51.66
Group 20(richest)	-196.69	-156.79	-23.08	-147.60
TOTAL	**-548.41**	**155.38**	**479.56**	**158.21**

Source: Simulation from the model

5. Conclusion

In order to achieve the Kyoto target of 5% below 2000 levels by the year 2020, this paper examines the effects of emission reduction of 11% in the baseline through the Emission Trading Scheme between industries generated carbon emissions into the atmosphere. The price is estimated at over $20 per tonne of CO2-e. The application of an emissions price results in an increase of over 13 percent in the price of electricity, with a decrease in the price of brown coal of over 30 percent. This emissions price is also estimated to reduce income, expenditure, and welfare across household groups. All permits are auctioned that generate an amount of permit revenue to the government. The permit revenue is used to compensate households in order to mitigate the undesirable effects caused by the emissions price.

This paper analyzes the effects of three scenarios of the revenue recycling on prices and on Australian households. The results show that the revenue recycling in the form of an equal lump-sum transfer per capita would create a higher consumer price increases, but create a smaller price decrease of capital and land rentals. This scenario also creates an increase in household expenditure and household income of most household groups, except the richest income group. In this scenario, 19 out of 20 household groups experience welfare gain, compared to other two scenarios. However, for low income household groups, the level of increasing their income, expenditure, as well as welfare in the form of lump-sum transfer per capita are smaller than those in other two scenarios. The highest increased level is achieved in the lump-sum transfer to 12 poor household groups.

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Disaster Adaptation by Community for City Sustainability. Case Study : "Poor vs Rich Settlements"

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Abstract
The presence of events caused by climate changing hit communities in Asia such as declining agricultural production and sea level rise at coastal area(Peng et al, 2004 in IPCC The Third Assessment Report). This phenomenon occurs at Jakarta's coastal area that is manifested in damaging 5 year-flood. This study aims to look the process how two different types and strata of neighbouring communities deal with flood. It happened in coastal communities at Muara Baru which is slum area and Kawasan Pluit which is dominated elite housing. As one developed coastal ecosystem, limitation access to integrated management of flooding becomes problem. Community's adaptation strategies are emerged to find out as an integrative solution to build resilience. Collective ability (in this case at coastal area) could as the potential strengths for community to keep away their activity and area residential from disasters (Dynes, 2002). This study uses qualitative methods that are explorative and comparative between sites through in-depth interviews and observations. The results obtained different adaptation strategies from two types neighbouring communities although they live at the same ecosystem. It identify by 3 factors consists: perceptions, ways of life and adaptation behaviours based on disaster cycle (pre, during, after). Therefore, the recommendation stated that the implementation of flood management can not be made uniform, it must adjust with local community's character.

Keywords: disaster management, adaptation, climate change,disaster, social class, community

Introduction

In most developing world like Asia, cities are facing increased risk of disasters with potential of economic and human losses from hazards as an impact of gaining development welfare. Hazards could threaten city development and sustainability by its disaster. Nowadays hazards are potentialy harm peoples become disaster because multiple factors such as vulnerbality and capability. It depends on how vulnerable and capable the city could coping the hazard, so it will reduce the impact of disaster.
Climate hazard become hot topic to describe the impact of climate change. Many cities througout South East Asia are potentially risk on climate hazards. Below is the visualization of Asia through the climate hazard map :

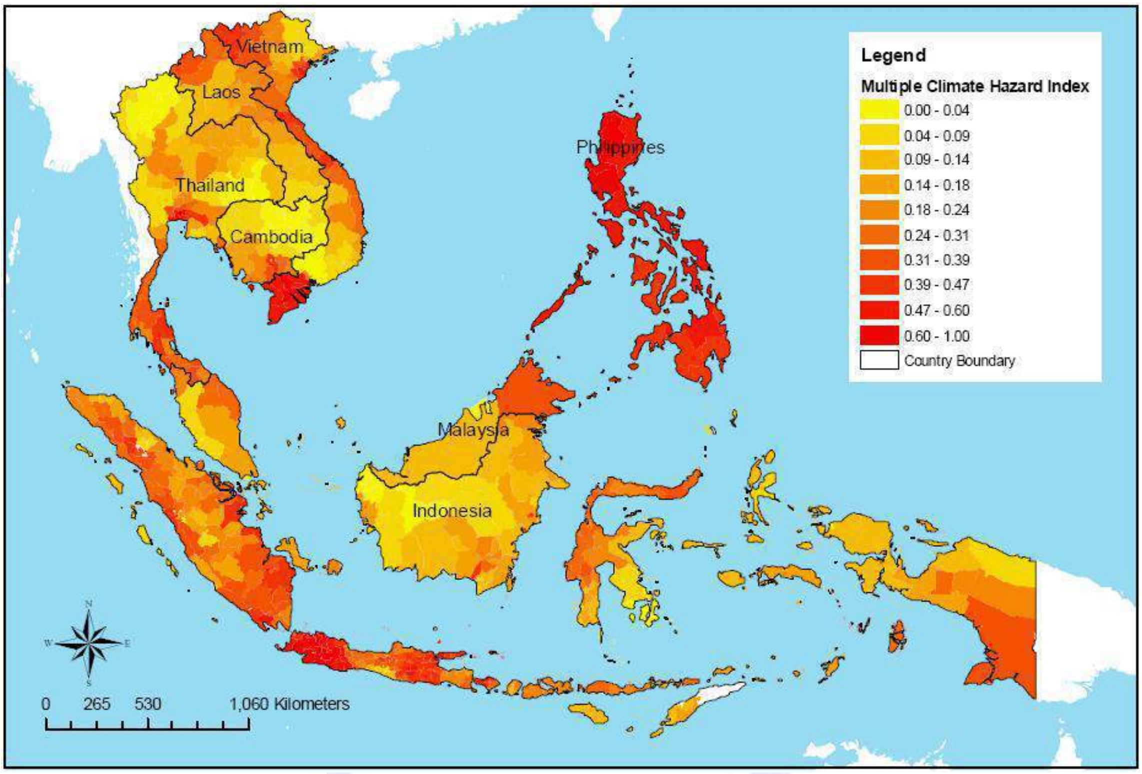

Figure 1: Climate Change Vulnerability Mapping in Southeast Asia

One of the impacts of climate hazard is flood disaster. Many Asia's city deal with this kind disaster because of the physical environment condition and quite dense population.

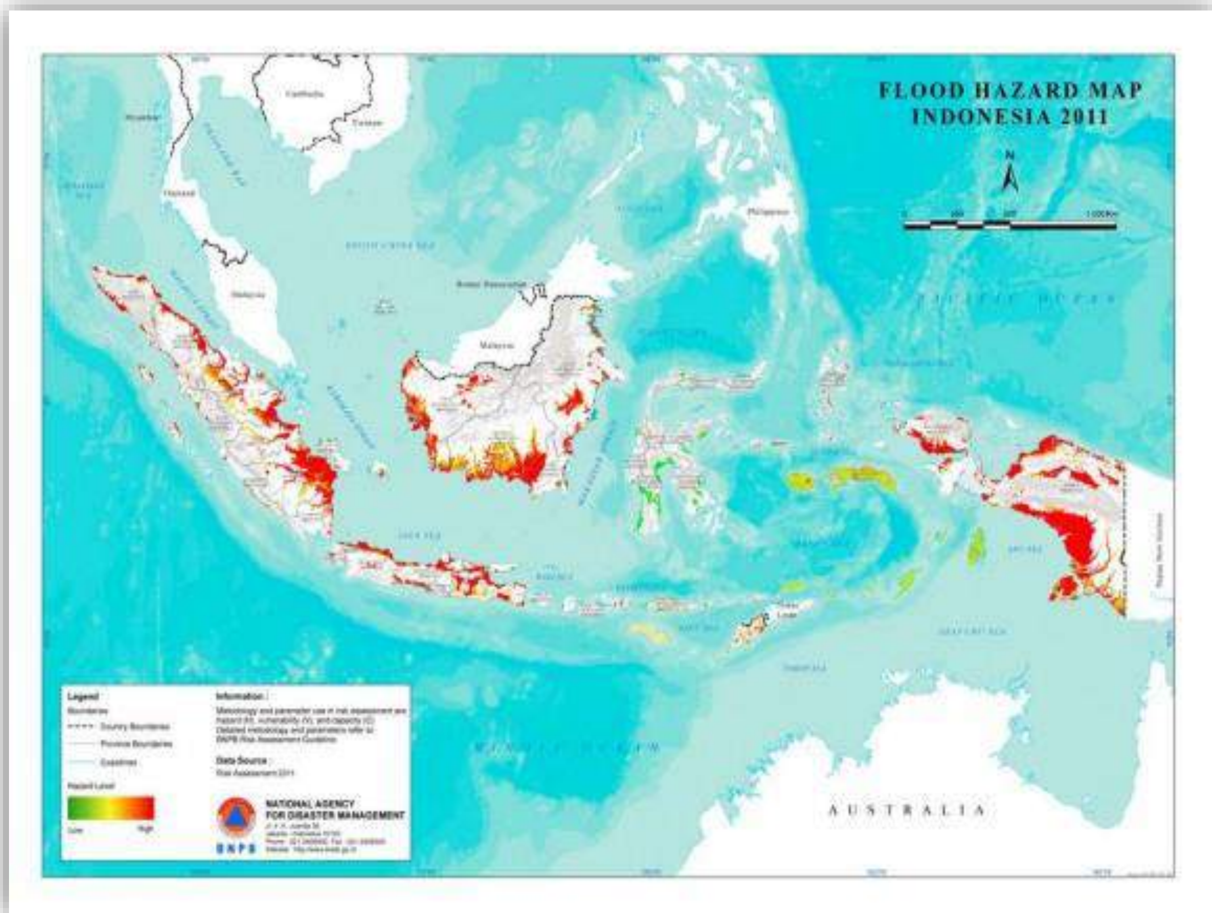

Figure 2 : Flood Hazard Map Indonesia 2011

Indonesia itself is the highest risk prone area at South East Asia. This country consist of more than 17.000 islands at the tropical area. Indonesia has special identity according to the location geologically and demographically as risk –prone area . It may be responsibility from all stakeholder in urban area to realize and “do” something for coping it.The most hazard could threaten is flood.

In the other hand, Indonesia is a huge country with more 8 megacities surround. Moreover, rapid population makes rapid activity at limitation space. It will increase the potential of conflict within natural or social resources and Indonesia faces this phenomenon. While density as social vulnerable meet the physical vulnerable, it become more risky this country having magnificeient disaster.

North Jakarta, Its Surrounding and Hazard

Jakarta is one example for disaster-prone cities in developing countries. According to mapping studied held by National Disaster Management Agency of Indonesia or usually called with BNPB (2012), Jakarta potentially hit by 10 types of disaster which are flood, extreme weather, high tide and abrasion, landslide, earthquake, tsunami, epidemic outbreaks of disease, building and settlement fires, social conflict and technology failure. The most frequent incident happen in Jakarta is flood, conflict social and building and settlement fires. For Instance Jakarta with Jabodetabek is the

6th rank densest of urban agglomeration in the world with 22 million population live at 1000 square miles (Demographia-World Urban Areas, 2011)

Meanwhile, North Jakarta faces an environmental problem, such as in 2009 flooding occurred in the northern coast of Jakarta derived from sea water or flooding of the river estuary abundant in Muara Baru, Penjaringan village and in the region Marunda, Cilincing Village as high as 50 s / d 150 cm. (www.kompas.com). This region experienced floods that have an impact on everyday activities paralysis for several months. Based on the interviews have been conducted with several leaders in the region, these events are often repeated during the tides and heavy rains in upstream areas. Although it has happened repeatedly, but still cause great material losses. Therefore, the incident is classified as a coastal disaster by the local government.

The other things that have serious problem at North Jakarta is the social segregation. It could bes seen at Penjaringan. The neighbourhood is extreme beetwen the elite housing and the slum area only separated by a high wall or common resources like dam. In general, the elite housing consist of rich people also Chinese as majority ethnic there and slum area consist of poor and local etnic communities.The extreme diffrences could trigger a horizontal conflict beetwen them.

This social potential problem will be tapered due to environment degradation and floods. It’s not surprise, considering Jakarta as dense populated city in low land of rivers delta. Through the activities of reclamation and the construction of elite residential -besaran along with construction of the plant - the plant in the port resulted in a decrease in environmental conditions such as widespread flooding, loss of mangrove habitat and deprivation of rights - social rights such as the loss of the existence of a public beach (WALHI in SEA Seminar in Jakarta, 2008).

Despite the complexity of these issues, but people still choose to stay and activities in the region that is "difficult" due to the floods and their impact. Adverse flooding and is seen as a barrier to the move by many people in general, but it is understood differently by communities living on the coast. Purport to be important to explore to find out why they have remained in the disaster prone region.

Type of collective action in the form of adaptation also seen in Penjaringan, North Jakarta. The strategy used from residents in each community varied but not coordinated with one another. This region consists of a variety of community based on economy class residential dwelling identified from either the well-planned luxury residential, as well as traditional irregular settlements with the term "kampung".

Muara Baru and Pluit in Penjaringan are mutually neighboring region ever flooded. Muara Baru included in the high category in the coastal vulnerability index issued by the Ministry of Marine Fisheries. Based on the results of interviews to kelurahan office (Fitrinitia and Bayu, 2010) states that the Muara Baru is RW worst affected by the floods and floods when the overflow reservoir. Almost every year there is a major flood as high as 50 -100 cm and the time post at a particular location will experience a puddle for 2-3 months (Sentosa, 2009). While it is still from the same source, to the Pantai Mutiara is located in Pluit also been flooding due to levee 2006 -2007. However, for the past few years till now not been a big flood. Only in some areas near the shoreline were flooded when the tide.

It is a very unique conditions, whether two difference types of communities living together neighborhood deals with flood, but most of them have minim effort to move away their settlements to other part of cities. It lead us to have big question "Why they still love their setllements area whereas the flood hit them every year and have big potential of social segregation"? Based on that question, we could draw how they adapt about that condition,-the condition that in risk prone zone?

Methodology

However, also based on BNPB's studies, disaster risk reduction initiated by local government not yet run optimally particularly on vulnerable groups of the poor. Even, Fitrinitia (2011) stated that Jakarta government mechanism for disaster management still as top down process and has not put forward the abilities of community that is already owned by them although with limited access.

This study used a qualitative approach in synergy with the method of collection, processing and data analysis is qualitative. It aims to demonstrate the community's response to the flooding. After that just knowing their adaptive measures in order to survive. So that these things into consideration most appropriate to use a qualitative approach.

By using a qualitative approach as well, researchers can obtain other symptoms that may arise at the time of data collection, data processing and data analysis considering the introduction of research on the character of a society is quite extensive, so it is not hindered by the limitations of the movement of researchers.

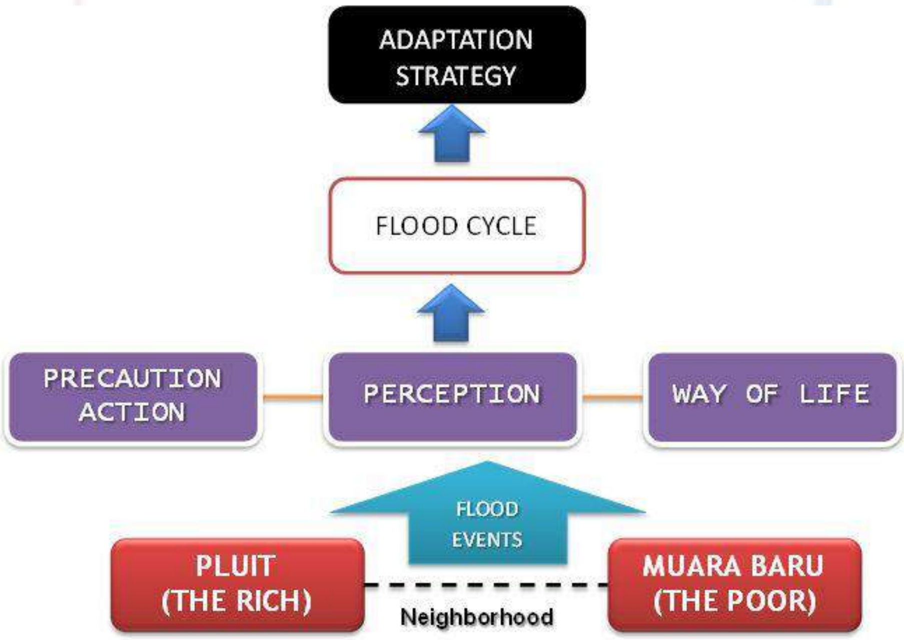

Figure 3 : Research Mindset

There are 17 respondents which are representative from Muara Baru-the Slum and Kawasan Pluit-the elite housing.

Findings – The Situation and Floods between Pluit and Muara Baru

Muara Baru and Pluit community area indeed never experienced flooding. It is still common until 2011 in Muara Baru, while in Pluit area for the 2002 flood and tidal flood in 2008. But in both communities still felt alive under threat of flooding taking into account the physical conditions of the region continues to decline quality. It is the cause of the continuous undermining the sustainability of life experienced by residents in the coastal border. The threat of environmental degradation in the end does not recognize the economic and social strata, as well as with the case. Both of these communities is the description of "risk society" as a result of environmental stresses such terminology presented by Beck, 1992. In this case the actual likelihood of exposure due to flood conditions at comparable or lower-middle between the community and the luxury communities.

Figure 4 : People live in Muara Baru

The difference is the impact felt by citizens. Muara Baru feel the impact interfere with the activity of work, reducing the revenue to health while the impact is felt in Pluit the extent of the disruption of activities and distrust of insurance against residence. When returned to the sociological terminology, the impact of flooding that occurred in these two communities can have a massive social implications both material and immaterial.

Figure 5 : People live in Pluit

The size of this effect is influenced by the capacity to overcome the ability of prevention is done by the citizens. This is the criticism of thought Beck delivered by Mythen, 2004 that the economic and social class remains into consideration when talking about the capacity of the prevention of environmental damage. This looks like in Pluit community with all its financial capabilities, they can fill the vacuum environment and disaster management that should be filled by the local government. This community is quite optimal answer to the problems of environmental solutions.
Things look different in Muara Baru community, with prevention capabilities materially limited, they rely on the efforts of disaster management to the government. But the process was not optimal so that is done by people in this community are only reducing the impact of flooding to adapt to those things that happens like a flood.

Findings- Perceptions, Ways of Life and Adaptation behaviours

As has been stated in the literature, that action can be manifested as a result of the perception that emerged in response to external stimuli. Continuation of the perception that this is a form of resistance to stimulate the emergence of adaptation actions undertaken by each of -masing community.

Differentiation is visible when Muara Baru community compared to Pluit area mainly of physical infrastructure such as luxury homes and permanent while in Muara Baru with a semi-permanent occupancy even tend rundown. However, this differentiation does not mean anything -what when these two areas under threat of disaster (flooding) due to the location of its location on the coast.

The district stated that the limitations of this region does not become a hindrance to increasing population in each - each community. Motivating factor to stay in this area is stronger than fears of a flood-prone.The response of the flood together with the community in Muara Baru, eventually got used even though in the beginning feel troubled. The process of adaptation to the environment given what happened in this community. When in the beginning was worried then interrupted, after already handled well they perform usual activities especially when it has no flood again.

Therefore, from the perception of these two communities when portrayed in the range, then the following is the description of a range of adaptation experienced by the community:

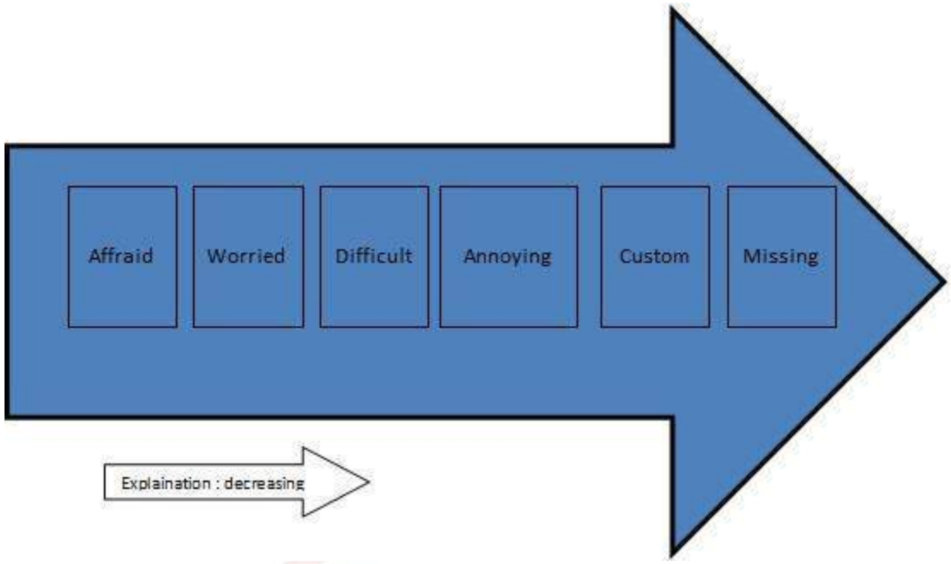

Figure 6 : Adaptation gradation range by Community

Based on the picture can be seen the process of adaptation to erode the fear community accustomed to the extent that there are two communities. This process does not look at the economic and social strata. Even an informant expressed his desire to be the flood after so long they do not feel the floods.

Findings- Way of Living

Seeing the quality of life it can be identified by way of daily community life. In this study will try to see through livelihood, the fulfillment of daily needs and habits - kebiasaan done collectively.

It will be seen the difference of the way of life in these two communities are still Society and patembayan which are characteristic community still familial / traditional and modern industrialized community governed by a formal reference. This characteristic difference is marked by interaction with the citizens and the environment.

Findings- Adaptation Activity

Resilience according to Pelling, 2003 is the ability of people to take action adaptation of the suppression of the threat of catastrophic events in this case is flooding. Conditions how people can face the floods but can perform everyday life is an act that reduces the impact of the flooding.

In the section that describes the response of citizens against floods both in the community and Pluit Muara Baru think they are friends and no longer be a problem that has worried the flood. The assumption is of course accompanied by actions that they think this is enough to manage the impact of flooding. This action appears at the initiative of citizens in each - each community is not based on the direction of the government for performing actions harm reduction. The results of the manifestation of perception and way of life also affects the actions taken at the time of the action (resilience) in flood management

Conclusion

Potential disaster for the poor and the rich are relatively the same, but the adaptation process is slightly different depending on the economic and cultural strata layer. The difference in the level of needs of each community to its environment. The difference is obvious when the need for a clean environment, healthy, comfortable, safe from the threat of disaster appeared in the community with economic and social strata above. As for the community's economic and social strata below have not felt as a necessity for a good environment. They have not felt good environmental conditions will also provide feedback to the health, quality of life and lack of hazards. As an initial hypothesis, one of the influential factors are the factors that determine the level of education that need. Through education will get a further understanding of the feedback to the human environment should work in harmony.

Disaster adaptation strategies is also a picture of a reciprocal relationship between humans and the surrounding environment. It is obtained in order to get the point of balance between man and his environment. Once the objective has given environmental -keuntungan advantage for the community living in it, then more and more people will depend on that. When the greater reliance primarily for gain, the greater the human behaviors that are destructive to nature. At the time the environment was no longer provide benefits but trouble for the community in it, then there is kompromisitas community to the surrounding environment. This is affecting the reasons to perform management actions that are tapping -These actions against environmental threats. If not maintained, then there human relationship with nature deadlocked on two sides.

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The Impact of Agglomeration Economies on Energy Efficiency in Japan

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Abstract
With environmental constraints being strengthened worldwide, an important question that arises for Japan's economic policy is how best to achieve regional economic growth along with energy efficiency. This study examines the impacts of agglomeration economies, which boost economic growth, on the energy efficiency of Japanese manufacturing industries. Using a prefectural-level panel dataset from the Energy Consumption Statistics by Prefecture, this study obtains new empirical results: (1) agglomeration economies improve the energy efficiency of Japanese manufacturing industries; (2) localization economies positively impact the improvement of energy efficiency in rural areas, while urbanization economies positively impact the improvement of energy efficiency in large metropolitan areas. Thus, it is determined that agglomerating similar industries is effective in improving energy efficiency in rural areas; however, in large metropolitan areas, it is more effective to agglomerate diverse industries in order to improve energy efficiency. In general, industrial agglomeration as a result of economies of agglomeration, based on localization, occurs for the most part in medium-sized cities. The finding therefore suggests that it is more appropriate to formulate strategy in terms of medium-sized cities than large metropolitan cities in improving the energy efficiency of manufacturing industries located in rural areas.

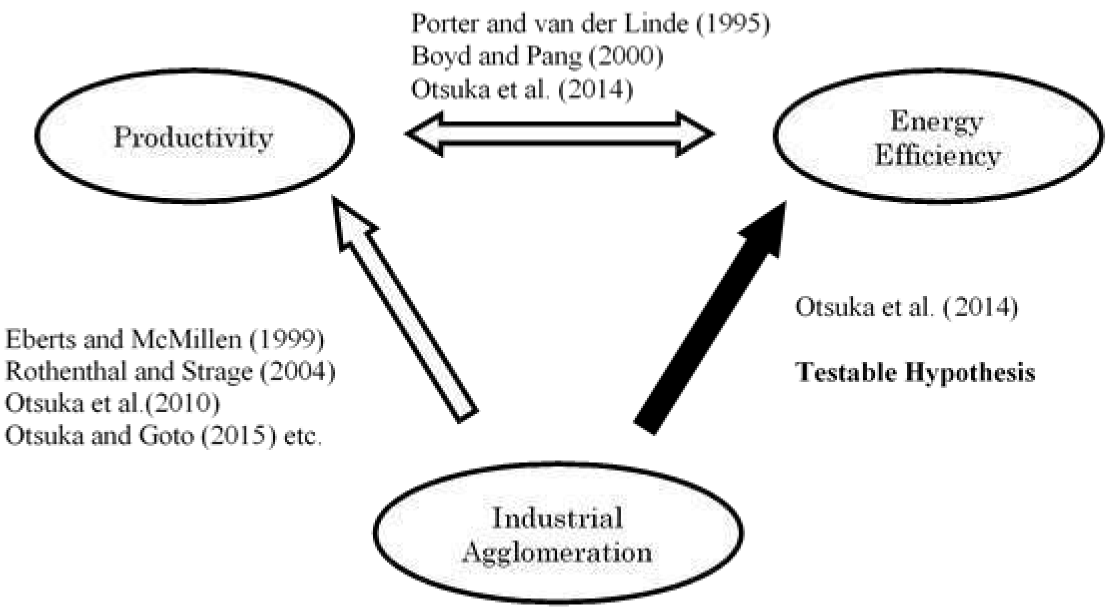
Keywords: Energy Efficiency, Agglomeration Economies, Regional Science

Introduction

One of the most important issues in Japan, as a country confronting environmental constraints, is to find a way to reduce CO2 emissions by improving energy efficiency while improving economic growth at the same time. Following the two energy crises in the 1970s, manufacturers within the industrial sector, which represents the major share of energy consumption within our country, have worked to improve energy conservation due to stringent environmental regulations. Manufacturing industry is an important sector in Japan and has the continuing ability to improve regional economies. However, in recent years, due to the globalization of the economy and the influence of policy factors such as environmental regulations, Japan's ability to compete internationally has been impaired. This has resulted in a significant reduction in the strength of Japanese manufacturing industry, with a consequent negative impact on regional economic growth. Therefore, in order to promote regional economic growth under the environmental constraints of reducing CO2 emissions, it has become necessary to improve productivity whilst still achieving energy conservation. In other words, it is important to balance the issues of improving energy efficiency and increasing productivity within the manufacturing sector. Examining these issues is crucial not only for improving the developmental policies of regional economies, but also for improving energy and environmental policies.

It is well known that industrial agglomeration plays an important role in improving industrial productivity. The benefits associated with economies of agglomeration have been discussed for over a century (Marshall, 1890). In achieving agglomeration economies, specific cost savings and productivity gains can be obtained by concentrating industries spatially. These effects can be categorized as localization economies and urbanization economies (McCann, 2001). The former are the economic benefits earned from clustering similar industries and having them work together; the latter refers to the economic benefits derived from clustering and agglomerating different industries together. Agglomeration economies enhance industry productivity and serve an important role in strengthening competitive advantages worldwide, as seen in many studies (Eberts and McMillen, 1999; Rothenthal and Strange, 2004). Furthermore, it has recently been observed that an agglomerated economy displays not only significantly improved productive efficiency, but also greatly improved total factor productivity (Otsuka et al., 2010; Otsuka and Goto, 2015). However, although it has been determined that these agglomeration economies have been a factor in improving industry productivity, there has been no mention in past studies that they may also have been a significant factor in improving energy efficiency.

In order to maintain a competitive advantage worldwide, it is expected that industries that have strict environmental regulations imposed on them (such as CO2 emission reductions) will invest significantly more in research and development to increase productivity. When industries are spatially agglomerated, it makes it easier for a specific company that has developed technological knowledge to share and transfer information with other companies through face-to-face communication and the inter-organizational transfer of worker knowledge. In other words, agglomeration plays a huge role in improving the interconnectivity and synergy of an industry as a whole by creating both informal and formal mechanisms for transferring technological knowledge (Fujita and Thisse, 2002). From another perspective, innovations that arise under environmental constraints are known to be associated with the development of energy-efficient production systems. Porter and van der Linde (1995) state that efforts to improve the productivity of the entire manufacturing process to meet environmental regulations have resulted in significant reductions in energy use as well as huge improvements in productivity (the "Porter Hypothesis"). Meanwhile, Boyd and Pang (2000) and Otsuka et al. (2014) make it clear that improving productivity has a direct influence in improving energy efficiency. In other words, they claim that energy efficiency plays a role as an indicator of improved productivity. Based on these studies, it is expected that improvements in productivity achieved under environmental constraints through economies of agglomeration have a direct connection with improvements in energy efficiency (see Figure 1). In fact, it has recently been noted that urban agglomeration has had an effect on increasing energy efficiency in both the residential and the transportation sectors (Newman and Kenworthy, 1989; Bento and Cropper, 2005; Brownstine and Golob, 2009; Karathodorou et al., 2010; Su, 2011, etc.). Within the industrial sector, which accounts for a large proportion of our nation's energy consumption, there are manufacturing industries that act to pull economic growth forward at the rural level. However, few studies have looked at how these industries might influence energy efficiency were they to be clustered together. One of the exceptions in this respect is Otsuka et al. (2014), which indicated that agglomeration economies affect the energy intensity levels of the industrial sector. In order to evaluate energy efficiency properly and implement future environmental policy, it is vital to explain this effect in detail. As a continuation of Otsuka et al. (2014), this study therefore aims to clarify whether agglomeration economies in the manufacturing industry have a direct effect on energy efficiency.



Source: Otsuka et al. (2014)

Figure 1. Testable Hypothesis

Next, Section 2 discusses the determinants of energy intensity, which is treated as a proxy for energy efficiency. The data used in the analysis are explained in Section 3. Section 4 provides the results of the analysis; finally, Section 5 presents the conclusions and policy suggestions.

Determinants of Energy Intensity

Energy intensity, defined as the ratio of production output and energy consumption, is often used as a standard index to indicate energy efficiency when analyzing energy policies. This index is also used in the International Energy Association's report on the energy policies of G8 countries (IEA, 2009). This study will therefore use energy intensity as a proxy index to measure energy efficiency (*ENERGY*) as defined by the IEA.

Table 1. Energy intensity in manufacturing, GJ/million yen

	Y 2008	Change from 1990 (%)		Y 2008	Change from 1990 (%)
1 Hokkaido	77.84	-18.00	25 Shiga	19.17	-32.06
2 Aomori	57.37	-54.26	26 Kyoto	9.86	-48.58
3 Iwate	30.70	-40.07	27 Osaka	27.25	-32.50
4 Miyagi	40.04	10.51	28 Hyogo	57.01	-25.94
5 Akita	27.03	-23.91	29 Nara	17.47	15.39
6 Yamagata	12.56	-38.27	30 Wakayama	70.14	-57.62
7 Fukushima	18.71	-46.30	31 Tottori	35.84	9.55
8 Ibaraki	68.32	-28.72	32 Shimane	28.27	-34.35
9 Tochigi	17.15	-28.63	33 Okayama	177.06	-34.69
10 Gunma	17.86	-21.82	34 Hiroshima	73.83	-36.29
11 Saitama	16.49	-31.82	35 Yamaguchi	138.66	-26.10
12 Chiba	169.34	-31.52	36 Tokushima	31.90	-47.22
13 Tokyo	3.92	-60.54	37 Kagawa	51.81	-32.57
14 Kanagawa	63.25	15.42	38 Ehime	86.73	-2.32
15 Niigata	36.42	-32.38	39 Kochi	86.16	-5.54
16 Toyama	31.68	-35.91	40 Fukuoka	58.23	-41.66
17 Ishikawa	12.61	-31.11	41 Saga	17.05	-30.38
18 Fukui	26.19	-31.12	42 Nagasaki	14.03	-26.25
19 Yamanashi	12.00	-18.81	43 Kumamoto	23.21	-30.06
20 Nagano	12.54	-35.81	44 Oita	187.69	-49.73
21 Gifu	22.33	-28.44	45 Miyazaki	35.46	-61.00
22 Shizuoka	17.88	-46.62	46 Kagoshima	22.11	-39.50
23 Aichi	27.10	-29.39	47 Okinawa	61.19	-20.87
24 Mie	68.20	-51.91	Mean	47.18	-34.47

Table 1 shows the energy intensity statistics of the manufacturing sector in 47 prefectures in Japan. Tokyo, with the highest population concentration, shows the lowest value of 3.92 GJ/million yen. Energy intensity is also low in other prefectures with relatively high population densities, such as Kyoto. On the other hand, energy intensity is high in regions like Chiba, Oita, Okayama, and Yamaguchi prefectures, where petrochemical complexes are found. This may be because energy-intensive industries are located in these areas. When comparing energy intensity figures for 1990 and 2008, it is clear that energy intensity statistics are improving nationwide. It is assumed that this is a result of an increase in manufacturers' capital investments to improve energy efficiency amidst the heightened need for environmental control and management.

The focus of this research is to reexamine the relationship between energy intensity and agglomeration economies. This study will use location quotient (*LQ*) as an index to demonstrate localization economies. The location quotient for industry *i* in location *j* will be defined as follows, with *Y* as the amount of production:

$$LQ_{ij} = \frac{Y_{ij} / \sum_{i} Y_{ij}}{\sum_{j} Y_{ij} / \sum_{i} \sum_{j} Y_{ij}}$$

The numerator is the production share of industry *i* in region *j*. The denominator shows the production share of industry *i* nationwide. Therefore, if the measurement exceeds 1, then that region has a high production share of industry *i* when compared with other regions in the nation. When the number surpasses 1, that particular industry is characterized as a core industry, indicating that it is concentrated in a specific area.

This study will use population density (*DENS*) as a proxy index to demonstrate urbanization economies. The driving force behind urbanization economies is the diversity of industrial structures (Fujita and Thisse, 2002). “Density” is used as an index based on the assumption that diverse industries will be agglomerated in high-density areas (Ciccone and Hall, 1996). In measuring population density, the denominator is calculated as the residential area with lakes, forests, and fields deducted from the total area. Population density is known to increase energy consumption efficiency in the residential and transportation sectors. However, the type of impact that population density has on energy efficiency in the industrial sector has not yet been revealed.

This study will add several socioeconomic variables to explain differences in energy intensity in agglomeration economies. The selection of socioeconomic variables (with the exception of agglomeration economies) is based on the variables used in studies by Otsuka et al. (2014). First, the capital-labor ratio (*KL*) is incorporated. This will help in considering how much capital concentration or density affects differences in energy intensity. Second, this study will consider the implicit impact of the vintage of capital stock. Low replacement investments in capital stock may lead to the possibility of low energy efficiency in that local industry. On the other hand, a local industry with high replacement investment in capital stock has an increased probability of its being replaced with more energy-efficient capital stock, resulting in higher energy efficiencies. In order to measure this vintage effect, this paper will consider the investment rate of capital stock per year (*IK*).

The study will also incorporate climate data, in order to consider the influence of climatic changes on production activities. Heating degree days (*HEAT* and cooling degree days (*COOL*) will be specifically considered. Since the population tends to concentrate in areas where the climatic conditions are pleasant, the above indices will be considered to control for and measure the impact of climate. Previous studies have indicated that these indices influence energy consumption. Finally, the time trend (*TREND*) variable will also be considered to explain annual changes in energy efficiency over time.

Data

This study analyzes manufacturers in the following industry sectors across 47 prefectures in Japan; 1) Chemical, Chemical Textile, Pulp, and Paper; 2) Iron and Steel, Non-ferrous metal, Cement, and Ceramics; and 3) Machinery. The final energy consumption share for the Chemical, Chemical Textile, Pulp, and Paper industries in the manufacturing sector is 42%, followed by 34% for the Iron and Steel, Non-ferrous metal, Cement, and Ceramics industries. Both of these industrial sectors are extremely energy intensive. On the other hand, the final energy consumption share of the Machinery sector is as low as 3%. Due to availability of data, the period for analysis is from 1990 to 2008. The data analyzed are from the annual panel data of each prefecture.

The final energy consumption data for the industry sectors used in this paper are from the "Energy consumption statistics by prefecture" produced by the Ministry of Economy, Trade, and Industry (METI). Data regarding the amount of production, the denominator used to calculate energy intensity, are based on actual production values according to economic activity as indicated in the "Annual Report on Prefectural Accounts" issued by the Japanese Cabinet Office. The rest of the socioeconomic data are mainly derived from the Central Research Institute of the Electric Power Industry (CRIEPI) regional database. Data on heating degree days and cooling degree days are calculated from national meteorological agency data[1]. Since climate data are obtained from meteorological centers located in each city, prefectural climate data is the mean of city data.

Tables 2 demonstrate the descriptive statistics of the variables. When observing energy intensity, manufacturers in total averaged 62.082 GJ/million yen based on all samples; 247.146 GJ/million yen for Chemical, Chemical Textile, Pulp, and Paper; and 166.037 GJ/million yen for Iron and Steel, Non-ferrous Metal, Cements, and Ceramics. Both figures far exceed that of the entire manufacturing sector and are low in terms of energy efficiency. On the other hand, Machinery shows a low figure of 5.320 GJ/million yen, proving to be high in energy efficiency. When examining the changes over time, it is clear that the manufacturing sector has seen significant improvements in energy efficiency between 1990 and 2008, with a reduction of –34% over this period. During the observation period, Iron and Steel, Non-ferrous Metal, Cements, and Ceramics also showed an improvement in energy efficiency. In contrast, the energy efficiency level of the Chemical, Chemical Textile, Pulp, and Paper sector is clearly getting worse, with the energy efficiency figure increasing by 25% when comparing the statistical data of 1990 and 2008.

Looking at the variables that represent agglomerated economies, the location quotient is on average 1.029 in the manufacturing sector; this is greater than 1, which indicates that many regions in Japan specialize in manufacturing. Furthermore, from 1990 to 2008 the location quotient has increased, implying an increase in agglomeration among similar trades and industries. In all three industrial sectors considered, the mean of the location quotient of all samples exceeds 1. This figure has increased each

[1] The number of heating degree days in one year is the cumulative difference between 14°C and the average temperature on each of the days in one year in which the average temperature drops below 14°C. The number of cooling degree days in one year is the cumulative difference between 22°C and the average temperature on each of the days in one year in which the average temperature goes above 24°C.

year. Population density, like the location quotient, seems to have increased slightly as well. In 1990, population density was 1336 persons/km^2 and in 2008, it increased to 1363 persons/km^2. At the same time, the agglomeration of diverse industries seems to have strengthened. Based on the above points, it is assumed that industrial agglomeration increased during the observation period.

Table 2. Descriptive statistics

		ENERGY (GJ per million yen)				LQ				DENS (people per area)
		Manufacturing	Chemical, Chemial textile, Pulp & Paper	Iron & Steel, Non-ferrous metal, Cement & Ceramics	Machinery	Manufacturing	Chemical, Chemial textile, Pulp & Paper	Iron & Steel, Non-ferrous metal, Cement & Ceramics	Machinery	
1990	Average	72.001	225.484	188.766	8.557	0.984	0.986	1.044	0.900	1335.625
	Standard deviation	73.514	297.848	196.368	9.275	0.360	0.797	0.677	0.568	1573.908
	Max	373.346	1326.228	781.784	59.741	1.915	4.047	2.677	2.460	8455.839
	Min	9.939	2.610	5.197	0.000	0.233	0.055	0.292	0.007	259.334
2000	Average	64.267	242.659	155.548	3.895	1.042	1.047	1.093	1.027	1350.236
	Standard deviation	63.249	382.494	173.255	2.760	0.369	0.906	0.676	0.579	1585.034
	Max	272.602	2089.242	729.857	16.411	1.954	4.895	2.706	2.391	8412.870
	Min	10.532	0.000	0.499	0.000	0.271	0.053	0.283	0.018	259.501
2008	Average	47.184	279.244	167.137	2.483	1.059	1.088	1.124	1.136	1363.230
	Standard deviation	43.737	685.758	200.413	1.881	0.364	1.065	0.788	0.579	1660.391
	Max	187.686	4032.789	811.404	7.978	1.802	5.195	3.201	2.467	8924.134
	Min	3.922	0.000	0.000	0.000	0.220	0.045	0.239	0.012	254.400
full-sample	Average	62.082	247.146	166.037	5.320	1.029	1.033	1.091	1.014	1353.887
	Standard deviation	61.752	525.749	178.118	5.435	0.367	0.894	0.705	0.565	1584.638
	Max	373.346	11059.129	910.027	59.741	1.982	5.327	4.053	2.881	8924.134
	Min	3.922	0.000	0.000	0.000	0.219	0.021	0.239	0.005	254.400

		KL (million per capita)				IK				WARM (degree day)	COOL (degree day)
		Manufacturing	Chemical, Chemial textile, Pulp & Paper	Iron & Steel, Non-ferrous metal, Cement & Ceramics	Machinery	Manufacturing	Chemical, Chemial textile, Pulp & Paper	Iron & Steel, Non-ferrous metal, Cement & Ceramics	Machinery		
1990	Average	16.690	43.249	38.448	12.733	0.112	0.099	0.090	0.159	1033.401	408.033
	Standard deviation	7.119	22.912	25.070	4.471	0.021	0.030	0.026	0.042	435.361	167.911
	Max	39.039	97.822	122.349	23.883	0.154	0.214	0.154	0.254	2479.345	921.711
	Min	7.465	8.024	11.369	2.011	0.066	0.044	0.033	0.042	1.572	17.853
2000	Average	27.734	65.136	62.818	21.246	0.069	0.064	0.058	0.100	1120.986	404.752
	Standard deviation	10.106	33.081	38.052	6.068	0.017	0.021	0.040	0.035	563.481	152.062
	Max	60.954	148.268	191.233	33.957	0.115	0.134	0.289	0.205	3053.700	917.641
	Min	12.336	12.494	18.620	5.519	0.045	0.027	0.023	0.049	0.752	27.917
2008	Average	36.647	87.617	84.332	26.340	0.089	0.081	0.070	0.131	1024.501	365.452
	Standard deviation	11.573	79.240	42.588	7.790	0.021	0.039	0.027	0.048	502.026	185.886
	Max	66.178	540.293	200.295	43.869	0.145	0.204	0.148	0.270	2582.736	1047.309
	Min	15.124	14.750	18.393	5.668	0.058	0.030	0.024	0.018	30.469	4.049
full-sample	Average	26.629	63.560	59.914	20.251	0.076	0.073	0.061	0.108	1081.547	357.312
	Standard deviation	11.444	41.137	37.691	7.172	0.024	0.036	0.030	0.047	500.517	181.444
	Max	70.340	540.293	218.555	43.869	0.241	0.370	0.296	0.489	3053.700	1251.458
	Min	7.465	8.024	11.369	1.907	0.030	0.016	0.014	0.011	0.207	0.000

Source: Otsuka et al. (2014)

If the capital-labor ratio is regarded as a characteristic socioeconomic variable acting outside of agglomeration economies, the average capital-labor ratio of the entire manufacturing industry is 26.629 million yen per capita. In contrast, compared with the entire manufacturing industry, the average sample of the capital-labor ratio of the Chemical, Chemical Textile, Pulp, and Paper; and Iron and Steel, Non-ferrous metal, Cement, and Ceramics industries are higher at 63.560 and 59.914 million yen per capita, respectively, which is considered capital intensive. Yet another contrast is with the Machinery sector, where the capital-labor ratio is registered at a low value of 20.251 million yen per capita. When observing the sequential change in all industries from 1990 through 2008, it is understood that there will be increases in capital intensity. This is because of advances in mechanization related to production processes. Finally, the investment capital ratio of the entire manufacturing sector is 0.076. There could be a small variation within each industry. The average value for the Machinery sector is 0.108. There is also the possibility of upgrading production facilities.

Empirical Results

Based on Otsuka et al. (2014), an analysis of agglomeration economies and energy efficiency is performed. The model used in this analysis is:

$$\ln\left(ENERGY_{jt}\right) = \beta_1 \ln\left(LQ_{jt}\right) + \beta_2 \ln\left(DENS_{jt}\right) + \beta_3 \ln\left(KL_{jt}\right) + \beta_4 \ln\left(IK_{jt}\right) \\ + \beta_5 HEAT_{jt} + \beta_6 COOL_{jt} + \beta_7 TREND + \alpha_j + u_{jt}$$

The main variables used are logarithmic values; j = region ($j = 1,\dots, J$) and t = time ($t = 1,\dots,T$). Energy is energy intensity, or in other words, the amount of final energy consumption per unit of production. *LQ* is the location quotient and *DENS* is the population density. Both *LQ* and *DENS* are variables that represent agglomeration economies. *KL* represents the capital-labor ratio obtained by dividing capital stock by the number of employees. *IK* is the investment capital ratio obtained by dividing capital expenditures by private sector capital stock. *HEAT* are the heating degree days and *COOL* are the cooling degree days. *TREND* is the time trend, while ε is the item error.

The estimated parameters are α and β. In order to use panel data, α expresses the individual effect. It is predicted that $\beta 1$ and $\beta 2$ will be negative when agglomeration economy improves energy efficiency. The coefficient $\beta 3$ is negative when capital and energy consumption are negatively correlated; it is positive when capital and energy consumption are positively correlated. It is predicted that the coefficient $\beta 4$ will be negative, since new capital investment is expected to improve energy efficiency. In addition, if energy efficiency is growing with time, $\beta 7$, which is the coefficient of the time trend variable, has a positive sign; if the opposite is true, it has a negative sign. In addition, it can be inferred that in order to compare the regression coefficients, a standardized variable may be used.

Table 3 shows the estimation results. The *F*-test, which was performed to confirm whether the individual effect actually exists, finds the null hypothesis—that no individual effect exists—rejected in all industries at the 1% significance level. The Hausman test, which assumes that the observed individual effect is a result of the random influence, rejects the null hypothesis at the 1% significance level. Therefore, the estimated results shown in Table 3 are the results of the fixed-effect model. Furthermore, in addition to the test conducted for individual effects, a test that uses model accounting for annual effects is also conducted. However, since it is confirmed that the variable that accounts for the annual effects appears as a trend, it is decided that the annual effect is available as a time-trend variable.

First, the entire manufacturing sector is examined. The result shows that agglomeration economies lead to higher energy efficiency. Because both the explanatory value and the dependent variable are logarithmic values, $\beta 1$ through $\beta 4$ correspond to the elasticities. For that reason, the bigger the value of the estimated parameter (i.e., the greater the elasticity of the associated variable), the bigger is the influence of the explanatory variable on the dependent variable. Thus, the influence of population density is far greater than the influence of the location quotient. More specifically, the result of the variable of local quotient is –0.5122, whereas the result of the variable of population density is –0.6403, showing that the effect of the latter is far greater. In other words, looking at the entire manufacturing sector, there is greater energy efficiency when there is an agglomeration of diverse industries rather than an agglomeration of similar industries. This result is contrary to Otsuka et al. (2014). The "plus" sign in the capital-labor ratio shows that capital and energy efficiency have a complementary relationship. The investment capital ratio shows a "minus" sign, which is the expected result. The time trend ratio also shows a "minus" sign, but these estimated parameters are not large and their impact is not as important.

Table 3. Estimation results

	Manufacturing		Chemical, Chemical textile, Pulp & Paper		Iron & Steel, Non-ferrous metal, Cement & Ceramics		Machinery	
ln(*LQ*)	–0.5122	***	–0.4238	***	–0.5423	***	–0.1352	***
	-0.0285		-0.0668		-0.0639		-0.0522	
ln(*DENS*)	–0.6403	***	–0.0060		–2.5626	***	–0.3200	
	-0.2036		-0.7061		-0.7376		-0.5061	
ln(*KL*)	0.3485	***	0.2318	***	–0.9814	***	–0.0098	
	-0.0318		-0.0774		-0.0811		-0.0436	
ln(*IK*)	–0.0410	***	–0.0113		0.0189		–0.0206	
	-0.0055		-0.0176		-0.0196		-0.0133	
HEAT	–0.0292		–0.0095		0.1409		0.1062	*
	-0.0227		-0.0846		-0.0875		-0.0584	
COOL	0.0331	***	–0.0092		–0.0464		–0.0311	
	-0.0106		-0.0405		-0.0418		-0.0276	
TREND	–0.0573	***	–0.0384	***	0.0555	***	–0.0372	***
	-0.0034		-0.005		-0.0071		-0.0043	
F test	289.39	***	34.544	***	42.321	***	62.631	***
Hausman test	88.376	***	30.699	***	173.55	***	83.458	***
Adjusted R^2	0.9846		0.7741		0.7607		0.8956	

Notes. Standard deviation is listed within parentheses. The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Next, the estimation results of the Chemical, Chemical Textile, Pulp, and Paper industries are reviewed. In these industries, few variables are statistically significant, including the location quotient variable and capital labor ratio variable; however, the time trend variable is more significant. As expected, the elasticity of the location quotient is a "minus." However, compared with the entire manufacturing sector, the parameters are smaller and the impact that agglomeration economies have on energy efficiency is also relatively small for this industry. As for the Iron and Steel, Non-ferrous metal, Cement, and Ceramics industries, both the location quotient variable and the population density variable show a statistically significant "minus." In particular, the elasticity of population density is substantial and demonstrates that the agglomeration of diverse industries has a strong effect on energy efficiency. In addition, the capital-labor ratio coefficient also shows a "minus." In contrast to the result from the entire manufacturing sector, capital and energy consumption are inversely related. The elasticity of time trend is a "plus," and this result also differs from that of the overall manufacturing sector. Although the impact is not large, it is significant. Finally, the results for the Machinery sector show a "minus" in the location quotient coefficient that is statistically significant. This demonstrates that the localization economy has a significant effect on energy efficiency. However, the size of the parameter for the Machinery industry is small compared with those for the other industries. The result for the time trend variable in the Machinery industry shows a "minus" sign, but this is also not large, although it is significant.

The impact of localization economies is observed in all manufacturing sectors. On the other hand, the impact of urbanization economies is only observed in the Iron and Steel, Non-ferrous metal, Cement, and Ceramics industries. This impact is relatively significant. Therefore, there is a strong possibility that the results of these particular industries reflect the impact of urbanization economies on the entire manufacturing sector. With these results as a background, it can be seen that there is a difference in business dynamics between different industries (Otsuka et al., 2014)

The key focus of this analysis is to demonstrate how much agglomeration economies can contribute to improvements in energy efficiency. Table 4 shows the annual percentage rates of change that agglomeration economies have made on energy efficiency, based on an estimation equation. Regarding the mean changes in energy efficiency of manufacturers nationwide, localization economies show an annual rate of –0.384%, whereas urbanization economies show an annual rate of –0.013%. This implies that the influence of location quotient far exceeds that of population density. Despite the fact that population density does not change during the observation period, the change of location quotient is relatively significant.

The rate of change in localization economies is the highest in Kyushu at –1.724%; that of Tohoku is also high. On the contrary, in the greater Tokyo areas and in Kansai, where large cities are located, the annual rate of localization economy shows a "plus" rate, and therefore demonstrates that it has a negative effect on energy efficiency. A decrease in the economic activity of manufacturing industries has influenced these regions. On the other hand, urbanization economy greatly improved energy efficiency in the greater Tokyo areas where population density increased, such as Saitama, Chiba, Tokyo, and Kanagawa Prefecture. As the manufacturing industries grew in rural areas, localization economy played a big role in improving energy efficiency. In large metropolitan areas, it is speculated that urbanization economy played a role in improving energy efficiency as a result of the increase in population density. These results are in line with Otsuka et al. (2014); thus, we can confirm that these results are robust.

Examining specific sectors, the Chemical, Chemical Textile, Pulp, and Paper industries experienced only a limited influence from localization economies and much less than the manufacturing industry as a whole. In other words, energy efficiency would be improved by these industries agglomerating, yet the degree of improvement would be fairly insignificant. The degree of contribution of localization economies to the Iron and Steel, Non-ferrous metal, Cement, and Ceramics industries far exceeds the national average compared with that of the urbanization economies. In comparing regions, it is clear that localization economies as well as the entire manufacturing sector have strengthened in rural areas, especially in Tohoku. On the other hand, urbanization economies have had a huge impact in the greater Tokyo areas. Finally, the results show that the Machinery sector has contributed far more to localization economies than any other industries. This is observed mainly in the Kyushu area during the observation period, where it is assumed that this is due to the growth of the auto industry. Other regions where contributions have been high are Hokkaido, Tohoku, Chubu, Hokuriku, and Chugoku. Improvements in energy efficiency in these areas are considered to be due to increased production in the Machinery sector.

Table 4 Contribution of industrial agglomeration effects to energy efficiency in 1990-2008 (annual % rate)

	Manufacturing		Chemical, Chemical textile, Pulp & Paper		Iron & Steel, Non-ferrous metal, Cement & Ceramics		Machinery	
	Localization Economies	Urbanization Economies	Localization Economies	Urbanization Economies	Localization Economies	Urbanization Economies	Localization Economies	Urbanization Economies
Hokkaido	–0.372	0.097	1.273	0.000	–0.277	0.388	–0.636	0.000
Tohoku	–1.371	0.211	–0.771	0.000	–1.614	0.846	–0.353	0.000
Kita-Kanto	–0.530	–0.096	–0.986	0.000	–1.090	–0.382	–0.061	0.000
Greater Tokyo Area	1.091	–0.439	–0.001	0.000	0.265	–1.759	0.329	0.000
Chubu	–0.442	–0.083	0.041	0.000	0.128	–0.333	–0.152	0.000
Hokuriku	–0.216	0.042	–1.290	0.000	–0.837	0.168	–0.346	0.000
Kansai	0.049	–0.063	0.007	0.000	–0.500	–0.251	0.031	0.000
Chugoku	–0.558	0.202	1.924	0.000	1.188	0.81	–0.438	0.000
Shikoku	–0.554	0.257	–0.699	0.000	1.178	1.029	–0.391	0.000
Kyushu	–1.724	0.091	0.409	0.000	–0.008	0.363	–0.688	0.000
Okinawa	0.403	–0.361	–0.975	0.000	0.626	–1.446	–0.540	0.000
Mean	–0.384	–0.013	–0.097	0.000	–0.086	–0.052	–0.295	0.000

Notes: Zero values are due to the regression coefficient not being significant.
The relationships between the prefectures and regions are as follows:
Hokkaido (Hokkaido)
Tohoku (Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima, Niigata)
Kita-Kanto (Ibaraki, Tochigi, Gunma, Yamanashi)
Greater Tokyo Area (Saitama, Chiba, Tokyo, Kanagawa)
Hokuriku (Toyama, Ishikawa, Fukui)
Chubu (Nagano, Gifu, Shizuoka, Aichi, Mie)
Kansai (Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama)
Chugoku (Tottori, Shimane, Okayama, Hiroshima, Yamaguchi)
Shikoku (Tokushima, Kagawa, Ehime, Kochi)
Kyushu (Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima)
Okinawa (Okinawa)

Conclusion and Policy Implications

With environmental constraints continually being strengthened, an important question that arises for Japan's economic policy is how best to achieve regional economic growth and energy efficiency. The purpose of this paper is to demonstrate and reanalyze how industrial agglomeration affects energy efficiency in the manufacturing sector, based on Otsuka et al. (2014).

In order to strengthen competitive advantages worldwide, manufacturing industry is pushing forward to improve energy efficiencies by developing and improving energy-saving technology. As a result, looking at energy consumption as a whole, the share used by manufacturing industry continues to decline. However, the proportion still exceeds 50%, and this is still high compared with other industries. It becomes particularly clear that energy efficiency has not improved in industries that use a great deal of energy, particularly in the Chemical, Chemical textile, Pulp, and Paper sector. Many studies performed in the United States show that the more highly populated a region is, the more efficiently energy is used by its residential and transportation sectors. However, previous studies that target the industrial sector (manufacturing industry) could not be found. Reexamining Japan's energy policy reveals that short-term as well as mid- and long-term energy conservation, to be achieved through improvements in production processes, will be required.

The results of this study make it clear that agglomeration economies may lead to improved energy efficiency. From the values of the elasticities, it has been found that there is greater energy efficiency when there are more diverse industrial structures represented in high population density areas. While this trend is observed in the Iron and Steel, Non-ferrous metal, Cement, and Ceramics industries, the impact of population density is not statistically significant in the Chemical, Chemical Textile, Pulp, and Paper industries, or in the Machinery industries. This finding shows a discrepancy in the linkages between different industries, as mentioned by Otsuka et al. (2014).

In order to measure the degree of impact of agglomeration economies on energy efficiency, the changes in energy efficiency with different types of agglomeration during the observation period are calculated, and it becomes clear that the impact of localization economies is greater than the impact of urbanization economies. However, the trend also varies between regions. Specifically, the contribution to energy conservation due to localization economies where there are similar industries is much larger in rural areas than in large metropolitan areas. Conversely, the contribution to energy conservation due to urbanization economies where there are diverse industries is much greater in large metropolitan areas than it is in rural areas. It has therefore been determined that while agglomerating similar industries is effective in improving energy efficiency in rural areas, it is more effective in large metropolitan areas to agglomerate diverse industries to improve energy efficiency.

In general, industrial agglomeration undertaken as a result of economies of agglomeration, based on localization, occurs for the most part in medium-sized cities. In order to avoid congestion and soaring land prices, it is more desirable to agglomerate similar industries in medium-sized cities in order to enjoy the benefits of localization economies alone. In contrast, it is more advantageous to be in a large metropolitan area to profit from urbanization economies. The results of this analysis show that it is more effective to formulate strategy in terms of medium-sized cities than large metropolitan cities in order to improve the energy efficiency of manufacturing industries located in local areas. This suggests that an effective policy for improving energy efficiency of local manufacturing industries would promote the establishment of "compact cities" and the spreading of "smart communities."

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Sustainability of Local Food Supply Using New Agriculture Theory in Organic Farming Context in Uttarakhand, India

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Abstract
The purpose of this research was to explore the changes in livelihood of a group of farmers in Dehradun, Uttarakhand, India that had converted from conventional to organic farming. This research was also based on secondary data using *New Agriculture Theory (NTA)* as a guideline of proper resource management in land and water. The research was inductive and qualitative with *semi-structured face-to-face interviews* carried out with 15 farmers who had converted from conventional to organic agriculture mainly in Dehradun, Uttarakhand. The results of the study show that smallholder organic farms in India achieve the same or even slightly higher yield as conventional farms, using considerably lower nutrient inputs , but with a higher labor input compared to conventional farms. Organic farming has the potential for more sustainable use of natural resources, and reduces overall vulnerability of farm households; nevertheless, the drop of yields due to switching over to organic farming and the opportunistic behavior of some farmers are some of the immediate constraints. It was recommended for government to support more farmers financially in promoting organic farming. to simplify the certification process, to develop market linkages for the benefit of the farmers, and increase awareness of the local consumer about the importance of organic products.

Keywords : Uttarakhand India, Organic farming, New Agriculture Theory, Sustainability

Introduction

The global food crisis has been a concern for many decades. Especially in tropical countries, global warming represents a major threat to food security. The rise of food prices affects the poorest the most. It has been commonly attributed to overpopulation, but that seems to miss the real causes as food levels continue to outstrip demand even in a growing population. As projected by 2020 the world will require 50% more food supplies, as the population will increase. India, a developing country with a big share of the world population, has undergone a remarkable transformation over the past two decades. Faster growth has been brought about by a paradigm shift in economic polices that has opened the economy to foreign trade and markedly reduced direct tax rates and government influence over most investment decisions. The growth rate of average incomes has increased from 1¼ per cent prior to 1980 to 7% by 2006. (Sonnino & Marsden, 2006)

However, due to its agro-climatic regions, India has lots of potential to produce a large variety in agriculture, not least in organic crops. Some part of the country actually already inherited this tradition since ancient times. As a result, this holds promise for the organic producers to tap the market that is growing steadily in the domestic market related to the export market. Currently, India ranks 16th in terms of world organic agricultural land (including in conversion areas) by country in 2012. (FiBL & IFOAM 2014)

Table I : Projected Organic Agriculture India(GoI, 2009)

Total Production	976646 MT
Total quantity exported	37533 MT
Value of total export	Rs. 106 Million USD
Total area under certification	2,8 Million Ha
Number of farmers	1.95.741
Export Value	100.4 Million USD
Share of exports to total product	4 % approx.
Increase in export value over previous year	30 % approx.

Nevertheless, number of smallholder farmers are low and marginal cultivating areas of less than two hectares. Increasing land fragmentation, diminishing natural assets, high costs for external farm inputs, indebtedness, and pesticide-related health issues have threatened the livelihoods of many farming families (NCF 2006, MSSRF & WFP 2004, Ninan & Chandrashekar 1993). To support this movement, organic farmers groups and non-government organizations have formed an organic agriculture movement that supports organic farmers, establishes organic channels and tries to influence policies. Eventhough, there is plenty of research to support organic farming approaches; there is still a lack of scientific investigation into support strategies that meet stakeholders needs. Therefore, the aim of this research was to explore the changes in livelihood of a group of farmers in Dehradun, Uttarakhand India that had converted from conventional to organic farming. The research will use *New Agriculture Theory (NTA)* as a guideline of proper resource management in land and water (Royal Speech, 1994).

This theory is an alternative sustainable model to corporate producers and consumers that are separated through a chain of processors, distributors and retailers (Sonnino & Marsden, 2006)

There are two challenges for Indian agriculture for improving quality of life to alleviate poverty. One of the challenges relates to crop diversification away from food grains. More generally, a move towards diversification into fruits, vegetables and floriculture requires adoption of scientific methods of farming and investment in logistics. It also inevitably implies greater risks than those of producing food grains for assured markets at prices determined by the government. Moreover, after the implementation of green revolution technologies as the major production system in the world, there is growing evidence that the Green Revolution has, at its worst, increased inequality, worsened absolute poverty, and resulted in environmental degradation (IFPRI, 2002).The biggest revolution in the Indian rural sector will come from the revolution in retail trading which is on its way.

A second set of challenges relates to the availability of water for Indian agriculture. Inadequate and ineffective irrigation and a declining water supply required policies that encourage conservation of water and investments in water management. Correct pricing of water is crucial as a policy which moves away from giving free electricity to farmers because the latter only encourages excessive use of water for farming. While agriculture cannot be the engine for growth in the years to come, boosting agricultural growth and fostering linkages with the industrial and services sectors is crucial not only for raising the farmers' returns on high value agriculture but also for the sustainability of the growth process.

Using the basis of relations between "*human-economy-nature*" for sustainable development, organic farming will unite all agriculture systems that consider the balance of ecology, social issues and economy in agricultural production. The following practices will ensure sustainable agriculture: optimization of land use and crop management; efficient use of available organic fertilizing resources; agro-technical methods to protect crops from weeds; crop rotation; soil-protecting technologies for planned chemical land reclamation; preservation of agricultural and biological diversity at farms and its efficient utilization; stabilization of agro-landscapes through a uniform system of field-protecting forest belts; facilitation of proper use and preservation of water resources; usage of renewable resources; a harmonious balance between crop and animal production through integrated farming; and utilization of indigenous technical knowledge. (Kaswan, 2012)

Furthermore, the intensive use of synthetic chemicals to boost production has proved unsafe for nature. When there is a shift towards massive usage of agro chemicals in modern farming by many developed and developing countries, there are various effects on the water quality, soil nutrition, food and environment. Kaswan (2012) further summarized some harmful impacts due to chemical fertilizer. Application of nitrogen fertilizers such as *urea* and *ammonium sulphate* to soils produces acid by two processes. First, the natural process of oxidation of ammonia ions to nitrate ions releases acids. Part of the acids produced is neutralized by alkaline ions released by plants during the subsequent uptake of the nitrate ions. Secondly, since nitrate ions are not strongly absorbed by the soil they are liable to leach or move down through the soil. The negatively charged nitrate ions carry positively charged basic cations such as

Ca, K, Mg and Na in order to maintain the electric charge on the soil particles. A high nitrate concentration indicates likely presence of harmful bacteria as well. In condition, to high enrichment, oxides of N may occur in a state known as methaemoglobinema (*blue babies*), which generally affects the infants under six months of age. Repeated heavy dose of nitrate on ingestion is likely to cause carcinogenic diseases. Apart from this, over-use of N fertilizers leads to dwindling of earthworms from the particular area, and their absence means a loss of soil fertility. Also, contamination of soil by heavy metal through fertilizers such as cadmium from phosphate fertilizers has caught the attention of environmentalists (Kostial, 1986). Fertilizers contain heavy metals as impurities. The application of rock phosphate or its produce to soil always implies the addition of significant amounts of lead and cadmium into the soil. Using organic fertilizers can add more nutrition and cadmium to soil than mixed fertilizers (Arora et al., 1995). It can also cause the *eutrophication* of water as a process of enrichment of surface water bodies like lakes, reservoir and streams with nutrients. Nutrient enrichment of water bodies results in intense proliferation and accumulation of algae and higher aquatic plants in excessive quantities that can result in detrimental changes in water quality and can significantly interfere with the use of water resources.

Based on Surekha et al (2009) India has competitive advantages in the world markets due to low production costs and availability of diverse climates to grow a large number of crops round the year. The major products of organic farming in India are listed in the table below :

Table II : Major Organic Crops in India

Cereals	Wheat, Rice (Basmati)
Spices	Cardamom, Black pepper, White Pepper, Ginger, Turmeric, Vanilla, Mustard, Coriander, Clove, Cinnamon, Nutmeg, Chili
Beverages	Tea, Coffee
Pulses	Red gram, black gram
Fruits	Mango, Banana, Pineapple, Passion Fruit
Vegetables	Okra, Aubergine, Garlic, Union, Tomato, Potato
Oil Seeds	Sesame, Castor, Sunflower, Groundnut
Others	Cotton, Cashew nut, Herbal Extracts

Source : Agri. Stat at Glance. (2008)

Sustainability Indicators

Principal sustainability concepts cover environmental, economic, and social aspects. Only a small part of the literature on sustainability measurement integrates all aspects, most cases focus on one of three aspects (Singh, Murty, Gupta, & Dikshit, 2009). Both sustainable agriculture and sustainable farming criteria cover environmental and social issues. But this study focuses on smallholder farmers, which are in the upstream part of the supply chain; therefore, some criteria in sustainable farming are beyond the scope of this discussion. Hence, sustainable agriculture criteria are chosen only.

There are several sustainability indicators related to *Sustainable Agriculture*. However, they are either very restrictive or beyond the scope of this work, except the *Indicator of Sustainable Agricultural Practice (ISAP),* constructed by Rigby, Woodhouse, Young, and Burton (2001). It is designed for farm level and the need for data collection is minimized. A total ISAP score is obtained from four criteria in sustainability, namely: (1) minimizing off-farm inputs; (2) minimizing inputs from non-renewable sources; (3) maximizing use of (knowledge of) natural biological processes; (4) promoting local biodiversity or environmental quality.

The *International Federation of Organic Farming Movement* or IFOAM (2005) also listed the advantages of organic agriculture as follow:

- *Principle of Health*, organic agriculture is intended to sustain and enhance the health of soil, plant, animal and human beings as one and indivisible. In view of this, it constrains the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.
- *Principle of Ecology*, organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help to sustain them. Organic agriculture should attain ecological balance by means of utilizing locally available resources.
- *Principle of Fairness*, organic agriculture should build on the relationships that ensure fairness with regard to the common environment and life opportunities. Fairness characterized by equity, respect, justice and stewardship of the shared world, both among people and their relations to other beings.
- *Principle of Care*: Organic agriculture should be managed in a precautionary and responsible manner to protect the health and wellbeing of current and future generations and the environment. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the cost/risk of jeopardizing health and well-being.

2. Methods

2.1 Study Area

This research focuses on Uttarakhand, in the Western Himalayan Region of India. It has five distinct agro-ecological sub-regions divided mainly by altitude, varying from 300m to 3600m. Wheat, rice and sugarcane are the major crops found in Upper Dun, Bhabar; while in lower-lying Shivaliks also wheat, rice, finger millet, barnyard millet, amaranth, and maize crops are cultivated. Middle Gharwal-Kumaon and Upper Gharwal-Kumaon sub-regions with altitudes of 1200-1800m and 1800-2400m, respectively, grow wheat, rice, finger millet, jhangora, cheena, potato, barley, and chaulai. Various pulses (Masur and Kulat) are intercropped during early winter and after the rainy season. Dry and wet rice, taro, pumpkins, beans, corn, ginger, chili, cucumbers, leafy vegetables, and tobacco are also grown. Uttarakhand’s geographical area is 53,483 square kilometres, of which 65 percent is forest land and only 776 thousand ha (15 percent of the total land area) is cultivated. The irrigation of 44.6 per cent of cultivated area comes from canals and tube wells. Over hundreds of years, many slopes have been cut into field terraces, a common characteristic agriculture around the world. The region’s farmers have also developed advanced manure, crop rotation, and intercropping systems. Most land on the slopes remains not irrigated.

Irregularity of rainfall and worsening droughts have mostly disadvantaged the farmers. Thus, the green revolution in India has imposed the use of synthetic agrochemicals such as fertilizers and pesticides; combined with adoption of nutrient-responsive, high-yielding varieties of crops this has boosted the production output per hectare in most cases. However, in the long run the increase of production has slowed down, has declined productivity, and has affected the soil nutrients and human health as well. In addressing this problem, one organic farming organization in Uttrakhand named Navdanya is trying to rebuild self-reliance agriculture through organic farming practices. Populations who are living in rural areas thus make food available for their own consumption. These farmers were not dependent on the market, contrary to what we normally see in modern agriculture. Farmers re-learned the old skills and now grow varieties suitable to their land, rather than being dictated by the companies. The perversion of the green revolution is that the environment was modified to fit the plant. The organic farm, instead, grows local, indigenous, and climate resilient varieties. Organic farmers grow a variety of crops and maintain livestock in order to optimize use of nutrients and the space between species.

In Uttarakhand, a majority of farmers using fertilizers reverted back to organic ways of farming. It is important to recognize what are the main motivations for farmers to adopt organic. Based on Pratap (2009) their motivation is more on to stay organic rather than a choice to start organic since they already practiced organic long time before. About 40% of the farmers cited premium prices as motivating factor to stay organic and further improve their organic farming and get certified. Although there are no single reasons that can be attributed to the adoption of organic farming, it is a fact that more farmers grow organic because of the awareness of a market for organic products, because of the premium product price, and because of health hazards of chemical use in farming.

2.2 Data Acquisition and Processing

This research is based on *secondary data*. Information from literature on the historical evolution of the organic farming and the progress it has made both in India and abroad have been collected from sources like the websites of the *International*

Federation of Organic Farming Movements (IFOAM), books and periodicals, and newspaper reports. These have been liberally used for the preparation of the paper. The research was inductive and qualitative, although some quantitative data was used to support qualitative findings. Issues that were not considered before were able to emerge, and aspects that could not be quantified were explored. *Semi-structured face-to-face* interviews were carried out with 15 farmers who had converted from conventional to organic agriculture mainly in Dehradun, Uttarakhand. They were asked about income sources, land ownership, their motivations for adopting organic farming, factors that had supported the conversion, and their perceptions of what effects the conversion had on their assets, their livelihood outcomes, including income, health, nutrition and self-sufficiency, their vulnerability, and their external environment, including policies, institutions, and processes. The interviews were held in the farmers' fields and/or in their homes providing the opportunity to gather additional information by observation. Discussions with informed individuals/institutions, agriculture experts, social scientists, consumers, market intermediaries, Accreditation and Certification Agencies, NGOs and farmers were also held.

Table III : Socio Economic Profile of farmer

Farm characteristics	**Details**
Social parameters	Caste, education and age of the farmer, house type, family type, number of family members
Land holding	Own land, leased land
Crop rotation pattern	Area under main crops; crop rotation patterns
Agricultural equipment	Equipment for soil cultivation and transportation
Cattle	Stocks of cows, bullocks, buffaloes, goats
Incomes (other than from crops)	Milk sales, off-farm income
Agricultural labour	Family own labour (male, female), permanently hired labour
Irrigation systems	Micro-irrigation systems, well

2.3 Analysis

This research used *New Agriculture Theory (NTA)* as a guideline of proper resource management in land and water This theory is an alternative sustainable model to corporate producers and consumers that are separated through a chain of processors, distributors and retailers (Sonnino & Marsden, 2006).

The main purpose is to help farmers to be more self-reliant and living harmoniously with nature within society through a holistic management of their land. This concept has three levels of development: (1) household level; (2) community level; and (3) national level (Wibulswasdi, Piboolsravut, & Pootrakool, 2010).

The purpose of first level is to create *self-reliance* and *self-sufficient* at the households level. Assuming total area required is 2.4 hectares on average, it should be divided into four parts in a ratio of 30%, 30%, 30%, 10%, which may vary depending on geographic condition. Three portions of 30% each are for rice cultivation, fruits and vegetables, and for a pond. The remaining 10% is for housing and other activities. This level provides diversification that is effective for insect and weed control, water management, and soil management. So farmers' needs in food and nutrition are met sufficiently by themselves. They can also sell exceeding products in local, face-to-face, to earn extra income.

The second level is the community level, that aims to create sufficiency through collaboration among community members. Each household can share either different resources or amount that exceeds its need. Collaboration advances community to achieve economies of scale and scope so that costs of living are reduced and income is increased. For examples of collaboration, co-op based production, and money-saving groups. This is related to a spatially proximate format.

The third level, national level, is a concept to create value-chain by collaborating with others outside the community. Such collaborative activities should strengthen agriculture production or financial safety in the community. For instance, creating direct sales channels, raising funds and seeking funds by reaching out to banks, and other sources outside community.

The process from farm to plate of this theory is similar to a short food supply chain in three formats (Marsden, Banks, & Bristow, 2000), namely: (1) face-to-face: consumers buy a product direct from the producer; (2) spatially proximate: products are sold through local outlets in the area and consumers are immediately aware of its local nature; and (3) spatially extended: products are sold to the outside local area consumers who have no or little knowledge of the area.

3. Results

3.1 Conversion from Conventional to Organic Farming

Interviews with farmers who practice organic farming, most have sufficient basic knowledge about organic agriculture. Their awareness that sustainable agriculture requires long-term vision reflects their differences with farmers who are still farming with chemicals. Farmers largely convert to organic farming because of the uneasiness experienced with the existing agriculture system, which is predominantly based on chemicals. Some farmers perceive chemical agriculture to be a health hazard for them.

Yields in irrigated farms may go down during the conversion period from conventional to organic farming because the crop yields are boosted by artificial fertilizers and it takes time for the natural soil fertility to be restored. However, after conversion yields will be equal, if not higher than the yield during the conventional farming. In the rain fed farming, the situation is different; yields are significantly lower and thus, the difference in yields between the conventional and conversion period is narrow. Although there are only a few comparative yield studies at both global and national levels, certain studies have provided a broad indication about the productivity of organic farms vis-à-vis conventional farms. Conversion from the traditional low-external input system of cultivation rarely results in lower yields. However, when switching from external-input-intensive forms of agriculture, the yields may decline significantly, at least during the initial years of conversion, until the natural soil and fertility are sufficiently restored. (Kasturi, 2007). In relation to the cultivation cost, this argument is supported by a study done by Dr. Joginder Singh (2009) due to organic products of inorganic input, as the cost of cultivation showed decline in most crops in Uttarakhand as shown below :

Table IV : Cost of Cultivation Organic Vs Inorganic Crops (Rs/Acre)

Crops	Inorganic	Organic	% Decrease
Basmati	8390	7690	8,34
Non Basmati	7800	7600	2,56
Wheat	7400	6500	12,16
Finger Millet	3150	2800	11,11
Maize	4200	3800	9,52
Barley	3600	3320	7,78
Sorghum	3150	2800	11,11
Sugarcane	14500	13740	3,90
Peas	10070	10870	-7,94
Tomato	9400	9400	0,00
Potato	8500	8200	3,53
Cauliflower	9180	9980	-8,71
Ginger/Turmeric	5400	5500	-1,85
Chilli green/red	8600	7800	9,30
Tulsi green	3700	3700	0,00
Coriander Green	8350	7800	6,59
French beans	4500	4000	11,11
Soybean	4500	4000	11,11
Kidney bean	4500	4000	11,11
Mustard	4200	4500	-7,14
Union	8350	8450	-1,20
Eddoes (arbi)	5900	5700	3,39

3.2 Soil Fertility

Based on Shiva (1992), biological products not sold on the market but used as internal inputs for maintaining soil fertility were totally ignored in the cost-benefit equations of the green revolution. They did not appear in the list of inputs because they were not purchased, and they did not appear as outputs because they were not sold. So basically green revolution technologies created the perception that soil fertility is produced in chemical factories, and agricultural yields are measured only through marketed commodities. Nitrogen fixing crops like pulses were displaced (Rupela, 2007). Organic manures not only supply nutrients to crops and improve the soil texture in dry lands but also act as mulches. They protect crops against adverse temperature effects, improve seed germination, increase water retention capacity of the soil and create the right micro-climate for the development of beneficial soil microbes (Sharma, 1991; Reddy, 2010a).

3.3 Livestock

In integration with agriculture, livestock has a profound influence on its sustainability. Apart from providing additional income, livestock generates employment in the rural area itself. Livestock contributes directly to agriculture by producing manure and influencing the availability of organic carbon to soil. It contributes indirectly through its influence on income of the households. Integration of livestock and crop production, or mixed farming, allows the use of animal manure to increase soil fertility. Farmers recognize the benefits of using manure, and with the relatively high costs of mineral fertilizers, manure could play a greater role in maintaining soil fertility (Powell and Williams, 1995). Of the farmers interviewed, one farmer on average has two cows and one buffalo; some may have a goat. The livestock component of the farming system is crucial to maintain soil fertility, a supply of draught power, and food for the family (Reddy, 2001). The nutrient management system has become more closed with the weakened traditional linkages between forest and livestock (Turton *et al*., 1997). Increased income through livestock strengthens the capacity of a household to invest in productivity also enhancing measures through the purchase of off-farm inputs (George, 1996). Earnings from the landholdings of a majority of marginal, small and semi-medium farmers alone are not adequately sufficient for the household round-the-year and livestock rearing provides an alternative to these smallholders (Joshi and Jha, 1981).

4. Discussion and Conclusion

4.1 Organic farming improves farmers' livelihoods

The results of the study show that smallholder organic farms in India achieve similar or slightly higher yields as conventional farms, though nutrient inputs are considerably lower; and require more labour input compared to conventional farms. With lower production costs and a 20% organic price premium, gross margins for instance cotton are thus substantially higher than in the conventional system. Even if the crops grown in rotation with cotton cannot be sold with a price premium, conversion to organic farming can lead to a substantial increase in farm incomes. Hence, organic farming in a setting with assured price premium can significantly improve the livelihoods of smallholders. Most farmers in Uttarakhand shares that crops and livestock by products get better utilized in organic farm plugging back of residue to improve soil health and as pesticide from environmental angles. About 40% of the respondents expressed that there is a better economic use by farm products while the rest of them are on the view of remained the same.

Table V : Factor contributing to direct Economic Impact of Organic Farming

No	**Parameter**	**Plain Area**	**Hilly Area**
1	Yield effect (Rs/Acre)	-3022	-629
2	Price Effect (Rs/Acre)	2038	1899
3	Cost Effect (Rs/Acre)	790	268
4	Area effect (Rs/Acre)	757	583
5	**Total gain (Rs/Acre**	762	2121
6	Farm Size (acres)	7,6	3,2
7	**Per farm gain (Rs)**	5791	6787
8	Current Farm Income (Rs/Acre)	20833	17772
9	Total Farm Income (Rs/Annum)	158331	56870
10	**% Increase in Income**	**3,80 %**	**13,55%**

4.2 Organic farming has the potential for more sustainable use of natural resources

In the perception of most organic farmers, soil fertility significantly improved after conversion. To quantify the impact of conversion to organic management on soil fertility and water use, long-term field trials are likely to be more suitable. If organic management actually improves soil structure and increases water retention, this can reduce the crop's susceptibility to drought. As water is the main limiting factor for agricultural production in many semi-arid regions, this aspect deserves further investigation.

4.3 Organic farming reduces overall vulnerability of farm households

As organic farming involves less production costs and generates higher incomes, farmers are less prone to become indebted. For example, vulnerability of cotton farms – both for organic as well as for conventional farms – is highest when it comes to changes in cotton world market prices. To reduce the effect of drops in cotton prices, organic cotton projects could guarantee minimum purchase prices and develop organic marketing options for the main rotation crops. In the long term, conversion to organic farming can significantly reduce vulnerability of farm households as the additional income enables them to invest in better irrigation systems (e.g. drip irrigation) and to diversify their income sources (e.g. dairy farming or small-scale businesses).

5. Discussion

It remains an argument whether India's high population is reflected in its food scarcity. The argument is that people are hungry not because the population is growing so fast that food is becoming scarce, but because people cannot afford it. Food may be scarce, but it is international trade, economic policies and the control of land of agriculture that have lead to immense poverty and hunger. Therefore, poor access to food is one of the reason; not food scarcity due to over-population. Yet, problems in Indian agriculture are either related to stagnant productivity levels requiring heavy doses of research and improved practices of water management and cultivation, etc., or those that are directly the result of government policy design, e.g., spiraling input subsidies for agriculture which have eaten into government's capacity for public investment, inefficient marketing systems, and a highly inefficient public distribution system at subsidized prices for consumers.

The organic farmers in this study perceived that the conversion from conventional to organic agriculture had improved their livelihoods in a range of ways. They pointed out that over the long term the conversion had improved their net-farm incomes, reduced the risk of pesticide poisonings, lead to more self-sufficiency, improved food safety and reduced vulnerability, and improved the access to networks supporting knowledge exchange and political participation. However, risk and uncertainty related to the conversion period, such as temporarily declining yields and the lack of experiences and information, were mentioned as major constraints preventing particular asset-poor households from adopting organic farming. To date, lack of institutional extension and educational material on organic agriculture require farmers to rely on their own knowledge and farmers' networks.

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Marketing Mix to Promote Tourism in the Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi Province

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Abstract
This study specifically aims to investigate appropriate marketing mix model to promote tourism in Chonburi province. It consists of three main objectives: (1) to explore the components of the Nature Education Center for Mangrove Conservation and Ecotourism in Chonburi; (2) to study marketing mix in order to promote tourism; and (3) to study a model of marketing mix specializing for sustainably development. The techniques used for data collection were In-depth questionnaire and survey questionnaire. The data were analyzed by using t-test, f-test, and content analysis.

The results of the study revealed that: (1) this natural attraction consisted of four significant components of a tourist attraction which are place, management, participation, and activities in the attraction. (2) attraction, facilities and publicity of this natural attraction were the main factors which should be renovated and improved.

The recommendations are as follows: (1) Local government should renovate deteriorated building structures for visitors' safety and convenience such as pathway pavilion, toilets, interpretation signs, wayside exhibition concerning biological diversity, observatory tower, and boardwalk. In order to accommodate visitors and provide knowledge about the different ecosystems, the auditorium or lecture hall renovation and expansion is needed. Landscapes and clear trail signs should be redesigned. (2) Local government should properly and constantly publicize this natural attraction through press release and effective media such as leaflets, brochures, and websites. (3) Visitors and local people to appreciate nature in mangrove forest should be educated and increased awareness in protecting environment so as to conserve the natural attraction sustainably.

Keywords: Sustainable Tourism; Eco-tourism; Marketing Mix; Mangrove; Conservation; Tourist Attraction

Introduction

Thailand is one of the countries possessed a variety of natural resources, culture heritage, and historical sites which have been accumulated and transmitted from generation to generation. In Thailand, domestic tourism is popular among a number of tourists, both Thais and foreigners. As domestic tourism has brought a large exchange revenue and major income for developing the country, Thai government sectors and private sectors support this kind of tourism by promoting tourism, using public relations as a tool of tourism marketing, taking part in tourism development as well as promoting tourism as a tool for conservation and sustainable development. Located in suitable area, Thailand gains an advantage among neighboring countries because of its location. Tourists can commute conveniently when they desire to travel in Thailand. In addition, Thai government and concerned government sectors (e.g., Ministry of Tourism and Sports, Tourism Authority of Thailand, and etc.) realize the important of tourism so they establish tourism development policy and planning to support better quality for domestic tourism. The government and concerned business sectors have wisely planned tourism strategies targeting on sustainable development. They pay attention to promote sustainable tourism as well as cultural tourism. As you can see from tourism campaigns, they focus on ‘Thainess’ as a selling point. These are the reasons why domestic tourism in Thailand is popular for both international tourists and domestic tourists.

The Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi is located at Moo 3, Bang Muang district in Chonburi province. With and area of 30 Rai (118.5 acres), the nature education center is the last and the most plentiful mangrove forest or intertidal forest in Chonburi. Operated in cooperation among the Department of Forestry, Chonburi Provincial Administration Organization, and regional agency of Department of Forestry, the Nature Education Center for Mangrove Conservation and Eco-tourism has been established as a center for mangrove conservation as well as a learning center for public. Along 2,300 meters-length trails, the longest wooden bridge trails in Thailand, visitors can see natural diversity of mangrove such as mangrove forest and aquatic animals. Along the way, there are a pathway pavilion which visitors can learn about biological diversity, a rope bridge, and wayside exhibition board. Visitors can get knowledge and enjoyment in this natural learning center as it is rich in various kinds of mangrove such as Red Mangrove (Rhizophora Mucronata Poir), Rhizophora Apiculata Blume, Xylocarpus Moluccensis Roem, Xylocarpus Granatum Koenig, Avicennia Alba Blume, Grey Mangrove or Olive Mangrove, Tagal Mangrove, Yellow Mangrove, Cork Tree, and many other species of plants. It is not only fish farming, but also a natural habitat of various fish such as such as shrimp, black tiger shrimp, oysters, clams, crabs, fiddler crabs, mangrove crabs, small-scale mud carp (Cirrhinus microlepis), white seabass, and blenny.

In the Nature Education Center for Mangrove Conservation and Eco-tourism, there is also a bird observatory tower for visitors who desire to see and learn about numerous species of birds in the mangrove forest (Ministry of Natural Resources and Environment, 2013). Although the Nature Education Center for Mangrove Conservation and Eco-tourism is regarded as the last and the richest mangrove forest in Chonburi province, it has not received much attention from tourists as expected. One of the problems is the lack of funds to support the development of this natural attraction. Financial supports are necessary in several ways: marketing to promote this destination, destination management, natural attraction conservation, and etc. According to Li, M.et al (2007:308-317), problems of tourism development compose of three main factors: 1) too many tourists, over tourism carrying capacity, could deteriorate tourist attraction, 2) local economic development policies are ineffective, 3) the lack of financial support from government sectors to develop tourist destination to be more attractive and interesting for tourists. In addition, the Nature Education Center for Mangrove Conservation and Eco-tourism has neither arranged efficient marketing promotion nor an ongoing public relations strategy. From the above problems, the researcher is interested to study the marketing mix to promote tourism in the Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi province. In this study the researcher aims to investigate appropriate marketing mix model to promote tourism, encourage, and persuade travelers to visit this natural attraction. Meanwhile, the main goal is to increase awareness in protecting the environment so as to conserve the natural attraction sustainably.

Objectives

This study aimed: (1) to explore the components of the Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi province; 2) to study appropriate marketing mix in order to promote tourism in Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi province; and 3) to study a model of marketing mix specializing for sustainably development in Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi province.

Literature Review

Ecotourism is responsible travel in areas containing natural resources that possess endemic characteristics and cultural or historical resources that are integrated into the area's ecological system. Its purpose is to create awareness among all concerned parties of the need for and the measures used to conserve ecosystems (The Tourism Authority of Thailand, 1997).

According to Kotler, P. (1994) marketing is a process by which individuals and groups obtain what they need and want through creating, offering and exchanging products and value with each other. Similar to general marketing activities, Rechardson (1996) indicates that the designing of plans is important. They should be flexible and dynamic documents. He also point out that marketing is to establish, develop and commercialize long-term customer relationships so that the objectives of the parties are met. It is done by a mutual exchange and keeping of promise. Gronroos, C. (1989) according with Misiura, S. (2006) state that to prepare marketing research to identify target markets, understand opportunities, determine strengths and weaknesses, develop strategies for increasing tourism and prepare marketing strategies, collaborative marketing packages and cross-marketing program to maximize the impact of the sector is the significant process of marketing resources. Seaton and Bennett (1996) point out the procedure of marketing plans divides into six elements: 1) A situation analysis; 2) A review of the organization is mission; 3) Objectives and strategies for both financial and non-financial goals; 4) An action plan; 5) A budget; and 6) Evaluation of its effectiveness.

Research Methodology

In this study, the researcher use both qualitative and quantitative method. The target population were divided into three groups; tourists, government officers, and local people. Using Convenience Random Sampling, the samples of tourists were 400 Thai tourists traveling in Chonburi province. The second group of samples were five people; the director, head officer, and officers, working in the Ministry of Natural Resources and Environment in Chonburi. The other samples were 10 people including community leader and local people in Samed district. The second and the third group were selected by using Probability Method.

Research Instruments and Data Collection

The instruments used in this study were survey form, survey questionnaire and interview questionnaire.

The survey form was designed to explore the components of the Nature Education Center for Mangrove Conservation and Ecotourism in Chonburi province. It was based on concepts of significance and concerned theories such as Bornemeire et al. (1991) and Fennel (1999). The questionnaire was verified using the IOC (Items Objective Congruence Index) evaluation to ensure the content validity and appropriateness of the issues in the survey form. The data collection was conducted on 5th January, 2014 - 12th January, 2014. The researcher explored and inspected the sites in order to evaluate the potential of the natural attraction. The destination survey was analyzed by using Content Analysis.

The semi-structured and in-depth interview questionnaire was utilized for interviewing the participants about personal information, tourism SWOT analysis, marketing mix, tourism marketing promotion, and guidelines for promoting the natural learning center. The data collection was conducted on 27th February, 2014 to 12th March, 2014. The in-depth interview questionnaires were used to interview the concerned government officers and local people in the community nearby the natural learning center to investigate the opinion of toward marketing promotion of the Nature Education Center for Mangrove Conservation in Chonburi province. The data from the interview was analyzed by using Content Analysis. The data were analyzed from in-depth interview by using Content Analysis. Concerning the interview questionnaire, the main questions about marketing mix to promote tourism in the Nature Education Center for Mangrove Conservation and Eco-tourism in Chonburi province was constructed from the empirical studies and concerned documents. After that, the questionnaire was verified using the IOC evaluation form to ensure the validity and appropriateness of the questions.

The survey questionnaire was used to investigate 400 Thai tourists' opinion toward marketing mix of the Nature Education Center for Mangrove Conservation in Chonburi province. The designed questionnaire based on concerned theories, concepts, and the results of the interview questionnaire. The questionnaire was verified using the IOC (Items Objective Congruence Index) evaluation. It was composed of open-ended and close-ended questions using five-level-Likert Scale to grade respondents' opinions toward marketing mix. There were three parts in the questionnaire: (1) Personal Information; (2) Tourists' behavior in the Nature

Education Center for Mangrove Conservation in Chonburi province; (3) Tourists' opinions toward marketing mix of the Nature Education Center for Mangrove Conservation in Chonburi province. The data collection was conducted on 20th May, 2014 - 30th June, 2014. The designed questionnaires were distributed to the tourists traveling in the Nature Education Center for Mangrove Conservation in Chinburi province to investigate the opinion of toward marketing mix of the Nature Education Center for Mangrove Conservation in Chonburi province. The statistic used to analyze the data is Cronbach's Alpha. The SPSS software was employed to analyze the data using descriptive statistics to produce statistical output for each question. In the first part of questionnaire and the second part of the questionnaire, the data was was analyzed by using frequency and percentage. In the last part of the questionnaire, the tourists' opinions toward marketing mix of the Nature Education Center for Mangrove Conservation in Chonburi province, means and standard deviation were used to determine the tourists' opinion toward marketing promotion.

Results

From the survey study, the results founded that this natural attraction consisted of four significant components of the tourist attraction which are ecotourism site, management, participation, and activities.

The results of from the questionnaire were: The quantitative analysis of Tourists' personal characteristics and behavior. It was found that most travelers were female (56 percent), single (87.3 percent), the average age under 20 years (43.5 percent). Most of them have a bachelor's degree (34 percent) and graduated in high school (32 percent). Their professionals are university students and high students (63.3 percent). Most of them have no income (56 percent) and only 16 percent of tourists have revenue around 10,001-20,000 baht per month. It was found that the primary purpose to travel in the Nature Education was for nature study (69.2 percent), followed by recreation purpose (21.3 percent). Most of tourists traveled in group (69.7 percent) and 51.6 percent traveled to the Nature Education by bus charter.

The results from in-depth interview found that there were four groups of tourists visiting this natural attraction: 1) students and university students, 2) employees, 3) government officers, and 4) general public. They were mostly visited the Nature Education from Monday to Friday during office hours (around 9am - 4pm). The purpose of visiting was to learn about the mangrove ecosystems. Furthermore, it was found that the budgetary supports from the government were not enough for tourism promotion and development. There was no clarity on fiscal matters in order to develop tourist attractions in the country. Based on the interview with stakeholders, it was found that visitors did not pay much attention to the attraction or the Nature Education due to the fact that there was no improvement of this tourist attraction. In addition, relevant governors, concerned stakeholders and local community should involve or take part in natural conservation as well as marketing planning in the natural attraction. Besides, a number of tourism promotions and marketing activities should be provided continuously. Also, above the line advertising such as brochures, leaflets, and online media such as website also should be improved

A proposed model of the marketing mix to promote tourism in the Nature Center for Mangrove Conservation and Eco-tourism

Four significant components which are ecotourism site, management, participation and activities should be conserved and sustained.

- In term of tourism product, the Ministry of Natural Resources and Environment and local governors should help improve facilities in the natural attraction.
- In term of price, visitors should pay for the entrance fees with reasonable price.
- In term of place, visitors could contract the organization directly.
- In term of promotion, there should be efficient advertisements and public relations. In addition, the organization should continuously develop effective online media and arrange interesting activities in the Nature Center for Mangrove Conservation and eco-tourism.

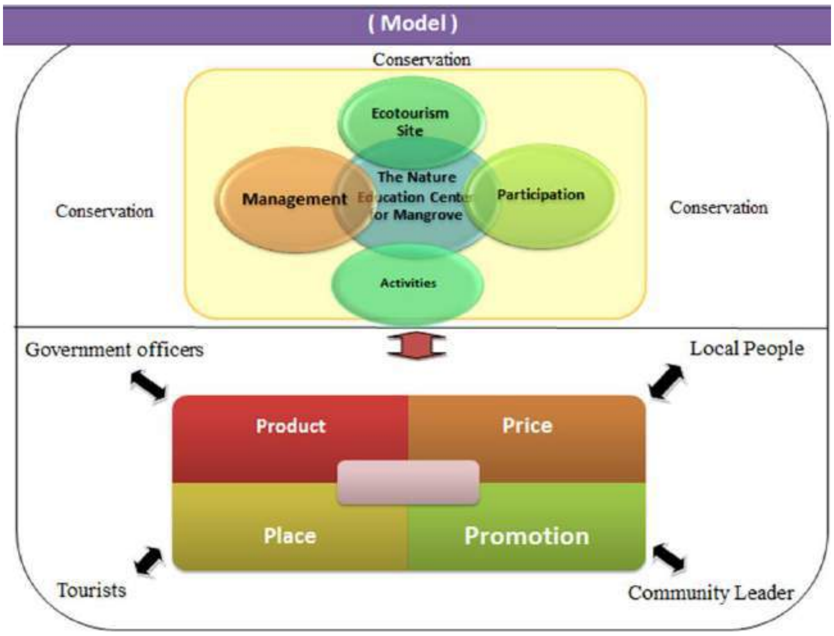

Figure 1: A proposed model of the marketing mix to promote tourism in the Nature Center for Mangrove Conservation and Eco-tourism

Conclusion

The results from the survey study, in-depth interview, questionnaire, it was found that the marketing mix planning to promote the destination are:

1) Attraction: *The facilities in the ecotourism site should be considerably developed.*
2) Price: *The respondents from the study agreed that the price should be affordable or reasonable, and they also suggested that the entrance fee should be around 20 baht.*
3) Place (or channels): *The entrance tickets should be able to purchase comfortably at well-known tourist spots.*
4) Promotion: *The concerned governors should continuously offer promotion, arrange public relations, and provide brochure for promoting this ecotourism site to become more popular among tourists. Online marketing media such as websites, YouTube, and Facebook should be created and developed to persuade travelers to visit this natural attraction*.

Recommendations from the study

1) Ministry of Natural Resources and Environment and local government should renovate deteriorated building structures for visitors' safety and convenience such as pathway pavilion, toilets, interpretation signs, food and beverage station, souvenir shop, wayside exhibition concerning biological diversity, bird observatory tower, and boardwalk.
2) In order to accommodate visitors and provide knowledge about the different ecosystems of the mangrove forest in Chonburi province, the auditorium or lecture hall renovation and expansion is needed.
3) Ministry of Natural Resources and Environment and local government should redesign landscapes and to provide clear trail signs.
4) Ministry of Natural Resources and Environment and local government should properly and constantly publicize this natural attraction through press release and effective media such as leaflets, brochures, websites, and etc.
5) Ministry of Natural Resources and Environment and local government should educate visitors and local people to appreciate nature in mangrove forests and increase awareness in protecting the environment so as to conserve the natural attraction sustainably.

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IPA Free Texturization Process for Monocrystalline Silicon Solar Cells by PTFE Mask

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Abstract
Silicon surface texturization is required for high efficiency solar cells to reduce light reflectance. Anisotropic chemical etching utilizes a mixture of alkaline solutions and isopropyl alcohol (IPA) in typical pyramidal texture process. However, the volatile pollutant and the cost of IPA are important factors of overall texturization cost and environment reduction approach. In this paper, we investigate an alternative texture process by using a polytetrafluoro-ethylene (PTFE) grids-based texturization approach of monocrystalline silicon wafers with potassium hydroxide (KOH) is proposed. The suitable openings and separation between the close contact of the PTFE grids and silicon surface are used to capture hydrogen bubbles and breach them from the surface, which leads to form random pyramid structures in the silicon surface. Using an optimized conditions this etching process with free IPA provided a low weighted reflectance of 11.82% without any anti-reflectance coating.

Keywords: Pyramid texturization, PTFE grid mask, free IPA, monocrystalline silicon, solar cells

Introduction

Typical silicon wafer with polished surface normally loses the incident light above 30%. Silicon surface texturization is an important process for solar cell fabrication to effectively reduce the reflectance of light. Anisotropic chemical etching is very effective in monocrystalline silicon to form random pyramids on the (100) oriented silicon surface. Uniformity of pyramid textures will be obtained the light collection and able to trap the light inside the cells by internal reflection that leads to good energy conversion of solar cells.

Alkaline texture etching is a very common in industrial production and a well-established method owing to great reduction of optical reflectivity of solar cells. Hydroxide by itself provides too fast etch rate in particular selective etching along (111) plane. Therefore, additives are typical required to reduce the etch rate. In typical pyramidal texture process, it can be seen anisotropic chemical etching utilizing a mixture of alkaline solutions such as potassium hydroxide (KOH), sodium hydroxide (NaOH) or lithium hydroxide (LiOH), and isopropyl alcohol (IPA) [1-3]. The silicate and hydrogen bubbles which are produced from KOH-Si reaction are allowed to accumulate at the interface between the silicon surface and solution that can inhibit pyramid nucleation. The hydrogen bubbles with 2-3 mm diameter sticking on the silicon surface seems to be "pseudo mask" to prevent etching on the surface during etching process.

IPA as an additive surfactant in alkaline solutions can improve the surface tension and diffusion dynamic of the solution. It is required for the complete formation of pyramidal structure all over the silicon surface since IPA removes the hydrogen bubbles adhering on the silicon wafer. Its suitably high concentration and operating temperature can improve the wettability of the silicon surface. However, high IPA concentration results in the decrease of the etching rate of silicon [4]. It has low flash point (<12°C) and boiling point of 82.4°C which is close to the texturing process temperature. As a result, IPA evaporates easily due to its low volatility in the heated etching process. More consumption of IPA into the solution to compensate the amount lost is required for a proper wettability of the silicon surface. In the present, alkaline anisotrotic etching is an industrial etching technique but the cost and volatile pollutant of IPA are important factor of overall texturization cost and environment reduction approach.

Due to high cost and easily volatility of IPA, there are many researches on low-cost silicon texturization focusing on the investigation in alternative solutions for surface texturing with reducing amount of IPA or new way with free IPA [5-6]. Several processing techniques to use the different chemical solutions were presented such as sodium phosphate (Na_3PO_4), tetra methyl ammonium hydroxide (TMAH) and sodium carbonate (Na_2CO_3) [7]. Nonetheless, the alternative solutions are quite more expensive than KOH. Recently, anisotropic chemical etching with free IPA was presented with using metal grids as an etch-mask that allows average reflectance of 15.1% and 10.7% for KOH and Na_2CO_3, respectively [6,8]. Metal equipment seems to be incompatibility in alkaline etching process in the long term. On the other hand, super-hydrophobic material such as polytetrafluoro-ethylene (PTFE) is friendly with alkaline solution that has very low surface energy of 18.5 mJ/cm^2. It is mostly possible to bring PTFE for an etch-mask. In this paper, the alternative texturization method with free IPA by using an opening grids pattern of super-hydrophobic mask is investigate in KOH solution.

Experimental

Polytetrafluoro-ethylene (PTFE) grids with different circle openings was used as an etch-mask in this study for removing hydrogen bubbles on the (100) p-type Si surface during KOH etching process. In order to optimize the size and uniformity of the pyramid, 3 different diameters of grid opening with 0.5, 1 and 2 mm for texturing and separations of grid opening with 1 and 2 mm were tested. The gap between the PTFE grids and wafers is 1 mm. The PTFE openings are utilized for the confinement of the hydrogen bubbles during the etching process. Monocrystalline p-type silicon wafers, (100) oriented and size 200 mm×200 mm with resistivity 7-8 Ω·cm were used for the texturization. The silicon wafers were etched in 5% hydrofluoric acid (HF) to remove native oxide and rinsed in deionized water before texturization. The etching was performed by placing the silicon wafers in the PTFE grid box and then the box was immersed in 3wt% KOH solution at 80°C for 50 min due to that this condition has been optimized in 3wt% KOH with IPA mixture. In this work, there is no surface-active additive added in the KOH solution.

After the etching process, integrating sphere surface reflectance of the textured surface was measured to characterize the optical loss. An UV-NIR SPECORD spectrophotometer with hemisphere mode was used with light in the wavelength range from 300 nm to 1100 nm at near normal incident light. The weight reflectance (%WR) was determined normalizing the hemispherical reflectance spectrum by the AM1.5D spectrum. In addition, the surface morphology of the textured silicon wafers was examined by a surface scanning electron microscope (SEM).

Results and discussion

From the different batches, the pyramids formed are strongly dependent on the utilization of PTFE grids on the silicon wafers. It seems that it is not only the condition of the KOH etching processes but also the structure of the PTFE grids to obtain the pyramid structures with satisfactory optical performance. The PTFE grids box was placed on the silicon wafers and they were submerged into the KOH solution. During etching process continued, it could be seen some generated hydrogen bubbles continuously were captured within the openings and then they were bigger and broke finally. It can be noted the PTFE grid removed the hydrogen bubbles, which adhered on the wafer surface to inhibit the texturing process by this course. Therefore, there is no basic difference in the anisotropic etching mechanism between the proposed method and other texturization techniques.

The influence of the diameter sizes of the grid openings and the separations on the reflectance of the silicon surfaces under optical wavelength is shown in Figure 1. The wafers were textured in 3wt% KOH solution at 80°C for 50 min. The values of the weighted reflectance were measured at the range of light wavelength from 300 nm to 1100 nm as detailed in Table 1. The reflectance of wafers textured in the same condition without PTFE mask was measured for comparison. The averaged reflectance was 27.55%WR for sample etched in free IPA solution with bare mask.

Under this condition with using PTFE grids, it is found that %WR evidently reduced compared to that textured without PTFE grids. When the wide separation at 2 mm and the separation at 0.5 mm were considered it can be observed that the measured reflectance decreases as the size of opening increases. It is possible due to ability of the bubble capture. On the other hand, when the separation is kept at 1 mm it is observed that the measured reflectance becomes weaker as the size of opening increases. The minimum reflectance was obtained at 11.82 %WR for using 1 mm separation and 0.5 mm sizes of openings that denoted as 1S_0.5D. It is due to that a perfect hydrogen bubbles removal process is obtained. It is also observed that a hydrogen layer is formed between the grids and the wafers in this situation. Therefore, based on the experimental results, it can be seen that 1 mm separation and 0.5 mm sizes of openings are the optimal condition in a novel approach of utilization of PTFE grid mask for texturing process.

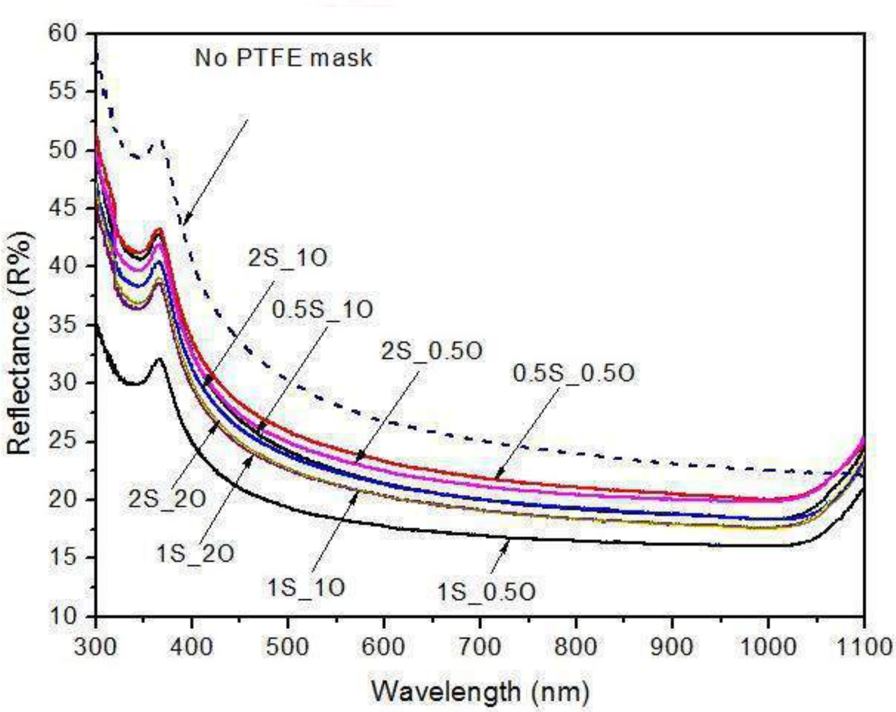

Figure 1 : Comparison of the reflectance curves of silicon wafers textured without PTFE grids, textured with different PTFE grid patterns. The gap between grids and wafers was 1mm. Texturization conditions: 3wt% KOH at 80˚C for 50 min.

Table 1. Comparison of the %weighted reflectance of the wafers etched in free IPA solution with the wafers placed in the different PTFE grids.

Separation of opening (S) (mm)	Size of Grid opening (D) (mm)		
	2	1	0.5
2	13.74%	14.40%	15.10%
1	13.76%	13.69%	11.82%
0.5	-	14.59%	15.67%

No PTFE grids	21.55%

Figure 2 shows the SEM images of the surface morphology of the silicon wafers textured in 3 wt% KOH solution at 80°C for 50 min with stirring magnetic bar. Without using PTFE mask in the texturing process, the formation of random pyramids is poor on the silicon surface as seen in figure 2(a). SEM image in figure 2(b)-(d) depicts the pyramids formed intensely with using PTFE grid masks. During the whole etching process the hydrogen bubbles are continually captured by the metal grids and removed from the silicon surface. Using the 1 mm opening metal grids with a separation of 1 mm between wafers and grids, uniform pyramids are fabricated and an average reflectance of 10.7% is achieved. The pyramid structures of 2S_2O sample obtained mean reflectance of 13.74 %WR had the average base size between 3 μm and

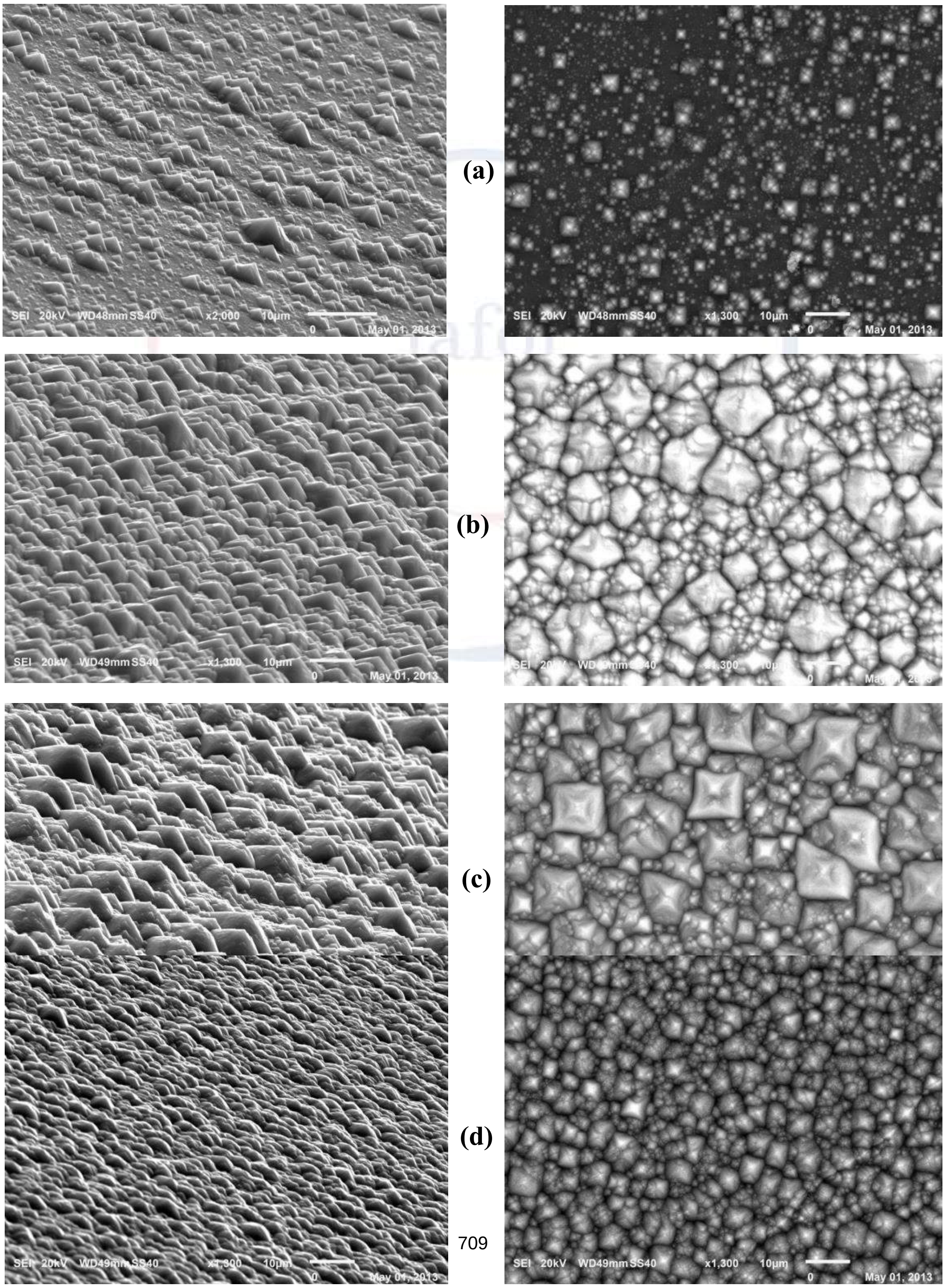

Figure 2 : The SEM images of the wafers etched in 80˚C, 3wt%KOH solution for 50min (a) with no PTFE grid comparing with using PTFE grid separations and openings of (b) 2 mm, 2 mm (c) 1 mm, 0.5 mm (d) 0.5 mm, 1 mm.

17 μm as shown in figure 2(b). Figure 2(c) shows the surface morphology of the silicon wafer etched in the solution using the PTFE grids with 1 mm separation and 0.5 mm openings. As can be observed from the figure, the formation of intensively large pyramid on the silicon surface was obtained. The weighted reflectance of 11.82% for 1S_0.5O sample is lowest based on the experimental results. It can be suggested that the completion of the etching process to use PTFE mask with 1 mm separation and 0.5 mm openings was obtained. Therefore, the surface coverage of the sample improved substantially. However the uniform pyramids on the silicon surface are very small as shown in figure 2(c), when the separation between the close contact of PTFE grids and wafer surface decreased from 2 to 0.5 mm. It is believed that the 0.5 mm separation was too small and hard to make bubbles breach easily in close contact with the wafer surface. The image of the small pyramid size relates with the increase of the reflectance.

Summary

This work has been investigated an alternative texturization method of monocrystalline silicon solar cells without adding any IPA based on PTFE grids as a super-hydrophobic material with 3%wt KOH solution. PTFE grids with appropriate openings and separation were used to capture the hydrogen bubbles and then remove them from the silicon surface. Using 0.5mm openings and 1mm separation between the grid and the wafer, our optimized process utilized 3%wt KOH solution at 80 ˚C for 50 min with free IPA. Using this approach, reliable and uniform pyramid structures with a minimal value of average weighted reflectance of 11.82% were obtained. The proposed technique offers an alternative texturization that can reduce the cost and volatile pollutant of IPA in the etching process in photovoltaic fabrication.

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Effect of Organic Solution based Additive on Exhaust Emissions of an Indirect Injection Diesel Engine

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Abstract
Exhaust emission from engine combustion is concerned increasingly to environmental effect. Fuel additives mixed for reduction of the exhaust are more interested based on no modification of the engine. In this study, exhaust emission and performance of an indirect injection diesel engine were investigated under the various fuel test conditions with mixing additive based organic solution. The various fractions of palm oil biodiesel (POB) in the rest of diesel fuel from 2% to 100% denoted as B2 up to B100, respectively were considered. The improvement of POB fuel properties with using organic additive based oxidative desulfurization in the blended fuels in order to allow in the set regulations of Thai Department of Energy Business (DOEB). The modified fuels by blending the 0.1g additive in 2.5 liters diesel fuel tested were prepared and measured the physical properties such as viscosity, cetane number, flash point, heating value, and carbon residue of the modified fuels under ASTM standard test methods. The effect of the additive in POB blended fuel on CO, CO_2, and NO_x was investigated in this study. Comparing with the same fraction of POB blend without additive, the significant improvement of POB properties of all POB fuels adding the organic additive was obtained. Their properties for high POB fraction of B40 with additive are still allowed under the set regulations of DOEB. In addition, the experimental results showed the effective decrease of the exhaust emissions from using the organic additive in comparison with POB fuels in the same fraction.

Keywords: organic solution additive, diesel engine, palm biodiesel, fuel property, exhaust emissions

Introduction

Diesel engine generally emits exhaust in particular NOx more than emission from gasoline engine, which causes higher pollution. Increasing ambient air pollution force the researches to concern clean alternative fuels for diesel engines. Palm oil biodiesel (POB) is an alternative fuel due to its various advantages, such as abundant biomass resources, biodegradable and environmental friendliness over fossil fuel [1]. Moreover, biodiesel predominantly produced from biomass is becoming cost competitive with fossil fuels due to the widespread availability of biomass resource [2]. However, some POB fuel properties with high exhaust emissions are not allowed in the set regulation of energy business. Addition of organic additive is an alternative for improving POB fuel properties and reducing the exhaust emissions [3,4].

In the present, there are several kinds of bio-solution based additive to be synthesized for appropriate bio-oil blends, for example, ethers based (ETBE: $C_6H_{14}O$ and TAEE: $C_7H_{16}O$ etc.) [5], ethanol based (C¬2H5OH) [6] or glycerol based ($C_3H_8O_3$) [3] in palm biodiesel. The influence of organic solution based oxidative desulfurization blending in palm oil biodiesel has been studied insufficiently. Thus, the aim of this work is to verify the comparative engine performance and gas emissions of an indirect injection (IDI) pickup automobile which was fueled by POB with additive at the different POB fractions from B2 to B100.

In this study, the commercial organic additive based oxidative desulfurization was used oxidizing the sulfur compounds in the diesel fuel to sulfones. Due to their high polarity, the sulfones thus formed are readily removed from the fuels by polar extraction. The commercial organic additive is thus highly effective in removing sulfur compounds from the fuels. The influence of the additive in POB fuel under varying fuel fractions was examined. In order to determine the available POB fraction and achieve the reduction of the exhaust emissions, an IDI pick-up diesel engine was tested on a FPS 2700 chassis dynamometer. All tests were performed without any modifying engine. NOx, CO and CO_2 emissions from the engine were measured by Testo 350 gas analyzer.

Experimental Procedures

The various POB fuel fractions in the rest of diesel fuel from 2% to 100% denoted as B2 up to B100, respectively were tested. A small amounts of the additive of 0.1g in 2.5 liters POB fuel were used for dosing in the various POB blends. The physical characteristics of the tested fuels were measured in this study including kinematic viscosity, flash point, cetane index, heating values, and carbon residue. The influences of the additive on the physical properties of the various fuels tested were investigated. The various POB fuels blending the organic additive were produced by means of an ultrasonic shaker for 15 minutes in order to obtain the uniform suspension.

The used vehicle in this experiment was a standard pickup car with a manual gear box. The schematic of the experiment setup is shown in Figure 1. The tested engine specifications were listed in Table 1. The FPS 2700 chassis dynamometer under the simulation of road load conditions with eddy current brake was conducted in this experiment. Measuring accuracy of the chassis dynamometer is of ± 2%. The performance correction was use by following a standard of SAE J. 1349. Each engine test was repeated 3 times to ensure the average data calculation for the analysis. Owing to the different fuels tested, each engine test was on a standard of the operating conditions.

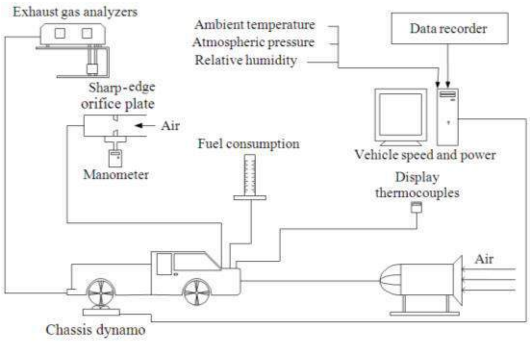

Figure1: The schematic of experiment setup

Table 1: Test engine specification

Engine	TD27(New)
Displacement	2663 cc
Bore x Stroke	96.0 × 92.0 mm
Cooling system	Water cool
Intake Method	Natural aspiration
Maximum Power	83.8 bhp@4000rpm
Maximum Torque	166Nm-@2200rpm

Exhaust emissions and gas temperature, according to SAE J816B specifications were measured by a Testo 350 gas analyzer. Measurement resolutions for NO_x, CO, and CO_2 are 0.1%, 1.0%, and 0.01% ppm, respectively. Meanwhile, measurement capacity for NO_x, CO, and CO_2 are in the range of 0-500 ppm, 0-10,000 ppm, and 0-50% vol., respectively. Exhaust emission values were measured directly by sampling the gas emission data, which was detected at the exhaust pipe with the analyzer probe as shown in Figure 1. The test cycle was repeated three times. The software provides extraordinary data management capability and the ability to import/export data.

Results and discussion

The obtained data of basic properties of the blended fuels is detailed in Table 2. It is noted that when the additive was blended in the POB fuels with all fraction conditions, the quality of all basic properties was improved for all blended POB conditions. Moreover, the property values of the blended POB fuel were allowed under the ASTM standard except B50 and B100 blended fuel below the standard. As can be seen, all viscosity and carbon residue values of the blended POB fuels decreased comparing with the same POB fuel fraction. Low viscosity and carbon residue can result in the fine aerosol distribution of the blended POB fuel and less soot in the pumping system. As illustrated, all cetane numbers, heating values and flash point of the blended POB fuel increased, which obtain the complete combustion and safer handling.

As illustrated in Figure 2, from the tested engine using the blended POB the exhaust NOx level effectively decreases throughout the engine speed test for all fraction conditions, especially the blended POB fractions above B20+Add, which obtain NOx emission increasingly reduced. This is mostly due to the organic additive based oxidative desulfurization is highly effective in removing sulfur compounds from the fuels. Under the set regulation standard, the appropriate POB fuel fraction at B30+Add resulted in the average minimal NOx emission of 12.35 ppm.
Figure 3 shows CO level emiting from the engine to be fueled by the different blended POB fuels comparing with B2 as reference fuel. It was found that high POB fraction above B10+Add obtained the effective reduction of CO emission. B30+Add fuel had an impact on the minimal CO level of 62.50 ppm average value.
As can be seen in Figure 4, the average CO2 emission was minimize of 0.57% vol from the engine using B30+Add. However, comparing with B2 the average CO2 level increased for using B2+Add and B10+Add, which correspond to the result of CO2 emission. It may be due to that the organic additive can effectively catalyze to high fraction of POB.

Table 2 : The basic properties of the test fuels

Fuel	Kinematic Viscosity (cSt)	Flash point (^oC)	Cetane index	Heating value (MJ/kg)	Carbon Residue (% wt.)
ASTM Standard	ASTM D445 1.8-4.1	ASTM D93 > 52	ASTM D976 < 50	ASTM D240 < 42.5	ASTM D524 <0.05
B2	3.92	66	56.87	44.39	0.01
B10	4.02	65	55.99	43.79	0.04
B20	4.11	70	56.92	43.64	0.07
B30	4.16	85	56.30	37.25	0.31
B40	4.38	83	56.53	37.40	0.31
B50	4.52	90	55.22	38.22	0.69
B100	5.46	135	49.04	37.62	0.89
B2+Add	3.53	64	61.35	45.89	0.05
B10+Add	3.62	71	60.97	45.41	0.05
B20+Add	3.72	72	59.76	44.62	0.04
B30+ Add	3.91	74	59.67	43.79	0.03
B40+ Add	4.05	81	58.78	43.44	0.05
B50+ Add	4.23	82	59.16	42.89	0.07
B100+Add	5.34	153	52.40	40.94	0.08

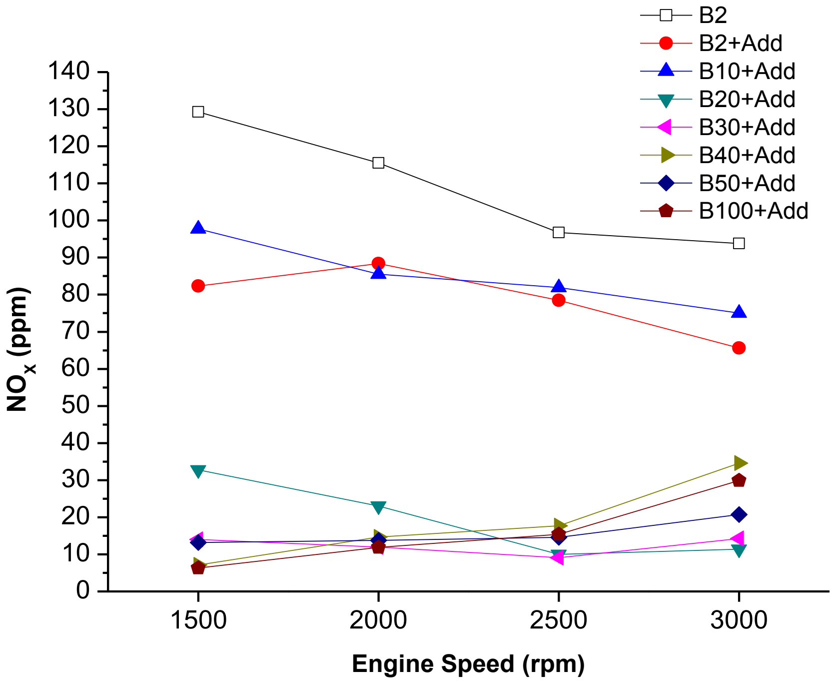

Figure 2 : NO_x emissions from the engine to be fueled by the blened POB fuels in the different conditions.

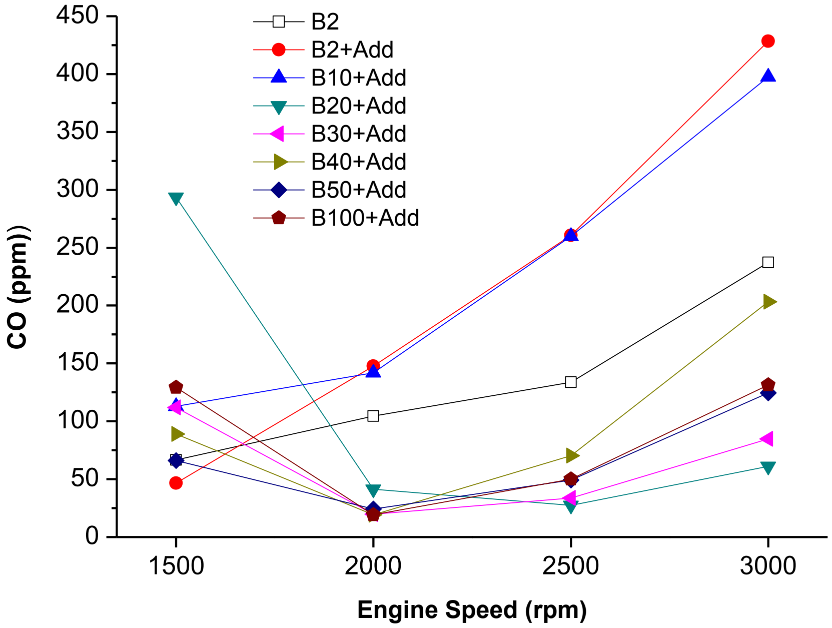

Figure 3: CO emissions from the engine to be fueled by the blened POB fuels in the different conditions.

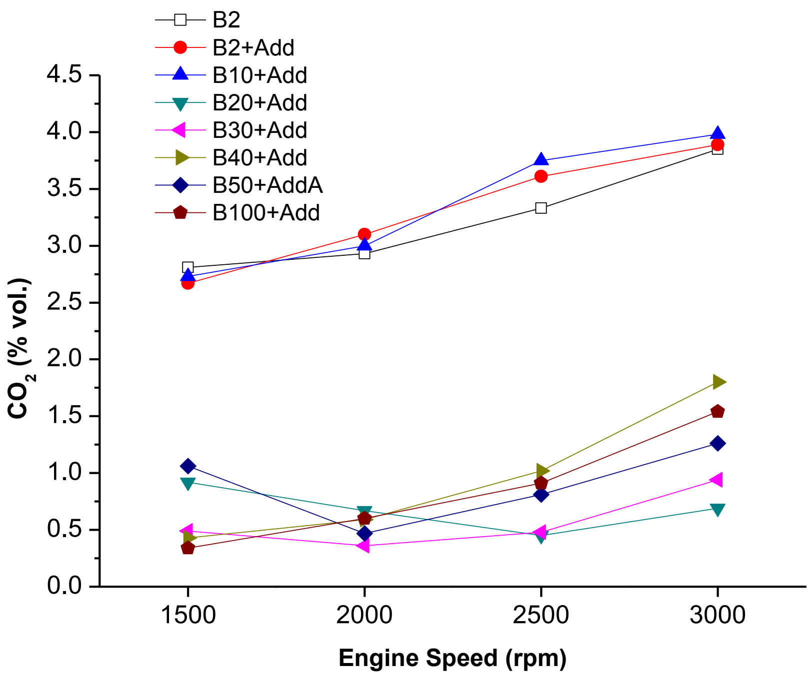

Figure 4: CO_2 emissions from the engine to be fueled by the blened POB fuels in the different conditions.

Brake power and wheel power were measured at the engine speed from 1500 rpm to 4000 rpm during engine operation to be fueled the blended POB fuels as shown in Figure 5. It was found that the brake power and wheel power for using the different blended POB fuels merely droped comparing with using B2. As be allowed under the standard, the brake power merely reduced by 0.97% and 2.80% for B30+Add and B40+Add, respectively, which compared with B2. Therefore, organic based oxidative desulfurization is an alternative additive for improving POB fuel properties and reducing exhaust emission.

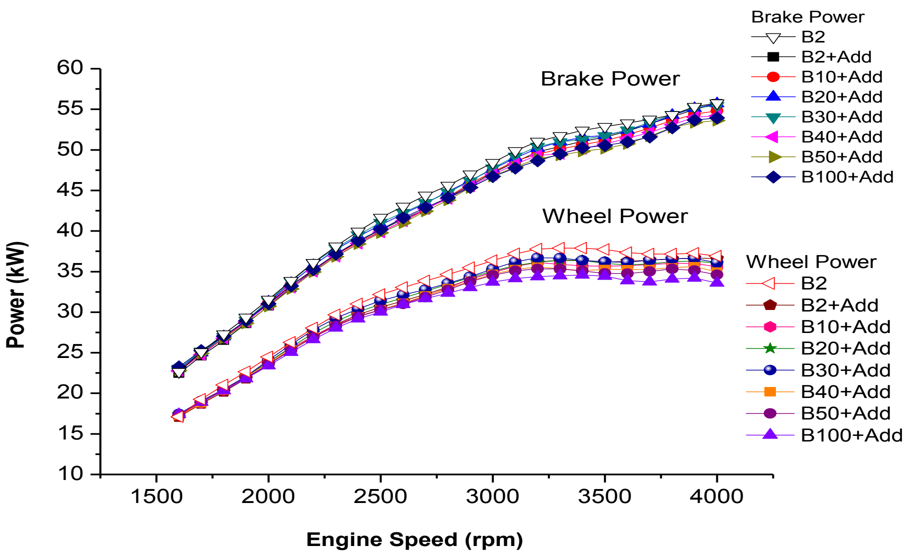

Figure 5: Variation of the brake and wheel powers for standard B2 and blended POB fuels

Conclusions

Adding organic solution based oxidative desulfurization as a catalyst in the POB fuels is an effective method to reduce the exhaust emission from IDI engine. The different blended POB fuel fractions were determined the physical properties under ASTM standard methods. It was indicated that organic additive blended in POB fuels is very effective on the reduction of the NO_x, CO, and CO_2 emissions because the organic additive based oxidative desulfurization is highly effective in removing sulphur compounds from the fuels. Under allowance of the set regulation standard, the appropriate POB fraction was B30+Add and B40+Add, which contributed to the maximum reduction of the exhaust emission. Meanwhile, the engine power measured from the tested engine fuelled by the blended POB fuels had the merely decrease, which compared with B2

Acknowledgment

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Optical Advances in the Field of Selected Solar Technologies for Exploitation in Building Energy Efficiency

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Abstract
Research findings in the scope of building science and building engineering are more frequently looking for a challenge related to current issues, recent progresses and future directions in the field of buildings, sustainability and creation of healthy built environment. One of the major factors contributing to this issue is also integration of new progressive materials and technologies on solar energy exploitation base. Those aspects in the area of renewable energy can contribute to the surveying of new building materials and innovative building envelope concepts based on interdisciplinary attributes of observation. It could be the one of the ways to improve thermal and energy performance of current building and including of new technologies, whose the aspects could potentially be implemented to improve energy efficiency of buildings. Recent advances in the field of solar technologies initiate fundamental strategy to apply the tools for improving the efficiency of all existing elements and concepts. Application of selective absorbent technologies may help us find new ways for optimization of energy consumption and mitigation of environmental impacts of buildings. In the building science for the field of renewable resources, the issues of solar energy, a progressive involvement is focused, among others, on the reflective, selective and solar cell technologies. Based on an optical analysis, the paper is focused on a spectral laboratory survey of those technologies to predominantly demonstrate its thermal aspects. The results of spectrophotometry and infrared spectroscopy represent an overview of indicators concerning with the optical efficiency of selected absorbent materials to be conceivably integrated in future energy efficient concepts.

Keywords: sustainable building, selective technologies, energy efficiency, optical survey, optical efficiency, solar absorbent features

Introduction

Due to expand new scientific knowledge, it is strongly recommendable to focus on current research and developments in the field of comprehensive building solutions and implementation of advanced material forms. Recently a wide range of progressive solutions has been described but they are yet to be not assessed from building physics (thermal and energy) point of view. Newly disseminated findings can be implemented to the field of Building Science. In the building science for the field of renewable resources, the issues of solar energy have also become of a crucial importance. Attention in this field is focused, among others, on the research, development and innovations of solar cells, collectors and various photovoltaic elements with interdisciplinary attributes of investigation. For the purpose of the near zero energy performance attributes and subsequent approaching of zero energy balance, the observation is also focused on the façade systems integrating passive or active heating and cooling solutions with aim to achieve the greatest rate of the energy self-sustainability of the whole building. From this point of view, basic requirement concerns on synergy between ensuring of improvements in thermal insulation functions for winter periods and on the other hand its elimination of overheating in periods of summer. Here we can additionally find the ways how to implement various solar technologies based on optical advances in applications of building integrated systems. Development and evaluation of different technical solutions and integration of new progressive materials are of a relevant interest of the ongoing research. Considering the most recent findings, it could be the one of the directions to improve thermal and/or energy performance of current building with direct relation of including the new technologies. Currently, numerous research activities deal with utilization of the recent technologies in the field of nanomaterials which, especially in the last few decades, have been undergoing steep progress. In the scope of research and development we frequently confront the application of tools for optimizing and improving the efficiency of existing elements and technologies. Potential way of development of solar technology includes even innovation of materials with solar technologies base, in particular reflective [1] [2], solar [3] [4] and selective [5] functions as those of the spectrally developed that may principally employ required parameters for specific cases of particular thermal radiation spectrum.

Thermal radiation spectrum in Building Exploitations

In general one of the most important roles in the mechanism of thermal radiation transfer is influenced by the optical properties of material depending, in an ideal case, upon the impact angle and the wavelength of radiation. The decisive range of the electromagnetic waves affecting the process of thermal radiation at the building surface is roughly within 0.40 to 40.00 μm. The characteristic regions are basically defined by boundaries in different cases of building applications (Tab. 1).

Each range of thermal radiation has a specific importance for building energy efficiency. An important aspect of thermal performance effect for the area of thermal radiation is depend on spectral irradiance of the sun with particular dependence on wavelength known as solar radiation spectrum (Fig 1a), whilst the spectral radiance intensity of temperatures typically related to buildings and build environment are demonstrated on Fig.1b as related to longwave radiation phenomena. Overall, the building envelope tends to be markedly chilled due to radiating heat exchange, especially under clear and cloudless sky conditions. The marginal condition of thermal radiation shifts towards longer waves in the longwave region.

Table 1 Characteristic regions of thermal radiation in building exploitations

character:	spectral range	building application
VIS	0.38 – 0.78 µm	especially concerning the reflective features of the surface finish color character
NIR	0.78 – 2.50 µm	predominantly on outdoor surfaces, the source of radiation being the Sun (T = 6000 K), or heat sources with thermodynamic temperature exceeding 800 K
LW	2.50 – 40.00 µm	predominantly on indoor surfaces, the source of this type of radiation being, e.g., current heating systems achieving thermodynamic temperatures around 350 K, as well as the sky as a source of cooling

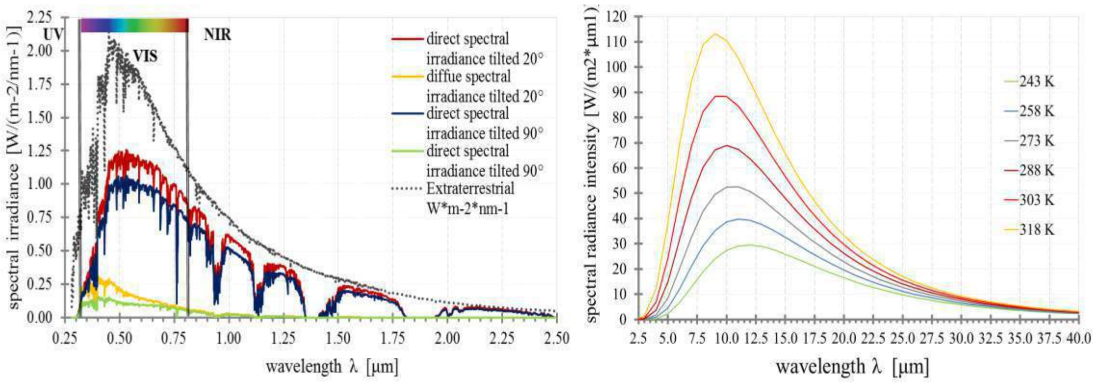


Figure 1 (a) Standard direct and diffuse spectral solar irradiance for 20º and 90° sun-facing tilted surfaces [6]; (b) spectral radiance intensity of temperatures typically related to buildings and build environment from -30°C to +45°C

Methodology of observation

As one of the aims of this study is to utilize potential technologies for building energy efficiency based on solar exploitation can be applied, the paper deals, basically, with the optical efficiency and its advances of selected solar technologies. For the purpose of this study, we use three groups of coatings representing solar technologies, the solar reflective and both of the absorbent of cell as well as selective bases. From the view of thermal aspects of building performance, it additionally introduces other evaluation indicators such as emissivity and Solar Reflectance Index (SRI). Since the production of recent solar technologies which can be applied in the progressive envelope constructions of buildings in both their active and passive forms, the objective of the study is to analyze reflectance parameters in the whole range of thermal radiation applying spectral analysis. Laboratory methods for estimation of solar reflectance and thermal emissivity were used for this study.

For the purposes of quantifying the solar reflectance, an UV/VIS/NIR spectrophotometer Perkin Elmer Lambda 1050 with 150 mm Spectralon integrating sphere (Fig. 2a) was used. This apparatus can register the spectral reflectance properties from 200 nm to 3 300 nm. Spectral curves and finally integrated values over 280 to 2 500 nanometers of Total Solar Reflectance (TSR) (Eq. 1) and of each specific region are presented, where R is percent reflectance, I is Solar Irradiance and dλ is the wavelength interval of integration. The solar reflectance of the analyzed surface is calculated by means of ASTM Standard G173 [6] for the hemispherical global tilt irradiance.

$$\%TSR = \frac{\int (\%R \times Id\lambda)}{\int Id\lambda} \times 100 \tag{1}$$

The Solar Reflectance Index (SRI) is exploratory calculated due to demonstrate material proper with respect to energy efficiency especially in building practice. The calculation of the SRI is performed according to ASTM E1980-11 [7] and based on quadratic formula (Eq. 2, 3). The standard conditions for this calculation are defined as the convective coefficient of 12 W/(m^2*K), solar flux of 1000 W/m^2, ambient air temperature of 310 Kelvin (K), and sky temperature of 300 K.

$$SRI = 123.71 - 141.35 \times x + 9.655 \times x^2 \tag{2}$$

$$x = \frac{(\boldsymbol{\alpha} - 0.029 \times \boldsymbol{\varepsilon}) \times (8.797 + h_c)}{9.5205 \times \boldsymbol{\varepsilon} + h_c} \tag{3}$$

For the purposes of quantifying the thermal emissivity, an infrared spectrometer Nicolet 380 from the Thermo Electron Corporation equipped with an integrating sphere Mid-IR ™ IntegratIR (Fig. 2b) from PIKE Technologies was used. The results were obtained by the DRIFT method and authenticated by repetitive measurements of each sample. Spectral curves of the reflectance as a function of the wavelength are presented for spectral range from 2.5 to 20.0 μm. As a result from the law of the conservation of energy and Kirchhoff's laws (Eq. 4), emissivity can be derived and consequently used for determination of the measurement results in terms of emissivity values.

$$\varepsilon = \alpha = 1 - \rho \text{ ,or } \varepsilon_\lambda = \alpha_\lambda = 1 - \rho_\lambda \tag{4}$$

As a consequence, Plank´s formula (Eq. 5) of spectral radiance intensity of 273 K black body $M_{0,\lambda}$ is used as the weighted function for determination of emissivity values.

$$M_{0,\lambda}(\boldsymbol{\lambda}, T) = C_1 \times \boldsymbol{\lambda}^{5} \times (e^{\frac{C_2}{kT}} -1)^{1} \tag{5}$$

Figure 2 (a) UV/VIS/NIR Spectrophotometer Perkin Elmer Lambda 1050 with 150 mm Spectralon integrating spheres; (b) FT-IR infrared spectrometer Nicolet 380 and integrated sphere Mid-IR ™ IntegratIR

As is well known, the significant region lies somewhere between 8.0 and 15.0 μm in building applications (as demonstrated in accordance with the maximum of spectral radiance intensity on Fig. 2b), where all the standard bodies radiate the maximum of its energy. It also represents an area of atmospheric windows where the outdoor conditions are transmissive to thermal radiation.

Solar reflective coatings

In general, coatings mainly create thin surface layers. Their character does not have much of an influence on the thermal resistance of building envelopes. However, they can markedly influence transfer effects on building surfaces and can therefore be relevant to the thermal performance of buildings as well as many others benefits. These benefits can contribute to reduction of heating and cooling loads of building environment, decreasing of surface temperatures of building envelopes, contribute to the reduction of the air temperature due to the heat-transfer phenomena therefore improve outdoor thermal comfort and finally reduce the heat-island effect [8] [9]. One of the assumptions of their improved thermal properties is based on the optical properties of the building surfaces that can be considered as significant for this area. Therefore, this issue can be quantified in terms of energy efficiency of buildings at two problem fields of the electromagnetic radiation spectrum in the optics. The first on the solar reflectance properties, while the second are further specified in the longwave radiation field of building surfaces and thermal emissivity parameters.
For spectral analysis purpose: The samples were collected and divided into two groups of coatings: standard facing coatings of acrylic base (group A) and based on hollow microspheres (group B). The table (Tab. 2) shows all the measured samples, their description, color and material base.

Table 2 Table of studied coatings on reflective base

Symbol:	Expression and description:	color
A1	Disperse acrylate facing coating, reference	white
A2	Disperse acrylate facing coating, reference	orange
A3	Disperse acrylate facing coating, reference	5% gray
B1	Facing coating of hollow ceramic microsphere base	white
B2	Facing coating of hollow ceramic microsphere base	orange
B3	Flexible coating consisting of hollow borosilicate microspheres	white
B4	Coating of hollow ceramic microsphere base	white
B5	Coating consisted of hollow ceramic and silicone microspheres	white

Table 3 Total solar reflectance values ρ_λ, *SRI* parameters, and total spectral emissivity ε_λ and reflectance ρ_λ as weighted values in measured infrared spectrum

Symbol:	ρ_λ	*SRI*	$\rho_{\lambda\ SRS}$ 0.3 – 2.5 μm	$\rho_{\lambda\ SRS}$ *VIS* 0.3 – 0.8 μm	$\rho_{\lambda\ SRS}$ *NIR* 0.8 – 2.5 μm	ε_λ 2.5 – 18.0 μm	ρ_λ 2.5 – 18.0 μm
A1	0.83	105	0.81	0.78	0.86	0.92	0.08
A2	0.54	65	0.53	0.45	0.63	0.94	0.06
A3	0.69	85	0.68	0.67	0.69	0.94	0.06
B1	0.85	108	0.83	0.81	0.86	0.94	0.06
B2	0.63	77	0.61	0.51	0.77	0.94	0.06
B3	0.83	105	0.81	0.79	0.84	0.94	0.06
B4	0.83	105	0.81	0.79	0.84	0.94	0.06
B5	0.79	99	0.78	0.75	0.82	0.93	0.07

The evaluated final results were authenticated by repetitive measurements of each sample (Table 3). The comparison of multiple measurements of each specimen enabled us to achieve results with negligible deviation and to simplify diagrams in showing only one single spectral curve representing one sample. The diagrams (Fig. 3a,c) show the spectral curves of reflectance in the solar radiation spectrum (200 nm to 2500 nm) and Spectral curves of the reflectance as a function of the wavelength (in spectral range from 2.5 to 20.0 μm) are shown in the figures (Fig. 3b,d).

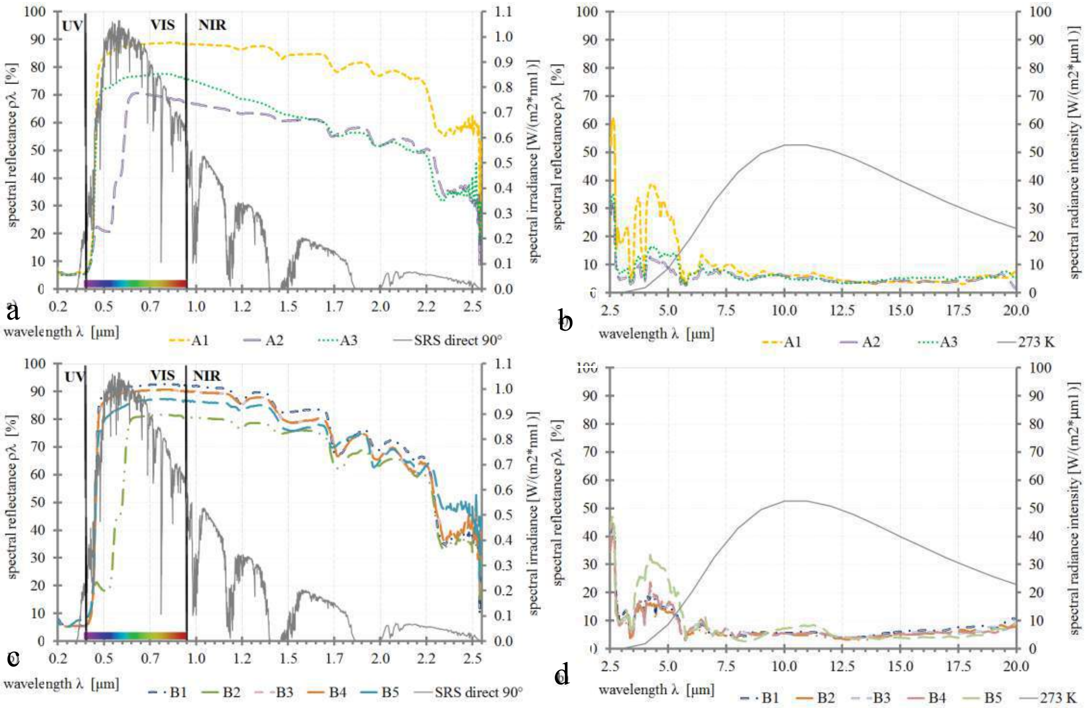


Figure 3 (a) Solar reflectance measurements gr. A (b) thermal emissivity measurements gr. A (c) Solar reflectance measurements gr. B (d) thermal emissivity measurements gr. B (c)

Solar cell technologies

Here the primary intention relies on the solar cells´ applications. The basic aspects of their efficiency also include involvement of the optical properties of materials making up cells integrated, to major extent, into solar and photovoltaic panels. Apart from others, there are efforts to implement all those progressive elements in various active and passive forms also as a part of building envelopes [10, 11] (BIPV – Building Integrated Photovoltaics). It also offers the way of their applications, in which the field of solar energy has recently indicated a significant expansion [12, 13, 14]. In particular, the continuously developed technologies and advances [15] of creating these elements can be used also in applications of progressive building envelopes or additionally in the innovative concepts of solar facades integrating the latest advanced material solutions. In these concepts they can actively contribute, to large extent, as part of the top envelope. On the other hand, their thermal properties may be used for secondary functions where, apart from the decisive indicators of their efficiency, observation must be also conducted to other thermal and optical parameters. In general, the overall efficiency of solar cells is quantified by the ratio of the electrical output of a solar cell to the incident energy in the form of sunlight. Several factors enter this indicator and affect the final efficiency value [16] including its reflectance efficiency, thermodynamic efficiency, charge carrier separation efficiency, and conduction efficiency values. Mainly the darks colored cells (dark blue, violet to black, or their mutual combination at refraction of light) are currently among the most frequently used solar cells. While dark colors approach the highest solar absorption values, from the view of optical efficiency they are still the most typical colors in all kinds of the industry. At present, there are also frequent requirements for the colorfulness, particularly in building envelopes, and they can contribute, to large extent, to a better variety and additional architectural measure in the final formation of buildings. The consequence of this is that solar cells with various color variations appear to have a relevant interest.

One of the key aspects in the production of solar cells is to minimize losses with the aim to achieve the highest possible efficiency [17]. In general, we distinguish the losses as optical and electrical. Optical losses are caused by the fact that a large part of solar radiation reflects back to space after falling on the surface of semi-conductors. From the solar radiation point of view, the color and glossiness of the surface are the decisive factors for the visible region, whilst the material composition and the texture of the surface are the leading ones for the near infrared. An important aspect is that their surface will adapt in such a way that its reflectance is reduced as much as possible. Various antireflective layers can be applied on the surface or a textured surface can be made by etching, which will erode the smooth and glossy surface to reduce its solar reflectance. These methods are able to reduce the rate of reflectance down to below 10%. In addition, the current technologies of antireflective layers cause properties which may thermally contribute to selective effects. Table 4 presents all values for individual regions and then it compares them numerically in bar graphs for selected colored crystalline solar cell technologies. Spectrally there are presented in terms of curves by following figures (Figs. 4 and 5)

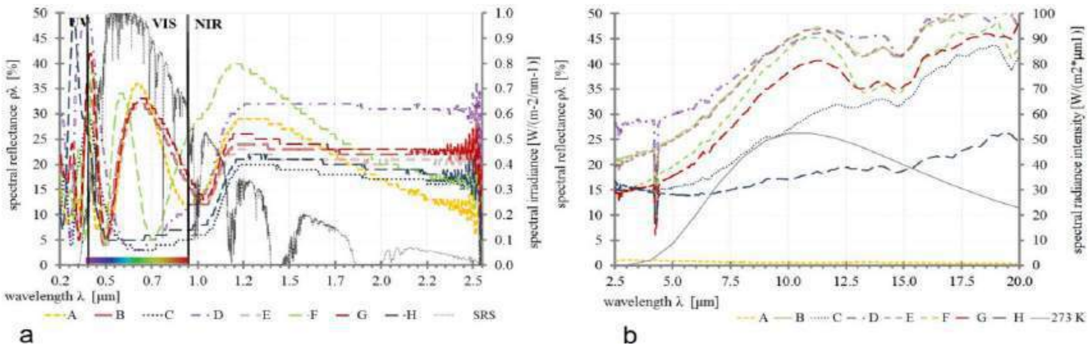


Figure 4 (a) Solar reflectance measurements (b) thermal emissivity measurements

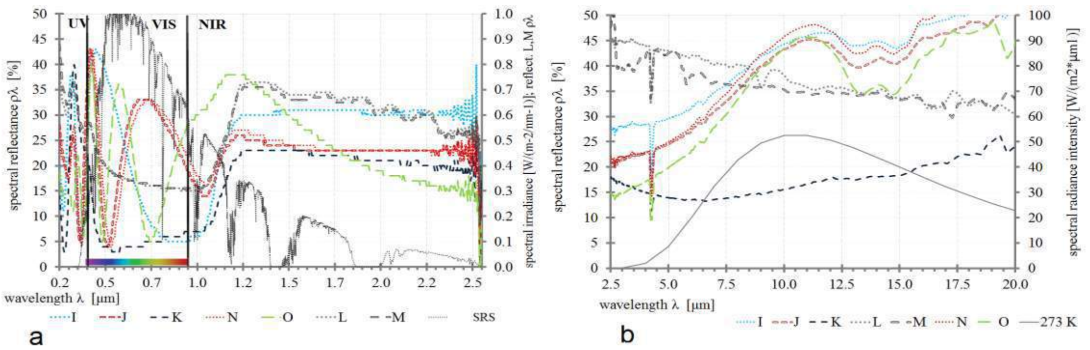
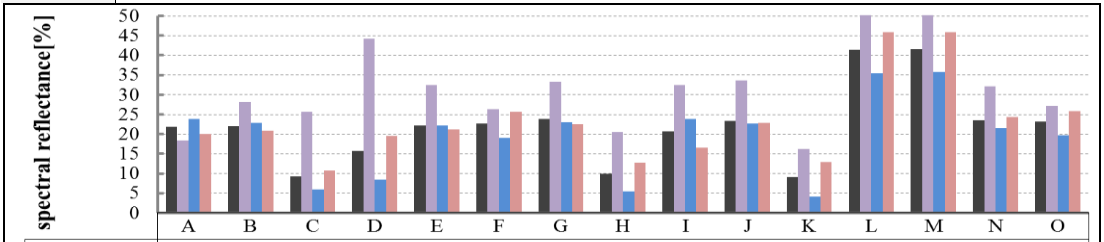


Figure 5 (a) Solar reflectance measurements (b) thermal emissivity measurements

Table 4 Reflectance ρλ, emissivity ελ and solar reflectance index SRI in particular spectrums



	A [%]	B [%]	C [%]	D [%]	E [%]	F [%]	G [%]	H [%]	I [%]	J [%]	K [%]	L [%]	M [%]	N [%]	O [%]
Colors															
ρλ: TSR	21.8	22.1	9.3	15.8	22.2	22.6	23.8	9.9	20.7	23.3	9.1	41.4	41.6	23.5	23.1
ρλ: UV reg.	18.3	28.1	25.6	44.2	32.5	26.4	33.3	20.6	32.4	33.6	16.2	51.8	53.2	32.2	27.1
ρλ: VIS reg.	23.9	22.8	5.9	8.5	22.2	19.1	23	5.5	23.8	22.6	4.2	35.4	35.8	21.5	19.7
ρλ: NIR reg.	20.1	20.8	10.7	19.5	21.2	25.6	22.5	12.8	16.5	22.9	12.9	45.9	45.9	24.4	25.8
ελ: IR reg.	83.3	62.8	76.2	61.0	63.0	67.0	62.8	83.6	61.1	64.2	84.7	61.2	63.5	62.4	66.7
SRI	6	7	0	0	7	11	10	3	4	9	2	34	36	9	11
Surf. Temp	80.0	79.8	77.0	83.5	79.8	78.3	78.7	81.3	80.8	79.0	81.6	69.6	68.7	79.1	78.3

Solar selective technologies

Finally, our recent knowledge can contribute to integration of selective absorbent technologies, as key absorbing factors that from thermal aspect point of view may be used to prevent heat loss in winter, decrease an overheating in summer and finally allow for the conversion of incident solar energy into thermal energy. Table 5 represents selected spectrally selective materials as compared with standard paints, whilst Figure 6 presents its spectral nature.

Table 5 Table of studied selective and standard technologies

S:	Material:	Surf. shade	color	*ρλ* 0.3 - 2.5 μm	*ελ* 2.5 -18.0 μm
1	Blacksmith refractory coating	semi-gloss	black	0.15	0.82
2	Standard synthetic coating	mat	black	0.04	0.94
3	Standard synthetic coating	gloss	black	0.05	0.93
4	Spectrally selective coating TiNOx - Nano	mat	black	0.10	0.06
5	Spectrally selective coating TiNOx - Cu	gloss	blue	0.05	0.07
6	Spectrally selective coating TiNOx - Al	gloss	blue	0.06	0.04
7	Titanium nitride coating	mat	black	-	0.45

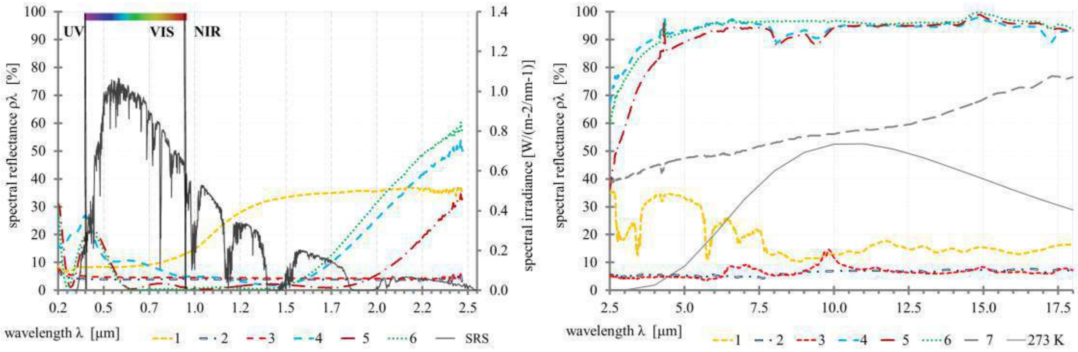


Figure 6 (a) Solar reflectance measurements (b) thermal emissivity measurements

Conclusion

The paper presents an overview of the optical efficiency in the field of selected solar technologies that was under observation to find the property of which the secondary functions may be applied to improve the thermal and energy efficient properties of building envelopes. The results are a comparison of spectral curves and reflectance radiative parameters which are of crucial importance for a detailed examination of heat transfer phenomena at the boundary with the surrounding built and urban environment. It can be observed from the results that the recent technologies and advances which are currently used to produce solar based materials may be used in applications where it is useful to activate the selective functions of surface layers to contributing of various thermal aspects of building envelopes in the heat transfer phenomena. The analysis demonstrates that from the colored solar cell area the blue mono-crystalline one indicates the most suitable properties in the analyzed indicators related to the attributes of building thermal performance.

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Corporate Social Responsibility Disclosures: A Study of the Financial Characteristics and Capital Expenditures of the S&P 500 Firms

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The Asian Conference on Sustainability, Energy & the Environment 2015
Official Conference Proceedings

Abstract
This paper examines the corporations' decision to disclose information related to corporate social responsibility (CSR) and its implications. While there are no accounting standards similar to those for financial reporting, companies here in the U.S. and abroad have voluntarily started disclosing CSR information. While a study as recently as 2010 shows that only 30 percent of S&P 500 firms issued CSR reports, this situation has changed dramatically in the last 5 years with respect to the extent and substance of CSR disclosures.

The issue of whether and how CSR disclosures are informative deserves attention. For investors, the potential interplay between financial results and CSR reporting provides an important piece of information. For a policy maker, this interplay provides an important dimension to consider with respect to environmental policy evaluation. For corporate managers, the impact of CSR disclosures on public image and the cost of capital plays an important role in strategic decision-making.

In this paper, I analyze possible motivators for the disclosure decision. I also examine how capital expenditures may be associated with CSR disclosures. I use data available from Bloomberg for measures of CSR. As expected, I find a positive association between CSR reporting and firm size; and between CSR disclosures and environmentally sensitive industries. More importantly, and this is the main contribution of my paper, I find a positive association between CSR disclosures and capital expenditures, but this positive association is reduced by the energy- and materials intensity of the industry in which a firm finds itself.

Introduction

Society's concerns with the impact of the corporate world in the last 50 years has gradually led corporations to a recognition of the need to take action to meet these concerns. One change has been the greater willingness of an increasing number of corporations to disclose information to the public concerning their corporate citizenship or what has become known as corporate social responsibility (CSR). According to McWilliams and Siegel (2001), CSR may be defined as "actions that appear to further some social good, beyond the interests of the firm and that which is required by law" (p. 117).

In this paper I focus on capital expenditures and ask whether they have a bearing on the extent to which a corporation behaves responsibly. Capital expenditures determine the trajectory of a corporation's growth, with a definite economic impact on itself and society at large. Drilling for oil and natural gas, for example, is such an activity. Whether this may be accompanied by responsible corporate behavior is an empirical question that has not been widely examined in the literature. Part of the reason for this has been a lack of readily available data for a wide range of companies and industries. This has changed in the past decade or so, as U.S. and international organizations concerning with CSR have started working with corporations for more disclosures and more uniformity in such disclosures. For example, the Global Reporting Initiative (GRI) based in the Netherlands has proposed a reporting framework for corporations to follow in disclosing CSR information. Disclosure scores and performance data on the environment, society, and governance (ESG) are now available from Bloomberg.

I. Review of the Literature

1. Voluntary disclosure and public policy

Voluntary disclosure theory (as explained by Dye, 1985 and Verrecchia, 1983) predicts a positive association between environmental performance and the extent of discretionary environmental disclosure. Environmentally superior firms disclose to signal their superiority, while poor performers tend to disclose less. This outcome is attributed to uncertainty on the part of disclosing firms concerning which type they belong to and also to the proprietary costs of disclosure.

2. Environmental disclosure and public policy

Lydenberg, Rogers, and Wood (2010) made the case for mandatory reporting of environmental impact in that it provides consistent and useful information to investors and policy makers. Crawford and Williams (2010), comparing the U.S. and France, found that regulatory pressures are important determinants of quality disclosures.

Lyon and Maxwell (2011) model environmental disclosures in which public policy may be conducive to disclosures that are more in line with environmental performance. Wiseman (1982), in her study of 26 companies, reported that there was no relation between environmental disclosures and actual environmental performance.

3. Determinants of Environmental Disclosure

a. Environmental Performance

Patten (2002) reported a negative correlation between environmental disclosures and environmental performance, and the correlation is more pronounced among firms in non-environmentally sensitive industries (ESIs). Social and political pressures may explain the negative correlation. Bad environmental performance leads to pressure to disclose, and ESIs are not affected as much by this pressure because they already receive more scrutiny. Ullmann (1985) developed a framework for predicting corporate social activity based on a stakeholder theory of strategic management.

Clarkson, Li, Richardson, and Vasvari (2008) focused on purely discretionary environmental disclosures and developed a content analysis index based on the Global Reporting Initiative sustainability reporting guidelines to assess the extent of discretionary disclosures in environmental and social responsibility reports. Using a sample of 191 firms from the five most polluting industries in the U.S., they reported a positive association between environmental performance and the level of discretionary environmental disclosures, consistent with the predictions of the economic theories of discretionary disclosure. However, for companies experiencing pressure for better environmental performance by external stakeholders, the social-political frameworks do provide a structure for predicting disclosures of environmental information when the company has not made a hard commitment to disclose the information.

A number of studies have explored the associations between environmental disclosures, environmental performance, and/or financial performance. Clarkson, Li, and Richardson (2004), examining and pulp and paper industry, found increased disclosures of environmental information when firms are more likely to pollute, when stakeholders become more aware of the firms' environmental liabilities, and when threats to obtaining regulatory costs decline. They also found that environmental capital expenditures yield gains for low-polluting companies, but not their high-polluting counterparts. Also, investors utilize data on companies' environmental performances to assess future environmental liabilities that are yet to be recognized.

Some companies manage their environmental disclosures in relation to performance. For example, Cho, Patten, and Roberts (2006) found that companies with higher political lobbying efforts have increased environmental disclosures and lower environmental performances, suggesting a management strategy to influence environmental regulatory procedures. This management also involves the use of reporting language, as reported by Cho, Roberts, and Patten (2010) in that the worse the corporate environmental performance, the more optimistic and vague the environmental disclosure language in the entity's annual reports.

b. Economic Performance

Al-Tuwaijri, Christensen, and Hughes (2004) arrived at different results from Patten (2002) when they considered endogeneity among environmental performance, financial performance, and environmental disclosures. They reported positive links, suggesting that environmental stewardship and economic success do not have to be adversarial objectives. Orlitzky and Benjamin (2003) provided general support for a positive relation between corporate socially responsible behavior and financial performance. Ruf, Mrulidhar, Brown, Janney, and Paul (2001) used stakeholder theory to explain a broader positive link between

corporate social performance and financial performance, suggesting that firms better serve their shareholders when they address other stakeholder concerns. Jose and Lee (2007) suggested that companies perceive environmental issues as a competitive advantage instead of a regulatory burden. In contrast to the above results, Murray, Alan, Donald Sinclair, David Power, and Rob Gray (2006) found no relation between UK companies' stock returns and their environmental and social disclosures. However, there was a positive relationship between a company's level of disclosures and the consistency of their financial returns (i.e. high disclosure levels correlated with consistently high returns, and vice versa).
In another study on market reactions, Blacconiere and Northcutt (1997) showed that the market-placed a value on environmental disclosure information surrounding U.S. environmental regulations in 1986 (the Superfund Amendments and Reauthorization Act). Specifically, chemical companies with pre-1986 environmental disclosures received better market reactions compared to companies disclosing under EPA regulations. This finding supports Blacconiere and Patten's (1994) earlier analysis of a different critical event - the 1984 Union Carbide chemical leak incident in Bhopal, India. In this study, investors also appeared to respond more favorably (i.e. not as negatively) to chemical companies that disclosed environmental information more thoroughly before the incident occurred.

Within industry subsectors like pharmaceutical, chemicals, mining, transport, electronics, and automobiles, whose activities either result directly in high environmental impacts or are at least are suspected of causing them, empirical evidence exists (see, for example, Ling and Mowen, 2013) that environmental information disclosure has become a competitive relevance.

Blacconiere and Patten (1994) found that chemical firms that disclosed more environmental information prior to the 1984 Bhopal disaster experienced a lower market reaction than firms releasing less information. Investors apparently found firms' environmental disclosures to be informative and conditioned their market reaction to the disaster accordingly. Roberts (1992) empirically tested the ability of stakeholder theory to explain social responsibility disclosures. She found that measures of stakeholder power, strategic posture, and economic performance are significantly related to levels of corporate social disclosure.

Cowen et al. (1987) examined the relation between a number of corporate characteristics and specific types of social responsibility disclosures, based on an extensive sample of U.S. corporate annual reports. Corporate size and industry category are found to correlate with certain types of disclosures while the existence of a corporate social responsibility committee appears to correlate with one particular type of disclosure.
Trotman and Bradley (1981) suggested some reasons why companies provide social responsibility information and examines the effects of four variables (size, systematic risk, social constraints, and management decision horizon) on the social responsibility disclosure practices of Australian companies.

Al-Tuwaijri, Christensen, and Hughes (2004) studied the relation among environmental disclosure, environmental performance, and economic performance. They found "good" environmental performance is significantly associated with "good" economic performance, and also with more extensive quantifiable environmental disclosures of specific pollution measures and occurrences.

King and Lenox (2001) found that the relation between environmental performance and financial performance may be conditioned on a firm's other characteristics, so that the relation may not be monotonic. This result may thus explain a lack of an association in some studies between environmental performance and financial performance.

c. Legitimacy theory

This theory suggests that firms disclose environmental information simply to gain permission from society to operate. Thus, if society is appeased by only a firm's level of information disclosure (i.e. words but not necessarily action), then improved environmental performance cannot be a guaranteed outcome. This potentially explains the lack of association between environmental disclosure and environmental performance, as reported by Walden and Stagliano (2003) and by Patten (2002).

Adams (2002) had a similar observation and argued that the reason for the increase in the number of companies producing environment reports is not regulation or public pressure but the desire to improve the corporate image with customers, regulators, investors, and the community.

d. Capital expenditures

Patten (2005) reported findings that suggest that projections of environmental capital expenditures were not as accurate as total capital expenditures, but did not explain why this may be the case.

Clarkson, Li, and Richardson (2004), examining and pulp and paper industry, found increased disclosures of environmental information when firms are more likely to pollute and when stakeholders become more aware of the firms' environmental liabilities. They also found that environmental capital expenditures yield gains for low-polluting companies, but not their high-polluting counterparts. Combining these results would seem to indicate that there is a negative association between environmental capital expenditures and environmental disclosures.

Cho, Freedman, and Patten (2012) examined the disclosure of environmental capital expenditures and reported a negative correlation between these expenditures and environmental performance, suggesting that these disclosures were designed to address political and regulatory concerns.

4. CSR Disclosure and Economic Performance

Ullman (1985) reviewed studies done in the 1970s and early 1980s and reported conflicting results that led him to suggest that CSR and its relation to economic performance was in need of a theory. Studies that have not found a statistically significant association between CSR and financial performance include those of McWilliams and Siegel (2000); Aupperle, Carroll, and Harfield (1985); Griffin and Mahon (1997); and Soana (2011). In contrast, among those who have reported an association include Waddock and Graves (1997), Cochran and Wood (1984), and McGuire, Sundgren, and Schneeweis (1988) (positive association); and Wright and Ferris (1997) (negative association).

II. Hypotheses and Model

Available empirical evidence suggests that while corporate SCR reporting is increasingly becoming more prevalent, the question of the link between such disclosures on the one hand, and actual environmental and social performance on the other hand, is still not definitely settled. A necessary condition for such disclosures to be informative is that the cost of disclosing is inversely related the disclosing firms' actual level of expenditure on environmental performance.

1. Hypotheses

The following are the hypotheses that I want to test in this paper.

Hypothesis 1: There is a positive association between capital expenditures and corporate social responsibility (CSR) disclosures, ceteris paribus.

Hypothesis 2: The positive relation between capital expenditures and CSR disclosures is moderated by the nature of the industry the firm is in.

2. Discussion of ESG_DISC

ESG is a measure of the amount of disclosure calculated by Bloomberg from essentially counting the number of items reported by firms as related to (1) the environment, (2) society, and (3) governance.

3. Model

$$\text{ESG\_DISC}_{it} = \beta_0 + \beta_1\text{*INV\_ASSETS} + \beta_2\text{*ASSETS}_{it} + \beta_3\text{*IND\_DUM}_i + \beta_4\text{*DT\_EQ}_{it} + \beta_5\text{*RET\_EQ}_{it} + B_6\text{*BETA}_{it} + u_{it} \quad (1)$$

where DT_EQ_{it} is the debt to equity ratio; RET_EQ_{it} is the return on the firm *i*'s equity in year *t*; $BETA_{it}$ is a measure of systematic risk; $ASSETS_{it}$ is the total value of assets, used as a measure of firm size; IND_DUM_i is the industry classification for firm *i*. Table 1 below shows the summary statistics of the variables in the model, while Table 2 presents their correlations.

4. Discussion of model

Roberts (1992), who used data for the period 1984-1986 from the Council on Economic Priorities (CEP) for 130 major corporations, found no significant relation between systematic risk and corporate social responsibility disclosure. She found mostly significant associations between social responsibility disclosures (excellent 2, good 1, and poor 0) and the other variables in the model. Similarly, Trotman and Bradley (1981) and Alexander and Bucholz (1978) also found no significant relation between systematic risk and corporate social responsibility disclosure. Wiseman (1982) used 26 companies' annual reports to study environmental disclosures. She found they were incomplete, and that there was no association between environmental disclosures and environmental performance.
Cowen, Ferreri, and Parker (1987) examined different types of disclosure: environmental, energy, fair business practice, community involvement, human resource, and products. Orlitzky and Benjamin (2001) address the relation between corporate social performance and risk; they argue that the better a firm's social reputation, the lower its total market risk.

Eichholtz, Kok, and Quigley (2009) found that "firms active in the refining and energy sector are more likely to rent green space than conventional office space in the same cluster, despite the higher expense. Other relatively heavy users of green office space are in the finance, insurance, and real estate sector and in public administration, while manufacturing, retail, and wholesale trade are underrepresented in green office buildings. These cross-industry differences suggest that intangibles, which may differ with the nature of firms and industries, play a role in determining the economic premium for green buildings." Eichholtz, Kok, and Quigley (2010) explained that environmentally sustainable buildings (with a "green rating") command higher rents (by 3 percent per square foot) and market values that are higher by 16 percent.

III. Empirical Results

Table 1 reports summary statistics of the variables used in estimating the model. The S&P 500 sample shows a standard deviation of ESG disclosures (ESG_DISC) that is about half of the mean, with a minimum of 11.57 and a maximum of 65.29. In Table 2, ESG_DISC is shown to be positively correlated with firm size (as measured by total assets, ASSETS) and with capital expenditures as a percentage of total assets (INV_ASSETS). On the other hand, ESG disclosures are negatively correlated with market risk (BETA) and with the return on equity (RET_EQ).

Table 3 reports the estimation results for four combinations of the model as specified in (1). In the simplest model with the traditional variables of size (ASSETS) and industry (IND_DUM), the signs of the coefficients are as expected, that is ESG_DISC is positively related to size and to industry (more energy- and materials-intensive industries disclose more). In the more complete model that allows for the interaction between capital expenditures and industry, Table 3 reports a negative association. That is, firms with greater capital expenditures would be more likely to disclose, but this tendency is affected by the type of industry the firms are in: industries that are energy- and materials-intensive would make a firm less likely to disclose when it incurs capital expenditures.

IV. Conclusions

The purpose of this paper is to investigate whether and how a firm's capital expenditures may affect its CSR reporting, and how such a decision may depend on the type of industry that the firm is in. This is an area of research that has not been examined extensively, partly due to the lack of readily available data and to how questions related to CSR reporting have been raised. I consider capital expenditures to be one of the most important decisions made by a firm, which have wide-ranging effects. I look at one effect, which is the decision to disclose CSR activities. We find that firms that undertake greater capital expenditures also disclose more of their CSR activities. But somewhat surprisingly, this decision is negatively associated with the intensity of energy- and materials usage by firms.

Table 1
Summary Statistics

	Mean	SD	Min	Max	N
ESG_DISC	29.85	14.48	11.57	65.29	1,571
INV_ASSETS	4.49	4.72	0	25.64	1,571
DEBT_EQ	92.06	188.62	-391.78	1,529.75	1,571
RET_EQ	21.06	28.64	-64.31	142.75	1,571
BETA	1.15	0.57	0.21	2.79	1,571
ASSETS ($ billion)	$44.926	$109.898	$0.982	$885.296	1,571

Note. ESG_DISC is the disclosure score, as calculated from counting the number of items reported as related to the environment, society, and governance. INV_ASSETS is the ratio of capital expenditures to total assets, in percent. ASSETS is the value of total assets, in billions of dollars. IND_DUM is equal to 1 if a company is classified as energy and materials intensive, and 0 otherwise. RET_EQ is the return on equity, in percent. BETA is a measure of risk, equal to the beta coefficient in a market model of returns. DEBT_EQ is the ratio of total debt to total equity. A balanced data set is used, which is applicable to the period 2010 to 2013. The variables are winsorized at 1 percent. The number of observations is 1,571, from a balanced panel applicable to the period 2010 to 2013 for 485 companies from the S&P 500 list.

Table 2
Correlations

	ESG_DISC	INV_ASSETS	ASSETS	IND_DUM	RET_EQ	BETA
INV_ASSETS	0.1024					
ASSETS	0.1978	-0.1235				
IND_DUM	0.2030	0.2835	-0.0884			
RET_EQ	-0.0695	-0.0667	-0.0274	-0.0483		
BETA	-0.0794	-0.1391	0.1718	-0.0313	0.0761	
DEBT_EQ	0.0600	-0.0533	0.1628	-0.0094	-0.0017	0.1187

Note. ESG_DISC is the disclosure score, as calculated from counting the number of items reported as related to the environment, society, and governance. INV_ASSETS is the ratio of capital expenditures to total assets, in percent. ASSETS is the value of total assets, in billions of dollars. IND_DUM is equal to 1 if a company is classified as energy and materials intensive, and 0 otherwise. RET_EQ is the return on equity, in percent. BETA is a measure of risk, equal to the beta coefficient in a market model of returns. DEBT_EQ is the ratio of total debt to total equity. A balanced data set is used, which is applicable to the period 2010 to 2013. The variables are winsorized at 1 percent. The number of observations is 1,571, from a balanced panel applicable to the period 2010 to 2013 for 485 companies from the S&P 500 list.

Table 3
Estimated model. Dependent variable is ESG_DISC

	MODEL 1	MODEL 2	MODEL 3	MODEL 4
INV_ASSETS		0.8913*** (0.000)	0.8938*** (0.000)	0.8124*** (0.000)
ASSETS	0.3952*** (0.0009)	0.0322*** (0.000)	0.0320*** (0.000)	0.0327*** (0.000)
IND_DUM	0.0282*** (0.000)	9.8293*** (0.000)	9.8510*** (0.000)	9.5606*** (0.000)
INV_ASSETS* IND_DUM		-0.9601*** (0.000)	-0.9788*** (0.000)	-0.9003*** (0.000)
RET_EQ			-0.0281*** (0.000)	-0.0246** (0.042)
BETA				-2.2258*** (0.000)
DEBT_EQ				0.0034* (0.066)
CONSTANT	26.8068*** (0.000)	22.5161*** (0.000)	23.1479*** (0.000)	25.5745*** (0.000)
R^2	0.054	0.109	0.111	0.118

Note. ESG_DISC is the disclosure score, as calculated from counting the number of items reported as related to the environment, society, and governance. INV_ASSETS is the ratio of capital expenditures to total assets, in percent. ASSETS is the value of total assets, in billions of dollars. IND_DUM is equal to 1 if a company is classified as energy- and materials-intensive, and 0 otherwise. INV_ASSETS*IND_DUM is the interaction variable between INV_ASSETS and IND_DUM. RET_EQ the return on equity, in percent. BETA is a measure of risk, equal to the beta coefficient in a market model of returns. DEBT_EQ is the ratio of total debt to total equity. A balanced data set is used, which is applicable to the period 2010 to 2013. The numbers in parentheses are P-values.

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Sustainable Advances of Windows in Energy Efficient Buildings: A Perspective Novelty Integrating of New Conceptual Solutions

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Abstract
As result of building industry and its produces, buildings account more than one third of the primary energy use and roughly a quarter of the generation of greenhouse gases worldwide. Therefore, a reduction of the energy demand of buildings and increased use of renewable energy are of a high importance of climate change mitigation as well as of whole society development. In the most essential respects related to buildings, energy savings and resultant consumption depend on building performance, both at whole building and individual components level. Building openings are one of the key elements, especially in residential area of buildings, where numbers of perspective advances are recently subjected for future directions of sustainable development. The paper specifically point out the technical aspects and key specifics in windows and doors, as those implemented in current residential buildings, especially for Central Europe locations. It practically presents an overview of recent advances and current state ideas in this field. Finally, the paper demonstrate a potential approach for future buildings, where progressive prototype based on own conceptual solution is introduced in accordance to requirements on energy performance of buildings while respecting and ensuring the principles of sustainability.

Keywords: sustainable window, energy performance, window optimization, insulated glass unit

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Introduction

Windows in building structures are important transparent structures which are designed to separate the external and internal environments of buildings. The external environment (exterior) is influenced by weather changes. The temperature range in the exterior of buildings in Central Europe fluctuates between -20 °C to +40 °C. On the other hand, the internal environment of residential buildings is artificially adjusted to a steady condition comfortable for the stay of people. The indoor temperature is maintained between 20 and 29 °C. The temperature gradient between the external and internal environments significantly contributes to the overall energy balance of buildings and has a direct relationship with the environment [1]. The use of materials and structures with the best insulation properties possible are optimised [2] using computer technology so as to remove any risks [3]. At the same time, the focus is on reducing the summer overheating of interiors, especially in buildings with wood-based walls [4, 5]. The quality of details is crucial in the design of windows [6, 7, 8]. The fitting of windows and connection to the walls has a considerable influence on the resulting acoustic properties [9, 10].

History and Current Situation

The development of windows in buildings progresses in accordance with the material and the technical possibilities of the time. Glazing always plays a key role in the construction of windows. In the past, it was not possible to produce sheet glass of large dimensions, and therefore windows divided into smaller opening parts were used (fig. 1). Window frames individually bearing interior and exterior glass were exclusively made of wood [11] and the gap between them ranged between 100-300 mm. Later (approximately since 1960), the window frame was unified due to material savings and both glasses with a distance of about 40 mm were attached to a single frame (fig. 2). The operating comfort improved because handling only one element was enough to open the window. Windows reached the insulation value of the heat transfer coefficient U = 2.4 $W.m^{-2}.K^{-1}$.

Figure 1: Double casement double-pane window

Figure 2: Single casement double-pane window
Source: stavokomb

The insulating glass technology, which started to be implemented in the development of windows after 1990, significantly improved the thermal insulation properties. The principle of insulating glass is a hermetically sealed cavity with a thickness of 12-18 mm between the panes. The space between the panes is filled with an admixture of gasses in production, e.g. argon or krypton. Over the life, the insulating properties significantly depend on the quality of the sealing of the space between the panes. The newly produced insulation double-pane windows reach the value of U_w = 1.2 $W.m^{-2}.K^{-1}$.

Since 2010, the use of the insulating triple-pane window in the 4-16-4-16-4 (mm) composition has been gradually becoming a better standard. The glazing reaches $U_w \leq$ 0.8 $W.m^{-2}.K^{-1}$. The assembly puts increased demands on the bearing capacity of the frame and fittings because the triple-pane window weights upwards from 30 kg/m^2.

Materials used for window frames that carry the panes are PVC, wood and metals. PVC-based materials (fig. 3a, 3b) are gradually gaining a dominant position in the market due to the ease of production, excellent insulation properties and resistance to weather effects. In addition, recycled materials may be advantageously used in production [12, 13]. Wooden frames are used exclusively with aluminium sheeting of critical parts from the exterior (fig. 4a, 4b) [14].

The development of window structures over the past 30 years is continually heading towards improved parameters [15, 16]. Sections of conventional windows from the years 1990-2010 are shown in fig. 3a, 4a. The frame and casement sealing has only two levels of tightness and glazing of the window casement with a double pane. Frames with three levels of sealing and glazed with triple-pane glass have been becoming popular since 2010 (fig. 3b, 4b). The width of the frame and the casement is $\geq$ 90 mm, which achieves the insulation capability of the frame $U_f \geq 0.9$ $W.m^{-2}.K^{-1}$.

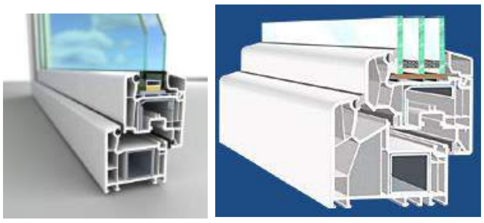

Figure 3a, 3b: PVC window section
Source: Veka

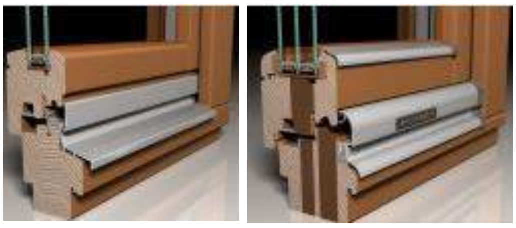

Figure 4a, 4b: Wooden window section
Source: Makrowin

The insulating glass is placed deeper into the casement to limit the linear thermal bridge around the glazing frame. This measure increases the visible height of the window frame and the casement which reduces the area remaining for glazing. For example, in a window opening with dimensions 1250/1500 mm, the proportion of the frame: glazing is 35 : 65 %!

Progressive manufacturers use low casement frames hanging in the interior in an effort to increase the area of glazing (fig. 5, 6), thereby improving the ratio of the frame areas in favour of glazing to 26 : 74 %. The casement remains as the carrier of fitting, the glazing is glued to it to increase the torsional stiffness.

Figure 5: Section of PVC window with a low frame Source: Internorm

Figure 6: Section of wooden window with a low frame. Source: Slavona Progression

A great disadvantage of standard windows from the architectural point of view is the immediately identifiable opening part which has a wide frame and casement (fig. 7 in the middle). In the new design, the casement is integrated using a smart solution (fig. 8).

Figure 7: Opening and fixed window.

Figure 8: Window with integrated casement frame.

The problem of limiting the effective area of the glazing is successfully resolved and other benefits are brought by a new patented design solution developed by the author of the paper.

The New Design

The basic idea that triggered the development of a window without a casement was the optimisation of production costs and elimination of redundant elements. The principle is based on the assumption that the insulating glass is self-supporting under certain conditions. The goal was to arrange the assembly so that the glazing has integrated fittings that provide the opening and tilting of the self-supporting casement (glass) (fig. 10).

#	Description	Thermal conductivity λ [W.m.K-1]
1a	External pane	1.0
1b	Second pane	1.0
1c	Internal pane	1.0
2	Composite profile	0.08
3	Window frame, wood	0.13
4	Fitting mechanism	50
5a	Tightness	0.35
5b	Exterior tightness	0.35
6	Inter-glazing spacer	0.25
7	Putty	0.5
8	Decompression cavity	0.025
9	Decompression cavity ventilation	-
10	External sill	-

Figure 9: Used materials and their properties

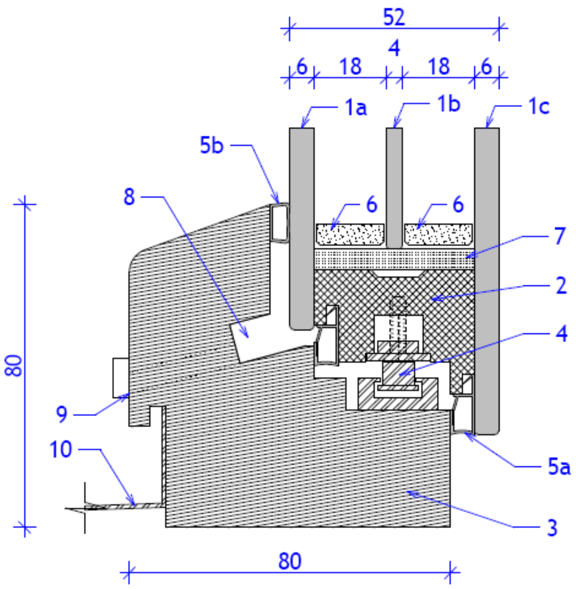

Figure 10: Cross-section at the sill

Used Materials

1. Insulating triple glazing (fig. 11). Glazing from the panes 6-18Ar-4-18Ar-6 weighing 40 kg.m^{-2} with insulation properties $U_w = 0.6$ W.m^{-2}.K^{-1}.

2. The integrated composite profile Purenit is glued between the inner and outer glass (fig. 12).

Figure 11: Section of PVC window with a low frame

Figure 12: Section of wooden window with a low frame

The prototype development workshop of the Technical University in Zvolen collaborated in the production. From the perspective of separation of glued joints, the glued joint was developed and tested in terms of cohesion of the composite material and glass (fig. 13) [17]. The test results confirmed that the bearing capacity of the glued bond exceeds the bearing capacity of the material (fig. 14). The glued joint exhibits excellent strength values and is safe and durable.

Figure 13: Pull-off test

#	Fmax (N)	A (m^2)	τ (Mpa)	note
1	860	0,001131	0,76	adhesive bond
2	1579	0,00144	1,097	adhesive bond
3	1473	0,00072	2,046	mass
4	1434	0,00072	1,992	mass

Figure 14: Pull-off test results

3. Window frame. The frame material is made of a base prism of laminated timber 84 x 86 mm (fig. 15) and provided with finishing. In terms of durability, the use of the PVC material is preferable. The possibilities of production of moulds for the special PVC profile are examined.

Figure 15: Manufacture of window frame

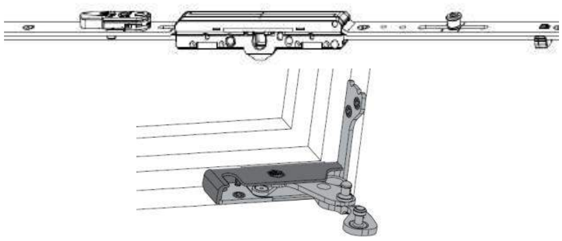

Figure 16: Window fittings. Low operator and concealed hinge. Source: Maco

4. Window fittings. We have negotiated with all major European manufacturers regarding the delivery of fittings for production. A low operator and hidden hinges from the manufacturer Maco won due to savings of space (fig. 16).
5. Sealing Ethylene-propylene-diene-monomer-rubber-based sealing is used at three levels of tightness.

Thermal Insulation Properties

The most critical part - bottom area of the window at the sill - was selected to assess the thermal technical properties. In other parts - lining and head, covering the window structure frame with a thermal insulation of the façade is considered, therefore the field of temperature will always end up being better. A comparison of the development of the temperature fields observed using software Therm 7.1. is shown in figures 17 and 18.

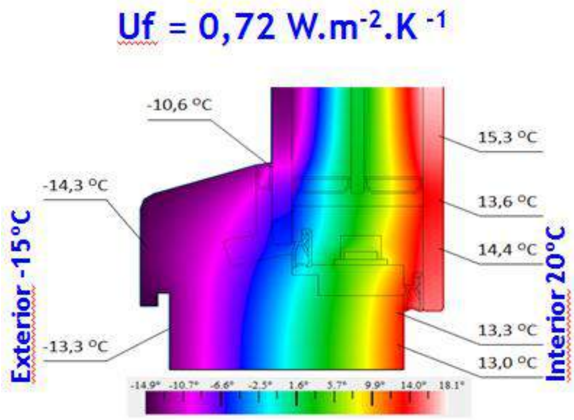

Figure 17: New window.
Temperature field and surface temperatures.

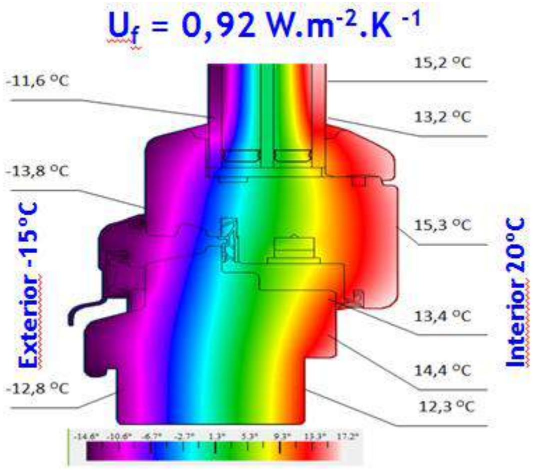

Figure 18: Standard window.
Temperature field and surface temperatures.

Conclusion

Based on two years of intensive development, a functional sample of an opening and tilting window without a glazing frame was manufactured. The design brings advantages in the elimination of the casement frame, thus reducing production costs and increasing the effective area of the glazing. The architectural appearance of buildings greatly benefits from the uniform appearance of the opening and non-opening assembly of windows when viewed from the exterior. Finally, we managed to optimise the thermal insulation properties of the innovated frame which reaches an excellent value U_f = 0.72 $m^{-2}.K^{-1}$ (fig. 17). The use of a new window element in buildings contributes to a reduction in energy demands which is in line with the principles of sustainability and efficiency in terms of the resources on the planet.

Acknowledgements

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Capacity Building Towards Improvement of Energy, Environment, and Community Development Compliance in Indonesia: A Case Study of Pesanggaran Power Generation

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Abstract
Gas Fired Power Plant of Pesanggaran is one of power generation unit that currently operated by PT. Indonesia Power – Generation and Service Unit of Bali. Having vision to become World Class Services Company, Pesanggaran Power Plant contributes to Environmental Compliance (PROPER) Awards by Ministry of Environment. PROPER clustered into compliance and beyond compliance assessment this represents quality of periodical environmental management. Previous period showing that Pesanggaran reach compliance step, and systematically improved for this year in order to reach beyond compliance awards.

Preliminary assessment indicates that Pesanggaran has a bright potential to improve its quality of environmental compliance. An essential step to accelerate the improvement is to assist the capacity building, not only restricted to environment itself, but also to energy and community development aspects as it assessed on PROPER. Capacity building covered several basic programs such as individual assessment of PROPER team, focus group discussion on excellent program of each aspects, workshop and internal coaching for reporting skill, and assistance on PROPER document viability.

About 20 in charge employee have been assessed on this program which is expected to increase PROPER results up to 15% of total score for Pesanggaran from compliance to beyond on energy sector. It is important to progressively improve the capacity building program for at least four years sustainable program as this paper will about to discuss. Supports from top management to all employees have a huge deal on this strategic capacity building program.

Keywords: Gas Fired Power Plant of Pesanggaran, Environmental Compliance, Capacity Building.

Introduction

Bali is the most worldwide renowned island in Indonesia prior to Greater Jakarta Area as capitol city. It also known that Bali has consistently familiar with its heritage and traditional culture that is connected to its pleasant view. Bali become recommended place to visit, contributes to local economic growth through tourism sector [1]. As a matter of fact, this condition drives higher energy demand, such as electricity, water supply, etc. PT. Indonesia Power – Generation and Service Unit of Bali, contribute to energy security aspect by generates electricity into Jawa-Madura-Bali (JaMaLi) grid interconnection system.

PT. Indonesia Power is an Indonesia's electricity generation company, a subsidiary of State Electricity Company (PT. PLN Persero). PT. Indonesia Power generates electricity with various source of primary energy, taking into account renewable and non-renewable energy, such as geothermal, diesel, natural gas, coal, etc. PT. Indonesia Power – Generation and Service Unit (GSU) of Bali using gas as primary energy through gas-fired power plant cycle. Currently there are three gas-fired power plant units that operated under GSU of Bali, such as Pesanggaran Gas-Fired Power Plant which located in Denpasar City, Gilimanuk Gas-Fired Power Plant in Jembrana District, and Pemaron Gas-Fired Power Plant in Singaraja, with total installed capacity is 427.59 MWe. Location of operated power generations in Bali is then figured in Figure 1.

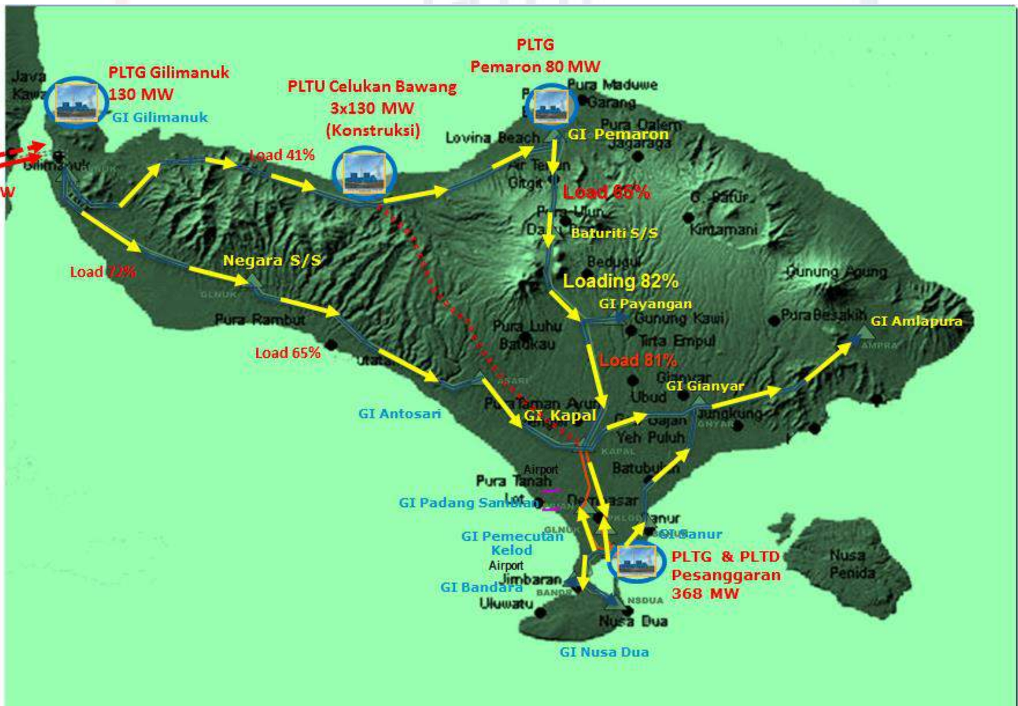

Figure 1: Power Generation System in Bali [6]

Despite having business in non-renewable energy sector, GSU of Bali is fully aware on sustainability that not only focused on business process, but also environment protection and social responsibility. It has proved that GSU of Bali contribute to government program in order to prevent degradation to the environment. One of the most integrated and prestigious government program is Environmental Compliance Assessment, that is nationally known as PROPER (Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup), annually assessed and awarded by Ministry of Environment.

Previous year shown that GSU of Bali has reached compliance step, and continuously improved to elevate its compliance to beyond compliance awards. Each of GSU of Bali which is Pesanggaran, Gilimanuk, and Pemaron Gas-Fired Power Plant, participated to PROPER in energy sector. Since previous PROPER document has not shown fatality on environmental program and main business process, it probably has technical problem, for instance lack of understanding or reporting skill. According to this case, both in charge leaders and all employees, have the same opinion to conduct responsible team with capacity building through educative program.

Since PROPER is not only limited to environment perspective but also consider other essential perspective policy of the system, resource utilization, and social responsibility. Several basic programs has been planned consist of individual assessment of PROPER team, focus group discussion to determine program of this year and its sustainability, internal coaching to improve reporting skill, and weekly assistance on PROPER document with underlined on its viability.

Materials and Methods

A. Materials

Capacity building that mainly discussed in this paper is strategic program based planning for supporting environmental conservation in Indonesia. Preliminary step has begun with site visit assessment, and continued to ongoing program over this year. This program is substantially required a guideline contains coaching module and strategic plan towards continuous improvement within goals of Excellency.

B. Methods

An imperative method on this program is regular coaching through integrated assistance. During this year, program that has been successfully held consist of preliminary assessment within site visit method. It contains individual assessment for PROPER in charge employee to re-assess each job description PROPER criteria. Following preliminary program, management decided to accommodate focus group discussion (FGD) directly after individual assessment. FGD mainly discussed about best practice program, preparation, and implementation on each PROPER aspects. Other program with continuing status is internal coaching with condition of simulation and practice on data processing and creating reliable document to be more structured. Moreover, coaching has to be monitored with regular assistance to avoid obstacles possibility prior to be assessed by Ministry of Environment.

Overview of Environmental Compliance Assessment (PROPER) in Indonesia

A. Regulatory Framework

Population growth has increased recently with impact on energy security, food security, and human security considered as global issue. This situation drives energy sector plays important role to secure energy supply. Government in Indonesia, through Ministry of Environment, contributes to this global issue by bringing together industries and its stakeholder. As part of energy industries that generates electricity, PT. Indonesia Power – GSU of Bali participated to this environment preservation program annually.

Annual assessment program hosted by Ministry of Environment, underlined Environmental Compliance Assessment (PROPER), regulated under Minister of Environment Regulation No. 06/2013 [2] that has been updated recently as Minister of Environment Regulation No. 03/2014 [3]. Overall industries that caused significant impact to the environment and social attention, neither regional nor global, have obligation to participate to PROPER. For energy sector, company that run power plant as core business within minimum installed capacity 55 MWe are welcome to participate.

B. Assessment Step

Previous publication [2] has described about assessment step of PROPER, which particularly divided into three main steps. According to updated regulation of PROPER, there are no changing steps on PROPER assessment which consists of:

- Preparation of periodical database, lesson learned review, and best practice program.
- Compliance assessment, a second step that evaluate compliance on basic environment aspects, such as water usage and its treatment of wastewater, air pollution reduction, hazardous waste management, and environmental permit (EIA, etc.). Each of energy industries have to fulfill periodical database that supported with accurate evidence. This step delivers results into comply (**Blue Category**) and not comply (**Red and Black Category**).
- Beyond compliance assessment, is the most difficult step due to very tight selection process. This step is optional, industries with Blue Category whether can choose to continue to this step or not. This step particularly assessed 9 (nine) aspects such as Environmental Compliance Executive Summary, Environmental Management System, Energy Efficiency, Hazardous Waste Management, Solid Waste Management, Emission Reduction, Water Efficiency, Wastewater Treatment to Minimize Stream Degradation, Biodiversity Protection, and Community Development. This step then delivers results into “just comply” (**back in Blue Category**), “beyond comply” (**Green Category**), and for those company that passed the minimum standard score, will be promoted to the “**Gold Candidate”** (**Beyond Comply with Excellency**) and continue to the next site verification process.

C. Environmental Goals and Improvements

Gas Fired Power Plant commonly known as non-renewable energy sector with business as usual way of thinking. GSU of Bali committed to change this paradigm to be non-renewable energy that concerns the most on environmental preservation and sustainability. We generate electricity for society within sustainable energy, environment, and social responsibility awareness. This motivation is reflection of top management commitment, supported by overall employee, as it shown on continuous environmental compliance improvement “from comply to beyond”.

Results and Discussions

This paper discuss about educative basic programs such as individual assessment of PROPER team, focus group discussion to arrange excellent program of each aspects, workshop and internal coaching for reporting skill, and assistance on preparation of PROPER document. These educative programs are implemented to every aspects assessed on PROPER, particularly strategic program as we discussed below.

A. Capacity Building General Program

- **Preliminary Assessment**
  Preliminary site assessment play important role to determine baseline of current condition and routine program. It has been assessed for at least 20 in charge employee with each specific in charge aspects [7]. Assessment consists of four days; begin with general assessment, continued to site assessment, document collection, and discussion for specific site condition of each generation unit (Pesanggaran, Pemaron, and then Gilimanuk). Preliminary site assessment situation is the depicted in Figure 2.

Figure 2: Preliminary Assessment on Gilimanuk (left) and Pemaron (right) Generation Site

- **Internal Workshop**
  As part of capacity building, internal training has been given for more than 25 employees per day. It was held in Pesanggaran main office during weekday in five days. Workshop has begun with basic knowledge of environment and lesson learned on previous results of PROPER in order to calibrate each in charge person perspective [8], as depicted in Figure 3. It was then continued to main topic, which was mainly discussed about:
  - Environmental Management System
  - Energy Efficiency
  - Hazardous Waste Management
  - Solid Waste Management
  - Emission Reduction
  - Water Efficiency and Wastewater Treatment
  - Biodiversity Protection
  - Community Development

Figure 3: Internal Workshop for Environmental Compliance – Capacity Building for Knowledge and Skill Improvement

Since environmental compliance assessment required evidence for assessment document and its harmony to the site condition, output of this workshop was aimed for improvement of knowledge and reporting skill of each in charge employee. Workshop methods contain two ways of discussion with interactive situation during all sessions. At the end of session, there was always simulation to create a viable document based on current criteria of Minister of Environment regulation.

B. Energy Efficiency for Better Future of Energy Security

Preliminary assessment was held at the beginning of this year, it has continued directly to focus group discussion (FGD) for more than 20 in charge employee. FGD mainly discussed about strategic program for beyond compliance achievement of PROPER this year. Strategic program will be continuously improved as five years period.

- Reduction of Internal Consumption Electricity with Solar Cell Program

  Our company generates electricity by using fossil fuel (High Speed Diesel) as primary energy. Although our core business focused on non-renewable sector, we always committed to contribute in energy efficiency through sustainable solar cell utilization. Solar energy is one of renewable energy which has a very high sustainability in tropical country, such as Indonesia. Solar cell effectiveness is depending upon a climate condition; it contributes 21% at windy and 30% at sunny weather.

Figure 4: Installation of Solar Cell Panel with Consideration Health and Safety Behaviors

Figure 4 described the installation of solar cell on administration building of GSU Bali without ignoring health and safety aspects. For the last four years, solar cell has significantly reduced electricity consumption for administration building for more than 36,000 kWh per year [9]. This condition is equals to 13,000 liter of fossil fuel consumption or economically feasible for saving up to 130,000,000 IDR.

C. Resources Utilization for Sustainable Environment Protection

This part mainly discussed about strategic program that has been implemented both in power plant area and environmental program based community development. Environmental aspects reported refer to the environmental beyond compliance criteria [3].

- <u>Hazardous Waste Management: Replacement of Tubular Lamp (TL) with Light Emitting Diode (LED) Lamp</u>

  This program has begun over three years, and still on going to replace partially (see Fig. 5). There were 492 spots of Tubular Lamp and Halogen Lamp installed, consist of office building, library, laboratory, warehouse, power house, control room, and risk management room [9]. Currently, LED lamp has replacing TL and Halogen usage as 100% by the end of last year (as per December 2014).

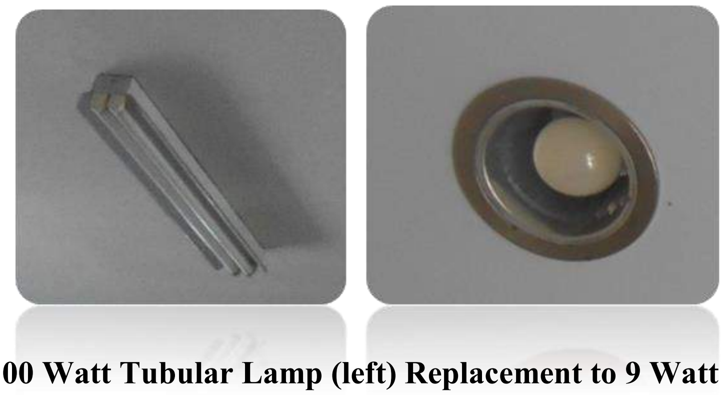

Figure 5: 100 Watt Tubular Lamp (left) Replacement to 9 Watt Light Emitting Diode Lamp (right) Around Main and Supporting Building

Since LED lamp has more lifetime than neither TL nor Halogen lamp, this program can reduce hazardous waste generation in the future up to 50 kg per year. Based on hazardous waste regulation from Government of Indonesia 101/2014 (Peraturan Pemerintah No 101 Tahun 2014), TL lamp waste categorized as hazardous waste from non-specific source with waste code is **B107d** [4].

- Solid Waste Management: Integrated Domestic Waste through Bank Sampah
  Bank Sampah (Bank of Domestic Waste) is an integrated program to manage domestic waste in economical perspective. Bank Sampah has initiated at the beginning of this year (January 2015) together with essential stakeholders as integrated partnership program. I Wayan Patut is a local coordinator within 30 members community of Serangan, Bali Province. One of recycle product that made from paper waste is depicted in Figure 6.

Figure 6: Handicraft and Souvenir as Recycle Paper Product

Waste generation in Bank Sampah is around 4,000 kg per day of organic waste and 300 kg per day of in-organic waste [10]. Several activities under this program consist of organic waste (such as composting) and in-organic waste management (such as handicraft, etc.). Main purpose of this program is to develop skill of local community based on sustainable environmental education and economical consideration as discussed above. Bank Sampah also has other advantages, such as increasing mainly income for community up to 40% and possibly bringing Bank Sampah as tourism object in Bali Province.

- Emission Reduction: Biogas Utilization Based Local Community Development

  As part of emission reduction program, our company volunteered at biogas utilization in order to reduce domestic fuel consumption. This program was initiated in 2013, underlined for local community empowerment around Bali (see Fig. 7 and Fig. 8). Currently there are two local coordinator of biogas program, consist of Ni Wayan in Klungkung, and I Wayan Kayun in Gianyar [11]. Their main utilization of biogas product emphasized on reducing internal fuel consumption.

Figure 7: Animal Waste Collection System Based Community Empowerment

Figure 8: Biogas Installation System (left) and Biogas Product for Daily Usage in Community (right)

Raw material used mainly from animal farm that consists of three cows, with average animal waste generation around 6 kg/day. This biogas program effectively can reduce Liquefied Petroleum Gas (LPG) demand for daily activities, most likely for cooking. An additionality of this program is to build a new paradigm of non-renewable energy demand into renewable energy utilization.

- <u>Emission Reduction: Energy Efficiency Program</u>
  Currently there are numerous energy efficiency programs that have been implemented around power plant area. One of program discussed in this paper is replacement of Tubular Lamp to Light Emitting Diode Lamp, as described previously [9]. It covered hazardous waste management aspect and also emission reduction aspect as a direct impact of energy efficiency. As per March 2015, it has been recorded that lamp replacement program contributed to reduce emission about 72,414 kg CO_2 per year, which equivalent to 19,769 kg of Carbon.

- <u>Water Conservation through Biopori Program</u>
  Biopori (or Bio-Porous) is common practice as part of natural water conservation. This program was initiated since year of 2013 and still on going in this year with 25 unit of Biopori installed around Power Plant area per year (see Fig. 9). As part of continuous improvement, we consider that infiltration rate of each Biopori unit has to be calculated and monitored in the future.

Figure 9: Biopori Installation in Local Community (left) and Around Power Generation Area (right)

Besides having water conservation program internally, we also built partnership with Environmental Agency of Bali Province (BLH Propinsi Bali) and Military District Command of Denpasar City (Kodam Denpasar). Nevertheless, local communities are always being part of environmental planning and monitoring program [12].

- <u>Wastewater Treatment to Minimize Environmental Degradation: The Best Practice of Gilimanuk Wastewater Garden</u>
  Wastewater Garden is a paradigm based on water conservation that integrated to pollution prevention to the environment. It has been implemented in Gilimanuk Power Plant Unit by using wastewater effluent to watering plants around green area as depicted in Figure 10. Although wastewater effluent has been treated in Wastewater Treatment Plant (WWTP), effluent still contain rich organic nutrient that essential to either crops or plants.

Figure 10: Crops around Gilimanuk Unit, Watered by Treated Effluent Wastewater

This program has several advantages, such as reducing domestic water consumption for plants watering which connected to reduce wastewater contamination load to the stream. As part of water efficiency, this program contributed to reduce water consumption around 2.4 m^3 per year [13]. Besides, effluent wastewater quality also plays important factor to minimize stream degradation that will be discussed to the further study.

- <u>Environmental Awareness Campaign in Jembrana District: Preserving Environment Through Educative Action</u>
  Having capacity building as strategic program is underlined to achieve better environmental compliance and beyond. Boundary of this integrated program does not only focus on employee capacity improvement, but also to community around our power generation area. One of socio-environment program that has been successfully implemented continuously is Environmental Awareness Campaign.

Awareness to the environment is a learning process, which has not come instantly. It plays important role, particularly for children as foundation knowledge since in early age. Main goals of this program intended to improve awareness in the future as sustainable responsibility. Environmental Awareness Campaign initiated in Gilimanuk Village - Jembrana District for over three years periodically. Education topic consists of Reboisation towards Supporting Tourism Village in Gilimanuk, Domestic Waste Management, etc. In addition, simulation after indoor education also became non-separated part at the end of campaign as shown in Figure 11.

Figure 11: Indoor Simulation of Environmental Awareness Campaign

At least 100 early age pupils have been educated in this campaign since the beginning of year of 2013. Education was held in Early Age Integrated Education of Aisyiyah (PAUD Terpadu Aisyiyah), Elementary School of Gilimanuk 3 (Sekolah Menengah Pertama Negeri 3 Gilimanuk), Junior Islamic High School of Gilimanuk (Madrasah Tsanawiyah Gilimanuk), and Junior High School of Melaya 3 (Sekolah Menengah Pertama Negeri 3 Melaya). Collaborative action has also involving The National Park of Western Bali (Taman Nasional Bali Barat), local community, and environmental team of PT Indonesia Power Gilimanuk [13].

D. Biodiversity Protection – Conservation Based Community Development

Power generation is one of energy sector that commonly require extensive areas. It has magnitude impact on degradation of biodiversity abundance. As part of socio-environment responsibility, we are committed to conserve natural biodiversity. Several best practice programs discussed as follows.

- <u>Coral Reefs Protection</u>
  This program initiated since 2010, collaborated with Kelompok Nelayan Segara Gunung, Pemaron Village. It has not only socio-environment impact, but also economic aspects for local community. Social and environmental positive impact can improve coastal environment knowledge to society that simultaneously preserving the environment. On the economics point of view, this program can improve local community's welfare up to 82 percent of regional standard income.

  Another point of view in this program is cultural and tourism aspect, whereas Coral Reefs has a beauty of nature, mainly in marine environment. Since Coral

Reefs associated with various marine biodiversity, this program has become interesting tourism object for diving and exploring aquatic ecosystems as shown in Figure 12 and Figure 13.

Figure 12: Coral Reefs Conservation within Bali Cultural and Heritage (left) and Growth Coral Reefs as Part of Conservation in 2010 (right)

Figure 13: Underwater Scenery of Coral Reefs – Diving Tourism Object (left) and Bali's Cultural Heritage with Coral Reefs Growing Around

This initiative program has brought our company to achieve the first prestigious achievement on socio-environment aspect. It has awarded under Corporate Social Responsibility (CSR) Awards of Indonesia in 2011 as Platinum Award Position [10].

- <u>Sea-Horse Conservation</u>

  Sea Horse (*Hippocampus* spp.) commonly discovered at narrow territory associated with Coral Reefs and Mangrove Root. Based on Ministry of Forestry Regulation 57/2008, Sea Horse classified as High Priority Marine Species that become the national environmental issue [5]. According to this situation, significant contribution required in order to conserve marine environment around Bali Island.

  We initiate this program since the beginning of year of 2011 and periodically monitored until present. We also collaborate with local community in Serangan, coordinated by I Wayan Patut. It has two monitoring groups with total of local community involvement about 35 members. This program also enhancing tourism objects around Bali Province which increasing people's welfare. It has calculated that involved community can increase their routine income for more than 65 percent of regional standard. Sea Horse Conservation Program is then depicted in Figure 14.

Figure 14: Release of Sea Horse in Serangan as Tourism Object (left) and Conserved Sea Horse (right)

This program recognized as best practice implementation of natural conservation. In 2014, this program became the best innovative action in Corporate Social Responsibility (CSR) Award in Indonesia, also considered as the second achievement on socio-economic-environment responsibility. Sea Horse conservation program has an iconic characteristic that achieved the most prestigious results as Platinum position [10]. Moreover, this program is still maintained periodically with local community in Serangan.

- Mangrove Preservation
  Mangrove is part of integrated marine ecosystem that also associated with Sea Horse and Coral Reefs, plays important role in the coastal environment. Mangrove has an ability to prevent coastal erosion and to control environmental degradation. At previous year, 1,000 Mangrove has been planted in the Mertasari Beach - Sanur, Southern Denpasar [14]. This program supported by PT Indonesia Power – GSU of Bali and Udayana University. It also collaborated with local and regional government, local community and education institution, from early age community to university student. Mangrove preservative action is then depicted in Figure 15.

Figure 15: Coastal Preservation with Emphasis on Mangrove Plantation

E. Community Development

As part of Corporate Social Responsibility (CSR), Community Development plays a new paradigm in this sector. Corporate has endorsed to be less charity and more focused on sustainable community empowerment. Successful CSR program measured as transformed local community to independent or self-powered at its exit goals. At this point, PT Indonesia Power – GSU of Bali has successfully developed a small community to manage their own program through economic institutional as subsequently discussed below.

- <u>Economic Institutional Cooperation for Local Community "Koperasi Bangkung Sari"</u>
  In year of 1990, this program initiated with a small local community in Banjar Ambengan, Bali Province. It was known as Kelompok Pembina Kesejahteraan Keluarga Pesanggaran (PKK Pesanggaran). PKK Pesanggaran has main activities on cultural and heritage, taken into account Balinese religious activities.
  Since 2006, PT Indonesia Power – GSU of Bali have taken actions to empower them as part of community development and successfully transformed to an independent community in 2009. This was also transformed PKK Pesanggaran into Bangkung Sari Community. Bangkung is a Balinese Language that means "female pig" and Sari means "product". This fundamental principle became a community paradigm to run saving and loan activities with underline of cooperative union system. Koperasi Bangkung Sari administrator and activities then depicted in Figure 16.

Figure 16: Koperasi Bangkung Sari Administrators and Activities

Koperasi Bangkung Sari has own tradition which consistently different with regular cooperative union system. Common cooperative union has net income at the end of year, which generally distributed to all community members. At Koperasi Bangkung Sari, end year net income given to member or their family that passed over in order to do Ngaben Ceremony [10].

Bangkung Sari managed by I Nyoman Karbinawa as general coordinator with six administration officer. At least this self-powered community has average revenue 150% than regional standard income. As per 2015 total members of Koperasi Bangkung Sari is 1,000 people that equals to people in Banjar Ambengan.

Conclusions

Every step of capacity building begun with teamwork either as top-down or bottom-up mechanism supported by all essential stakeholder. Practical perspective require strategic program to support environmental and social responsibility as part of small step to achieve environmental compliance and beyond. However, it has to be monitored and substantially innovative not only in power generation area, but also for living environment around.

Acknowledgement

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Make-Up Water Utilization Using WWTP Effluent Recycle: A Case Study of Grati Combined Cycle Power Plant, East Java Province, Indonesia

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Abstract

In 2013, average waste water production of Grati Combined Cycle Power Plant is about 3,801 m^3/month within only less than 8% (eight percent) has been reused for reboisation. It requires more effort to recycle effluent of Waste Water Treatment Plant (WWTP) in order to fullfil water conservation program and zero waste water of power plant with emphasis on Environmental Compliance (PROPER) Awarded by Ministry of Environment of Indonesia.

Installation of Brackish Water Reverse Osmosis (BWRO) to process effluent of WWTP can remove chemical and physical impurities in order to reach quality specification of raw water for boiler water. A pilot project BWRO can produce 4 ton/hour service water and reduce specific conductivity effluent of WWTP from 500 microS/cm to less than 20 microS/cm.

We also calculate financial analysis from this innovation, which resulted surplus is about IDR 320,060,578/annum from monthly batch BWRO operation of 160 m^3 within 5 years payback period. There is also non-financial benefit, connected to improvement of environmental management to achieve higher level of PROPER Award. Potential water conservation from this innovation is 1,600 m^3/month or 50% from total waste water by built effluent of WWTP storage pond capacity 300 m^3.

Keywords: Grati Combined Cycle Power Plant, Water Conservation, Environmental Compliance, BWRO

Introduction

PT Indonesia Power Grati Combined Cycle Power Plant (CCPP) produced electricity with installed capacity of 750 MW. It consists of Block I with the pattern of combined cycle operation and Block II with open cycle. Since operating with natural gas fuel in 2009 has been replaced with HSD (High Speed Diesel) fuel, Grati CCPP Block I becoming base load unit with 24 hours of operating hours. Coupled with the operation of CNG (Compressed Natural Gas) as a fuel for GT (Gas Turbine) Block II which able to increase electricity supply at peaker hour as a peaked unit.
Wastewater from the main processes in plants treated at the Waste Water Treatment Plant (WWTP) with the fundamental principle of neutralization and coagulation-flocculation. Treated water or WWTP effluent can be discharged into the stream, taking into account the sea, when the quality is in accordance with the quality standards that determined by Ministry of Environment Regulation under "Peraturan Menteri Lingkungan Hidup" No. 08/2009 [1].
This paper is aim to introduced a utilization of the WWTP effluent production with approach on the quality of domestic raw water or clean water. While the efforts of this recycle, that is reboisation program still not optimal yet. So it takes another attempt to utilize more wastewater.

Purpose and Objectives

This paper described a utilization of WWTP effluent with an addition of Reverse Osmosis so it can be used for service water and increases the national environmental compliance achievement in water efficiency criteria sustainably [3].

Methodology

According to this paper purpose and objective, there are several step of methodology, such as data collection and analysis, design, and examination, which described as follows.

Data Collection

The first step of this study has begun with data collection. It has taken into account in this study consist of WWTP effluent product and waste water quality. One of data collection is then shown in Table 1.

Table 1: Data Collection During 2013

Parameter	Unit	Standard of Quality	Laboratory Result (year of 2013)								
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
pH	-	6 - 9	7.82	8.01	8.9	7.53	7.45	7.54	7.09	6.36	7.85
Total Suspended Solid	mg/l	100	1.2	3.6	3.2	1.6	2.8	4	3.36	2	6.94
Oil and Grease	mg/l	10	< 1.05	< 1.05	<1.05	1.1	<1.05	<2.17	<2.17	<1.05	<2.17
Free Chlorin	mg/l	0.5	<0.004	<0.004	0.02	0.02	<0.004	<0.004	<0.004	<0.004	<0.004
Total Chromium	mg/l	0.5	<0.0269	<0.0269	<0.0269	<0.0269	<0.0269	<0.0269	<0.0269	<0.0269	<0.0269
Copper (Cu)	mg/l	1	<0.0169	<0.0169	<0.0169	<0.0169	<0.0169	<0.0169	0.002	<0.0169	<0.0169
Iron (Fe)	mg/l	3	<0.0413	<0.0413	0.128	0.0538	<0.0413	<0.0413	0.645	<0.0413	0.619
Zink (Zn)	mg/l	1	<0.0157	0.057	0.0806	0.0175	<0.0157	<0.0157	0.283	0.0411	<0.0157
Phosphat (PO4-)	mg/l	10	0.0883	0.554	0.246	0.098	0.037	1.57	0.814	0.04	1.6

Data Analysis

In this paper, the data was analyzed by engineering studies including operations and financial feasibility.

Analysis of Problems

In order to utilize WWTP effluent, discussions were made with Engineering Department with several options to be considered, such as:

1. Laboratory analysis WWTP effluent quality on November 16, 2010, the results meet Standard Healthy Regulation (Peraturan Menteri Kesehatan Republik Indonesia) 416/1990 as clean water [2].

2. Utilization of Effluent WWTP for domestic water; As part of problem analysis, there is also numerous of fundamental considerations, such as:
a. Splitting water tank for domestic and service water demand
b. Potential residual chemicals
c. Required pipeline facilities to the halls and/or buildings
d. Low investment cost of USD 23,077
e. Required Sand Filter and Chlorine Injection Facility
f. Conductivity product shall not changed

3. Utilization WWTP effluent to water service with Reverse Osmosis, with consideration that consist of:
   a. No need to manufacture additional tank
   b. The recycle water for use as water enhancer
   c. Low potential residual chemicals (mixed with desalination plant product water)
   d. The investment cost of USD 57,692
   e. Conductivity product decrease to be lower than 20 µS/cm

Operation Feasibility

Based on the alternatives above, the following step taken into account operations feasibility study to determine the best of it. Each alternative is assessed and calculated its feasibility as shown in Table 2.

Table 2: Operational Feasibility Study to Determine the Best Alternatives

No	Criteria	Weight (%)	Alternative 1 Filtration Unit			Alternative 2 Reverse Osmosis Unit		
			Remarks	Value	Score	Remarks	Value	Score
1	Cost	30	Cheaper	8	2.4	Expensive	4	1.2
2	Additional Investment	25	Tank and pipeline	3	0.75	-	9	4.25
3	Operation & Maintenance	25	Easy	8	4	complicate d	6	1.5
4	Risk	20	High risk for human	4	0.8	Low risk for human	8	1.6
	Total Score	100			7.95			8.55

Financial Feasibility

Besides conducting data analysis and technical feasibility, financial perspective of feasibility is also considered. It used technical economy approach to determine tangible and intangible benefit.

Design

Based on the design point of view, this study also performed design and capacity plant.

Monitoring and Evaluation

This study also monitored the quality and quantity of Reverse Osmosis product at commissioning and normal operation condition periodically.

Results and Discussions

This study discussed about implementation of the program and its beneficial impact, which consist of financial benefit. This study also implemented as water conservation program, which contributed to the national government program on environmental compliance and beyond.

Implementation

This study has filing process that started in 2012 to Reverse Osmosis unit normal operation in October 2013. Unit Reverse Osmosis (RO) in Grati CCPP consists of two systems, namely the pretreatment system and RO system. Pretreatment system consists of the Multi Media Filter (MMF) and Chemical Treatment, while the RO membrane system consists of modules and cleaning facilities. The schematic diagram of flow process is then depicted in Figure 1. As an example, permeate quality at commissioning of program is also shown in Table 3.

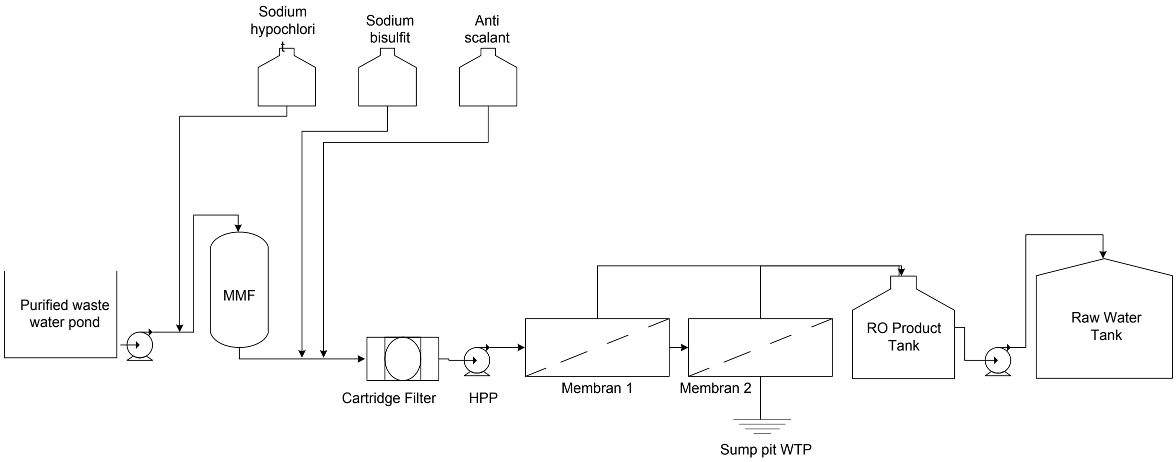

Figure 1: Schematic Diagram of WWTP Effluent Utilization with Reverse Osmosis Facilities

Table 3: Permeate Quality at Commissioning

4-Oct-13	pH	Conductivity (µS/cm)	Turbidity	Flow (LPM)
14.3	7.31	16.8	0.12	75
15.3	7.27	15.5	0.12	74
17	6.81	16.1	0.13	66
18	7.1	14.7	0.1	65
19	7.1	14.5	0.11	65
20	6.95	14.6	0.1	65
21.3	7.04	14.4	0.16	63
22.3	6.63	14.1	0.24	63
0.15	6.86	13.6	0.16	65
1	7.1	13.1	0.11	65

The increasing of WWTP effluent utilization is shown in Table 4 and Table 5. WWTP effluent used as raw material of RO unit and within this program, the amount of WWTP effluent utilized in 2014 has known significantly increase compared to the year of 2013.

Table 4: Utilization of WWTP Effluent before RO Program

Year	Month	Amount of Process Wastewater (m^3/month)	Amount of Utilized Wastewater for Watering (m^3/month)	Amount of Utilized Wastewater for RO (m^3/month)	Total of Utilized Wastewater	% Utilization for Watering	% Utilization for RO	Total (%)
2013	Jan	4010.60	405.00	0.00	405.00	10.10%	0.00%	10.10%
	Feb	4687.20	369.00	0.00	369.00	7.87%	0.00%	7.87%
	Mar	4435.60	207.00	0.00	207.00	4.67%	0.00%	4.67%
	Apr	4177.50	315.00	0.00	315.00	7.54%	0.00%	7.54%
	May	2847.60	351.00	0.00	351.00	12.33%	0.00%	12.33%
	Jun	3157.80	378.00	0.00	378.00	11.97%	0.00%	11.97%
	Jul	4261.60	342.00	0.00	342.00	8.03%	0.00%	8.03%
	Aug	4905.80	180.00	0.00	180.00	3.67%	0.00%	3.67%
	Sep	1107.90	450.00	7.92	457.92	40.62%	0.71%	41.33%
	Oct	3677.10	342.00	61.11	403.11	9.30%	1.66%	10.96%
	Nov	4127.40	153.00	101.15	254.15	3.71%	2.45%	6.16%
	Dec	4216.20	108.00	40.50	148.50	2.56%	0.96%	3.52%
Average		3801.03	300.00	17.56	317.56	10.20%	0.48%	10.68%

Table 5: Utilization of WWTP Effluent after RO Program

Year	Month	Amount of Process Wastewater (m^3/month)	Amount of Utilized Wastewater for Watering (m^3/month)	Amount of Utilized Wastewater for RO (m^3/month)	Total of Utilized Wastewater	% Utilization for Watering	% Utilization for RO	Total (%)
2014	Jan	4305.10	81.00	157.82	238.82	1.88%	3.67%	5.55%
	Feb	4240.50	94.50	309.32	403.82	2.23%	7.29%	9.52%
	Mar	-	90.00	244.41	334.41	-	-	-
	Apr	2211.30	99.00	180.02	279.02	4.48%	8.14%	12.62%
	May	2850.30	90.00	141.53	231.53	3.16%	4.97%	8.12%
	Jun	2013.20	126.00	174.78	300.78	6.26%	8.68%	14.94%
	Jul	1991.60	162.00	229.95	391.95	8.13%	11.55%	19.68%
	Aug	1678.80	126.00	55.73	181.73	7.51%	3.32%	10.82%
	Sep	4226.60	144.00	480.21	624.21	3.41%	11.36%	14.77%
	Oct	3648.70	135.00	261.21	396.21	3.70%	7.16%	10.86%
	Nov	1602.30	162.00	407.91	569.91	10.11%	25.46%	35.57%
	Dec	3911.10	132.75	470.65	603.40	3.39%	12.03%	15.43%
Average		2970.86	120.19	259.46	379.65	4.93%	9.42%	14.35%

Based on Table 4 and Table 5 above, it can be seen that there is a significant in total utilization of wastewater about 10.68 % in 2013 to 14.35 % in 2014. It has significantly increase effluent utilization as it shown in Figure 2.

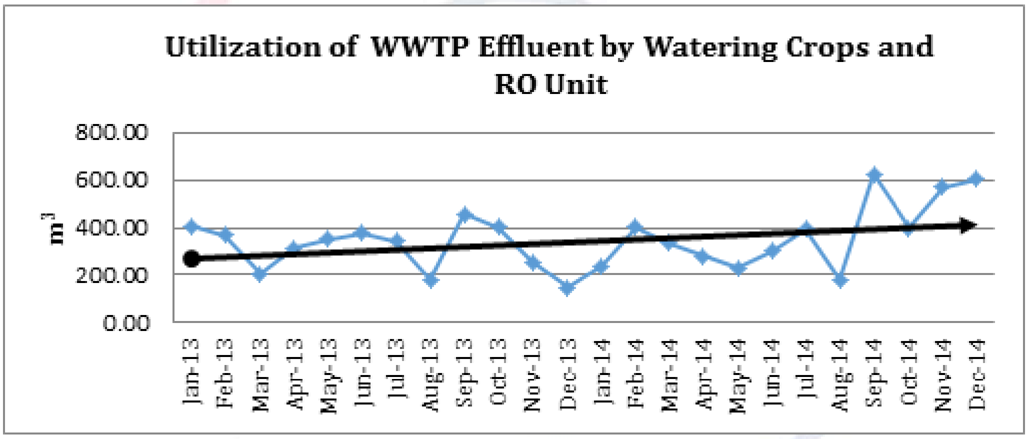

Figure 2: Wastewater Effluent Utilization for Watering Crops and Reverse Osmosis Unit

After the program has successfully implemented in the field, the amount of wastewater recycled to service water using Reverse Osmosis unit is about 259.46 m^3/month with total percentage of 9.42 percent (%).

Financial Benefit

The utilization of Reverse Osmosis unit to re-process WWTP effluent into water service recognized to be quite efficient. At this condition, technical and financial benefits are calculated as follows.

1. Reduce distillate water consumption = 259.46 m^3 per month
   Financial benefit = 867.2 USD per month
2. Reduce steam demand of Desalination Plant (DP) = 0.65 m^3 per hour
   Financial benefit = 1,184.5 USD per month
3. Calculation of Payback Period (PBP)

PV Cash Out (Investment)	= 57,692.31 USD
PV Cash In	= 67,608.53 USD
Net Present Value (NPV)	= 9,916.22 USD
IRR	= 13.22%
Payback Period (PBP)	= Year 5
Discounted Payback Period	= Year 5
Conclusion	= Decent

Conclusions and Recommendations

This study has several conclusions and recommendations which consist of:

- In 2013, the average production of wastewater in Grati Combined Cycle Power Plant monthly recorded about 3,801.03 m^3.
- As an additional effort to improve the efficiency of water consumption, Reverse Osmosis (RO) units significantly viable to utilize the WWTP effluent.
- Reverse Osmosis units can improve the utilization rate of wastewater ranging from 10.68 % in 2013 to 14.35 % in 2014.
- With Reverse Osmosis program, it has been calculated that financial benefit gained USD 24,620 annually and achieve payback period after five years period.

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Environmental and Biodiversity Information System "E-Bios" towards Supporting Environmental Compliance: Grati Combined Cycle Power Plant, East Java Province, Indonesia

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Abstract
As a company that leads the generation of word class services, Indonesia Power has a vision to become a public company with world-class performance and environmentally friendly. To fulfill that vision, Grati Combined Cycle Power Plant (CCPP) contributes to Environmental Compliance (PROPER) Awards by Ministry of Environment of Indonesia. One of assessment criteria of PROPER is assessment of biodiversity protection with reporting aspects that require the presence of data, system information and publishing system that can collect and evaluate status and trends of biodiversity resources, managed at least 2 years. This innovation can increase biodiversity score up to 40 points over 100 of total score.

Previously, in Grati CCPP, biodiversity data is manually recapitulated by the Division of Chemical and Environmental using basic Excel application. It causes some problem of difficulties, such as less structured and uneasy to find data due to offline system. We consider that creating application of E-Bios in order to process, evaluate, and present data in an online publication. In addition to better data integrity, E-Bios allows for publication of biodiversity data online as a solution to support Grati CCPP biodiversity innovation.

Keywords: Grati Combined Cycle Power Plant, Environmental Compliance, Biodiversity Protection, E-Bios.

Introduction

Indonesia Power has a vision to be a public company with world-class performance and benign environmental base. One step to reach this vision implemented by participated on Environmental Compliance Assessment, a program which initiated by Ministry of Environment (MoE) Indonesia. Environmental Compliance in Indonesia commonly known as PROPER (an abbreviation of Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup).

Grati Combined Cycle Power Plant (CCPP) has participated since 2010. At year of 2010 to 2012, Grati CCPP was awarded Green PROPER. PROPER assessment in 2011 used the new assessment method based on the regulation of Environment Minister Regulatory Framework 05/2011 about Environmental Compliance Assessment. Appendix II of it was explained about the Green and Gold Assessment Criteria which divided into [1]:

1. Environmental Management System
2. Resource Utilization
3. Community Development

Assessment criteria of resource utilization include biodiversity protection criteria. On the sub-criteria there were actual report and implementation aspects that require data, information, and publication system. It has to be able to collect information and support the status evaluation and biodiversity resources propensity and biological resources which have been managed at least for 2 years. That criteria become OFI (opportunity for improvement) for Grati CCPP which initiate to proceed the biodiversity data by using basic computer program. This paper mostly discussed about information system as the biodiversity online data collection and monitoring.

Objectives

This paper has several objectives, such as:

1. Data collection and evaluation of biological resources.
2. Online monitoring system of biodiversity protection.
3. Supporting Environmental Compliance achievement for Grati CCPP in Energy Sector.

Methodology

1. Analysis of Biodiversity Data Governance

   Generally, the business process of biodiversity data governance at Grati CCPP can be explained as follows:

   a. Field data collection implemented by Institut Teknologi Sepuluh Nopember Surabaya (ITS) Laboratory Team (Flora and Fauna) and Balai Besar Teknik Kesehatan Lingkungan dan Pemberantasan Penyakit Menular (BBTKL PPM Laboratory Surabaya or Envilab) for Benthos and Plankton analysis.
   b. The field data processed into a hard copy report.
   c. The hard copy report data recapitulated into Microsoft Excel application with the following format (Table 1.).

Table 1: Collecting Data Manual Template

No	Indonesian Name	Species Name	Abundance	Status	Index

Change manual data recapitulation system into Microsoft Excel program has some lacks:

a. The difficulty on data collection and evaluating biodiversity resources propensity and managed biological resources.
b. Unsupported status data publication and biodiversity propensity and biological resources which managed fast and accurately by online.

Infrastructure Design

The design of E-Bios infrastructure system is depicted in Figure 1.

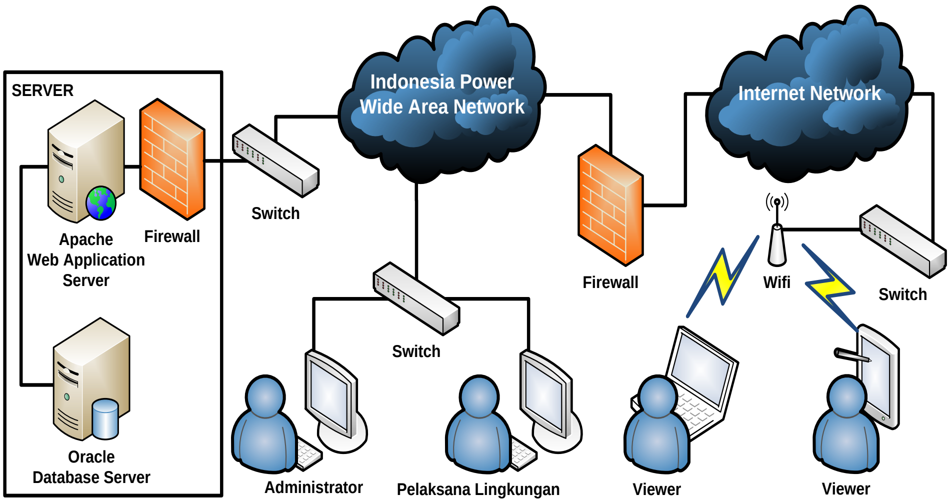

Figure 1: E-Bios System Infrastructure Planning

a. Apache web application server as the service provider of HTTP protocol. As application accesses request of client database connection, transaction process, etc. Apache runs program execution on the system then gives response to the client.
b. MySQL database server as the storing service provider and data processing (database).
c. The network infrastructure (switching, router, wifi, UTP cable)
d. The client devices; PC, notebook, tablet and etc., As long as it has the web browser as the client application and facility of network connection to access the application.

The minimum specification requirements for the server devices and client are EBIOS is shown in Table 2.

Table 2: Minimum Specification Requirement of Server Devices and Client of E-Bios

No	Specification	Server	Client
1	Processor	Intel Xeon 3,2 GHz	Intel Pentium 2,1 GHz
2	RAM	2 GB	1 GB
3	Hard disk	500 GB	100 GB
4	Network	Giga Ethernet Card	LAN / Wireless
5	OS	Windows / Linux	Windows / Linux

Applications Design

Based on the data collection process of biodiversity, the application design will be implemented using the following method:

a. Using DFD modeling approach (Data Flow Diagram) to clarify the definition of structure processing, function and application data flow.
b. The design of database based on the function structure and data flow defined. In this innovation, database design made with ERD modeling (Entity Relationship Diagram) as enclosed.

Results and Discussions

Implementation of Innovation

The information Systems namely EBIOS (Environmental and Biodiversity Informastion System) and has been used since January 2012. EBIOS can solve the problem formulation. This application can be accessed on the internet network by login using corporate username and email password [2]. The interface of E-Bios is depicted in Figure 2 to Figure 4.

Figure 2: Interface of E-Bios Monitoring System

In general, EBIOS's users divided into three access rights:

1. Entry operator: user with access right of inputting, deleting, and updating data.
2. Administrator: user with access right as applications administrator.
3. Viewer: website visitor with the right to see the data published.

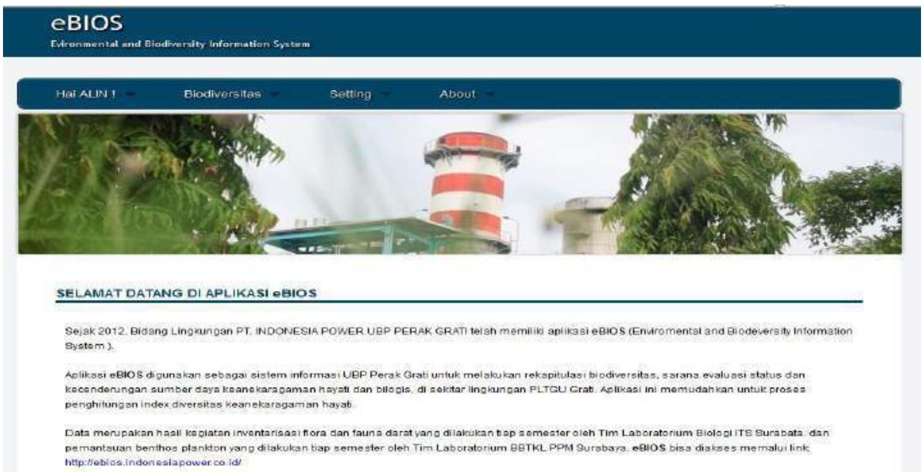

Figure 3: Welcome Page of E-Bios

This application was designed with the main menu as follows :

1. Biodiversity Data: the function of this to input, update, delete, search, and print report of biodiversity data number.
2. List of Biological Organisms: the function of this to input, update, delete, search, and print report of biological resource data.

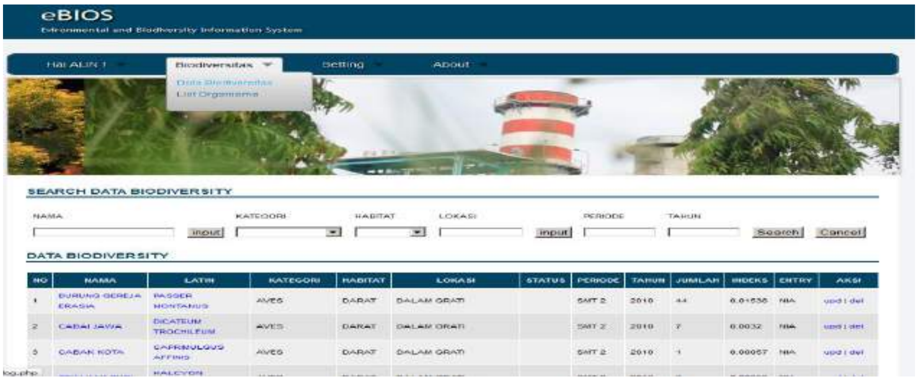

Figure 4: Data Recapitulation in E-Bios

EBIOS Home Applications

The display of the print report EBIOS application is depicted in Figure 5.

REKAPITULASI BIODIVERSITAS
BIDANG LINGKUNGAN UNIT BISNIS PEMBANGKITAN PERAK GRATI 23-04-2013

INDONESIA POWER

NO	NAMA	LATIN	KATEGORI	HABITAT	LOKASI	STATUS	PERIODE	TAHUN	JML	INDEKS
1	ALAP-ALAP SAPI	FALCO MOLUCCENSIS	AVES	DARAT	LUAR GRATI		SMT 2	2012	1	0.00136
2	BONDOL JAWA	LONCHURA LEUCOGASTROIDES	AVES	DARAT	DALAM GRATI		SMT 2	2012	16	0.01484
3	BONDOL JAWA	LONCHURA LEUCOGASTROIDES	AVES	DARAT	LUAR GRATI		SMT 2	2012	32	0.02626
4	BONDOL PEKING	LONCHURA PUNCTULATA	AVES	DARAT	DALAM GRATI		SMT 2	2012	32	0.02626
5	BONDOL PEKING	LONCHURA PUNCTULATA	AVES	DARAT	DALAM GRATI		SMT 2	2012	105	0.06688
6	BURUNG GEREJA ERASIA	PASSER MONTANUS	AVES	DARAT	DALAM GRATI		SMT 2	2012	46	0.03517
7	BURUNG MADU SRIGANTI	CINNYRIS JUGULARIS	AVES	DARAT	DALAM GRATI	1 (AB)	SMT 2	2012	4	0.00457
8	BURUNG MADU SRIGANTI	CINNYRIS JUGULARIS	AVES	DARAT	LUAR GRATI	1 (AB)	SMT 2	2012	13	0.01248
9	CABAI JAWA	DICATEUM TROCHILEUM	AVES	DARAT	LUAR GRATI		SMT 2	2012	3	0.00356
10	CABAI JAWA	DICATEUM TROCHILEUM	AVES	DARAT	DALAM GRATI		SMT 2	2012	5	0.00554
11	CABAK KOTA	CAPRIMULGUS AFFINIS	AVES	DARAT	DALAM GRATI		SMT 2	2012	3	0.00356
12	CALADI TILIK	DENDROCOPOS MOLUCCENSIS	AVES	DARAT	LUAR GRATI		SMT 2	2012	1	0.00136
13	CALADI ULAM	DENDROCOPOS MACEI	AVES	DARAT	LUAR GRATI		SMT 2	2012	1	0.00136
14	CALADI ULAM	DENDROCOPOS MACEI	AVES	DARAT	DALAM GRATI		SMT 2	2012	1	0.00136
15	CEKAKAK SUNGAI	HALCYON CHLORIS	AVES	DARAT	DALAM GRATI	1 (AB)	SMT 2	2012	2	0.0025
16	CEKAKAK SUNGAI	HALCYON CHLORIS	AVES	DARAT	LUAR GRATI	1 (AB)	SMT 2	2012	2	0.0025
17	CIPOH KACAT	AEGITHINA TIPHIA	AVES	DARAT	LUAR GRATI		SMT 2	2012	6	0.00648
18	CIPOH KACAT	AEGITHINA TIPHIA	AVES	DARAT	DALAM GRATI		SMT 2	2012	3	0.00356
19	CUCAK KUTILANG	PYCNONOTUS AURIGASTER	AVES	DARAT	DALAM GRATI		SMT 2	2012	9	0.00915
20	CUCAK KUTILANG	PYCNONOTUS AURIGASTER	AVES	DARAT	LUAR GRATI		SMT 2	2012	21	0.0186
21	GELATIK-BATU KELABU	PARUS MAJOR	AVES	DARAT	LUAR GRATI		SMT 2	2012	2	0.0025
22	GEMAK LORENG	TURNIX SUSCITATOR	AVES	DARAT	LUAR GRATI		SMT 2	2012	2	0.0025
23	KACAMATA BIASA	ZOSTEROPS PALPEBROSUS	AVES	DARAT	LUAR GRATI		SMT 2	2012	1	0.00136
24	KAPASAN KEMIRI	LALAGE NIGRA	AVES	DARAT	LUAR GRATI		SMT 2	2012	4	0.00457
25	KAPASAN KEMIRI	LALAGE NIGRA	AVES	DARAT	DALAM GRATI		SMT 2	2012	3	0.00356

Figure 5: EBIOS Application Printed Report

Advantages and Benefits

Financial Benefit

EBIOS development need low amount of cost due to it was developed with free software. According to it, Grati CCPP can save IDR of 66,440,000.00 because there will not be handled by third party anymore (source: procurement services contract application). The total cost analysis is then shown in Table 3.

Table 3: Total Cost Analysis for E-Bios

No	Contract	Total	Day	Cost / Day	Cost + Tax	Total Cost
1	Programmer	1	40	740,000.00	814,000.00	32,560,000.00
2	System Analyst	1	40	770,000.00	847,000.00	33,880,000.00
Total (Rp)						**66,440,000.00**

Non Financial Benefit

EBIOS application succeed in enhancing the PROPER score, specifically in Biodiversity Protection aspects, as can be seen in Table 4 [3], [4].

Table 4: Biodiversity Final Score of PROPER – Grati CCPP

No.	Assesment Criteria	2011	2012	difference
1.	Environmental Management System	83	85	+2
2.	Water Conservation	5	38.5	+33.5
3.	Emmision Reduction	33	55	+22
4.	Energy Efficiency	22	44	+22
5.	Biodiversity Protection	2	29	+27
6.	Hazardous Waste Management	38	8.5	-29.5
7.	Solid Waste Management	38	37.5	-0.5
8.	Community Development	33	34	+1
Total		**254**	**331.5**	**+77.5**

Conclusions and Recommendations

This study has effectively shown successfulness of Environmental Compliance achievement, so it can be conclude that:

1. EBIOS is the computerize system which able to help the biodiversity data processing in Grati CCPP.
2. EBIOS improves worker's effectiveness and efficiency in collecting data and evaluating the biodiversity propensity in Grati CCPP.
3. EBIOS has proven significantly improving the point enhancement of PROPER Grati CCPP as in Energy Sector for more than 1000 %.
4. Beside of giving simplicity and easiness to finance department so they can work effectively and efficiently, by running this application independently Grati CCPP will be able to save the maintenance application cost in the amount of 66,440,000.00 (currency in IDR).

Acknowledgement

Authors wish to thank to in charge leaders of PT Indonesia Power – Generation Unit of Perak – Grati for financial and non-financial support. We also thank to all Environmental Compliance team with cooperative and excellence teamwork.

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A Study of Electricity Utilization in Beach Resort Hotels, Chonburi Province for Energy Conservation

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The Asian Conference on Sustainability, Energy & the Environment 2015
Official Conference Proceedings

Abstract
This research investigates the standard electricity utilization in beach resort hotels based on a survey of four 4-star beach resort hotels in Chonburi, Thailand that was conducted in 2014. The main objective of the project was to know proportion of electricity in End-Use Category. Each hotel has total usable areas of 34,878.50, 24,706.56, 17,533.40 and 10,910.56 m2 with total air-conditioned areas of 17,364.45, 8,327.48, 5368.35 and 8,212.56 m2 respectively. The results shown that the hotel with most areas in usable, air-conditioned space and using central air conditioning system has the minimum index value of electrical consumption in air conditioning system to air-conditioned area equal to 72.36 kWh/m2/year. Unlike other three hotels with using split type air conditioning system that have this value equal to 89.92, 103.67 and 136.21 kWh/m2/year. Every hotel has the lowest proportion of electricity in lighting system compared with electrical consumption of air conditioning system and electric-mechanical system, which accounted for 5 – 10% of total electricity utilization and the maximum value of lighting density power is lower than 12 W/m2, which is considered the standard of Thailand Energy Conservation Promotion Act. Moreover, the study also found that the hotel with usable area most has annual electricity consumption for electric-mechanical equipment system that most in refrigerators, followed by pumps and other kitchen equipment, respectively which accounted for 53% of total electricity utilization. Finally, the results can also use as guidelines for designing beach resort hotels, Chonburi province for energy conservation, including the use of air conditioning systems appropriately.

Keywords: Beach Resort Hotel, Chonburi Province, Standard Electricity Utilization

1.Introduction

Nowadays, there are a lot of Beach Resort Hotels in Chonburi province, Thailand which provide 24-hour service (DEDE, 2005). The hotel business has highly using electricity ranked second from the department store which shown in figure 1.

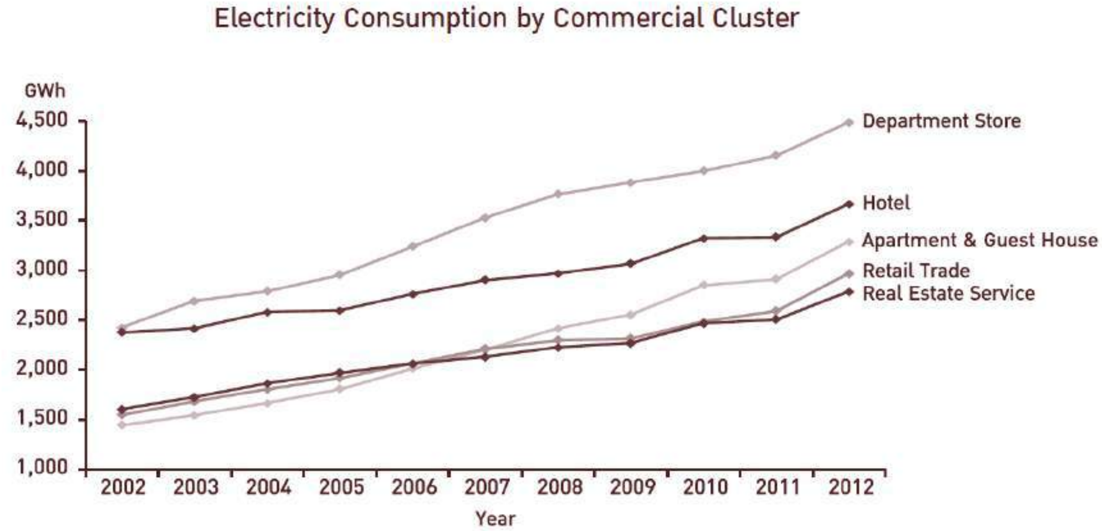


Figure 1: Electricity demand in most commercial clusters continuously increased from 2002 to 2012. In 2012, the business & commerce that accounted for high electricity consumption were as follows: department stores, hotels, apartments & guest houses, retail trade and real estate services, respectively (EPPO, 2012).

Moreover, the Thai government also issued the energy conservation promotion launched by the ministry of energy. The resort including Beach Resort Hotel must do the survey and have to report the energy consumption, energy efficiency and potentials of energy conservation in order to determine the energy conservation targets and plans (Royal Thai Government Gazette B.E.2009, 2009, pp.7-12). This research aims to investigate and study the characteristics of electricity utilization and also to know the potentials of energy conservation in beach resort hotel, Chonburi province, Thailand. By explore the quantity of standard electricity utilization of four 4-star beach resort hotels, related to be the controlled building by The Energy Conservation Promotion Act B.E.2535 (1992). By choosing the samples of beach resort hotels in Chonburi province, the appropriate building orientation and the use of materials would be suitable to maximize the energy efficiency of the building envelope system, but still have the highly proper electricity consumption as well.

2.Thailand Energy Conservation Promotion Act B.E.2535 (1992)

Ministerial Regulation Prescribing Standard, Criteria, and Energy Management Procedures In Designated Factories and Buildings B.E. 2552 (1992) announced that hotels in Thailand including Beach Resort Hotels in Chonburi province must do the survey and have to report the energy consumption which can be achieved through the application of guidelines for building energy management (Royal Thai Government Gazette B.E.2009, 2009, pp.7-12). The status and potentials of energy conservation that is consistent with the energy conservation promotion act can be checked from the databases of the Department of Alternative Energy Development and Efficiency.

(DEDE, 2010) So the researcher has screened a benchmark for monitoring preliminary references of energy conservation potentials as shown in Table 1

Table 1: The reference index value from the Department of Alternative Energy Development and Efficiency (DEDE, 2010)

<table>
<tr><td>Lists</td><td colspan="3">The reference index value from DEDE</td></tr>
<tr><td rowspan="2">Electrical use for air-conditioned space per area
(kWh/m2/year)</td><td colspan="3">Average</td></tr>
<tr><td colspan="3">172</td></tr>
<tr><td rowspan="2">Electrical use for lighting system per area
(kWh/m2/year)</td><td colspan="3">Average</td></tr>
<tr><td colspan="3">34.7</td></tr>
<tr><td rowspan="3">Energy Use Intensity; EUI (Total electrical use per total area)
(kWh/m2/year)</td><td colspan="3">Reference</td></tr>
<tr><td>Average</td><td>Standard</td><td>High Efficient</td></tr>
<tr><td>173.2</td><td>117.0</td><td>101.7</td></tr>
<tr><td rowspan="4">Lighting Power Density (LPD)
(W/m2)</td><td colspan="3">Average</td></tr>
<tr><td colspan="3">7.8</td></tr>
<tr><td colspan="3">Standard</td></tr>
<tr><td colspan="3">12</td></tr>
<tr><td>The proportion of air-conditioned space per total area
(%)</td><td colspan="3">67</td></tr>
<tr><td rowspan="2">Electricity Utilization Proportion (%)</td><td>Air Conditioning System</td><td>Lighting System</td><td>Other System</td></tr>
<tr><td>66</td><td>20</td><td>14</td></tr>
</table>

3. Methodology

This is a quantitative research to investigate and study the characteristics of electricity utilization and also to know the potentials of energy conservation in beach resort hotel, Chonburi province, Thailand. By explore the quantity of standard electricity utilization of four 4-star beach resort hotels, related to be the controlled building by The Energy Conservation Promotion Act B.E.2535 (1992). By choosing the samples of beach resort hotels in Chonburi province, the appropriate building orientation and the use of materials that would be suitable to maximize the energy efficiency of the building envelope system, but still have the highly proper electricity consumption as well. (Supornsahasransi, 2014) The 4 sample hotels were also selected by the beach resort hotels with area larger than 10,000 square meters, with 4-stars standard according to the Thailand Department of Tourism, classed under type-3 hotels by Thailand Hotel Act BE.2547 (2004) which are those hotels which provide accommodation, restaurant facilities and conference rooms to their guests, durations of business operation time are more than 10 years and the distances from Chonburi eastern coast are not more than 500 meters. All samples including 1) RAVINDRA BEACH RESORT & SPA, 2) THE GREENPARK RESORT, 3) SUNSHINE

GARDEN RESORT and 4) SUNSHINE HOTEL & RESIDENCES which contains physical characteristics of the buildings information as shown in Figure 2

Sampled Hotels	The Physical Characteristics of Hotel Building
RAVINDRA BEACH RESORT & SPA (277 rooms) 	**The Central Facilities** - Lobby Hall and Basement Parking : 2 Floors, 1 Building - The Convention Hall and BACK OF THE HOUSE : 2 Floors, 1 Building - ALL DAY DINING Restaurant and FACILITIES : 2 Floors, 1 Building - Beach Front Restaurant : 1 Floor, 1 Building - Spa and massage: 1 Floor, 1 Building **Accommodation Building** - Accommodation Room : 8 Floors, 2 Buildings - POOL VILLA : 1 Floor, 4 Buildings - POOL VILLA : 2 Floors, 1 Building
THE GREENPARK RESORT (194 rooms) 	**The Central Facilities** - Lobby Hall: 1 Floor, 1 Building - All day dining restaurant , Meeting room and BACK OF THE HOUSE : 3 Floors, 1 Building - Convention Room : 3 Floors,1 Building **Accommodation Building** - Accommodation room : 3 Floors, 4 Buildings - Accommodation room : 4 Floors, 1 Building - The Bungalow : 1 Floor, 18 units
SUNSHINE GARDEN RESORT (141 rooms) 	**The Central Facilities and Accommodation** - Lobby Hall and Residential room : 2 Floors, 1 Building - All Day Dining Restaurant and BACK OF THE HOUSE : 1 Floor, 1 Building - Convention Room : 1 Floor, 1 Building **Accommodation Building** - Residential: 3 Floors, 1 Building - Bungalow: 1 Floor, 17 Buildings
SUNSHINE HOTEL & RESIDENCE (275 rooms) 	**The Central Facilities and Accommodation** - Lobby, All Day Dining Restaurant , Residential Unit, Meeting Room and BACK OF THE HOUSE: 7 Floors, 1 Building - FACILITIES , CAFÉ and Residential Unit 12 Floors, 1 Building - Residential and Roof top swimming pool 7 Floors, 1 Building - Residential Building: 1 Building

Figure 2: Physical characteristics of the buildings information.

The study consists of 4 major steps which are:

1) The basic statistical data collection
2) Survey of Standard Electricity Utilization; SEU
3) The actual electrical data collection
4) To analyze and interpret data that is detailed as follows:

Step 1: The basic statistical data collection.
The basic statistical data collection is divided into 4 sections: 1) Size of areas, 2) Number of guestrooms, 3) Average occupancy rate, and 4) Durations of business operation time. The data collected by the survey, and asked for information courtesy of sampled hotels entrepreneurs

Step 2: Survey of Standard Electricity Utilization; SEU
Quantity of Standard Electricity Utilization; SEU is derived from the characteristics of electricity utilization which owned by 12 months individual departments operation of sampled hotels. The Units of electrical consumption is "kilowatt-hours (kWh)" made from various factors that affect energy consumption such as size of usable area, number of working hours, number of workers, hotel's operational characteristics, electrical device operational characteristics, etc. This information is derived from the basis physical collecting data and the survey by interviewing experts, entrepreneurs and employees of the hotel. Including the application of Standard Electricity Utilization Survey Forms from the Ministry of Energy (EPPO, 2015), as shown in Table 2

Table 2: Standard Electricity Utilization Survey Forms applied from the Ministry of Energy. (EPPO, 2015)

Name of Area	Device in each room	The Proportion of Work	Power (Watts)	Number of Device	Total Power (Watts)	Hours of use per day	Days of use per month	The Electrical units (kWh/Y)
Data part 1	Data part 2	Data part 3	Data part 4	Data part 5	Data part 6	Data part 7	Data part 8	Data part 9

Step 3: The actual electrical data collection.
The actual electrical data collection is the quantity of units actually used for total 12 months. The Units of electrical consumption is "kilowatt-hours (kWh)" derived from invoice/bill each month. This data is for analyze the potentials of Energy Conservation by comparison with the reference index from the Department of Alternative Energy Development and Efficiency (DEDE).

Step 4: Analysis and interpretation of data.
1) Preliminary Classification of standards electricity utilization survey is divided into three systems: a) air conditioning system, b) lighting system and c) electric-mechanical system by classifying each system based on the end-use electricity and types of electrical devices.
2) Calculated Energy Use Intensity (EUI) (kWh/m2) by comparing between Energy Use Quantity and size of area in order to realize the potentials of energy conservation according to reference index from DEDE.

3) Comparing electricity utilization information of the 4 sampled hotels to find the conclusion.

4.Results & Conclusions

The basic statistical data of the sampled hotels for the study are shown in Table 3 with the results on issues as follows:

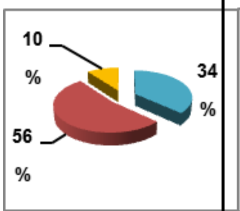
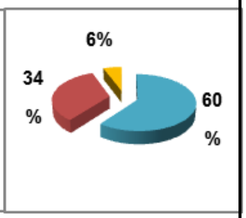
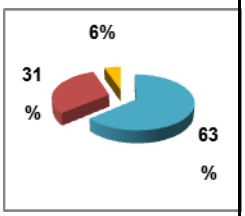
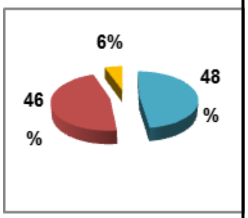
Table 3: The basic statistical data of all sampled hotels

Lists	**RAVINDRA BEACH RESORT & SPA**	**THE GREENPARK RESORT**	**SUNSHINE GARDEN RESORT**	**SUNSHINE HOTEL & RESIDENCES**
Number of Rooms (Room)	277	194	141	293
Total Usable Area (Square Meter)	34,878.00	24,706.56	17,533.40	10,910.56
Total Conditioned Area (Square Meter)	17,364.45	8,327.48	5,368.00	8,212.56
The Proportion of Air-Conditioned space to Usable Area	49.78%	33.71%	29.30%	75.27%
The Average Occupancy Rate (for the year 2014)	72.81%	80.87%	53.88%	81.05%
Duration of Business Operations.	2003-2014 (11 years)	2002-2014 (12 years)	1986-2014 (28 years)	1984-2014 (30 years)
The Distance from the Sea	By Sea (with private beach)	200 meters	266 meters	187 meters
Type of Air-Conditioned system	Central Air-Conditioning Type	Split Type	Split Type	Split Type

4.1 The characteristics of electricity utilization

The survey results are shown in Table 4 which found that "RAVINDRA BEACH RESORT & SPA", the hotel with most areas in usable and using central air conditioning system has the highest electrical consumption equal to 3,643,737.82 kWh/year .And the most annual electrical consumption is utilized for electric-mechanical equipment system which accounted for 53% of total electricity utilization. Unlike other three hotels (THE GREENPARK HOTEL RESORT, SUNSHINE GARDEN RESORT and SUNSHINE HOTEL & RESIDENCES) with using split type air conditioning system that the most annual electrical consumption is utilized for air conditioning system, which accounted for 48-63% of total electricity utilization, followed by the electric-mechanical system which accounted for 31-46% of total electricity utilization. Furthermore, it was found that all sampled hotels have the minimum electricity utilization in lighting system which account for only 6-10%

Table 4: The characteristics of electricity utilization in all sampled hotels

Lists	RAVINDRA BEACH RESORT & SPA	THE GREENPARK RESORT	SUNSHINE GARDEN RESORT	SUNSHINE HOTEL & RESIDENCE
Air Condition System (kWh/year)	1,256,540.53 34%	748,836.24 60%	556,506.14 63%	1,118,596 48%
Lighting System (kWh/year)	350,234.42 10%	79,042.68 6%	54,925.72 6%	129,603.47 6%
Mechanical System-Electrical Equipment (kWh/year)	2,036,962.87 56%	418,447.13 34%	270,076.72 31%	1,087,273.30 46%
Total (kWh/year)	**3,643,737.82** **100%**	**1,246,326.05** **100%**	**881,508.58** **100%**	**2,335,472.77** **100%**
Proportion Air-Con Lighting Mechanical-Electrical equipment				

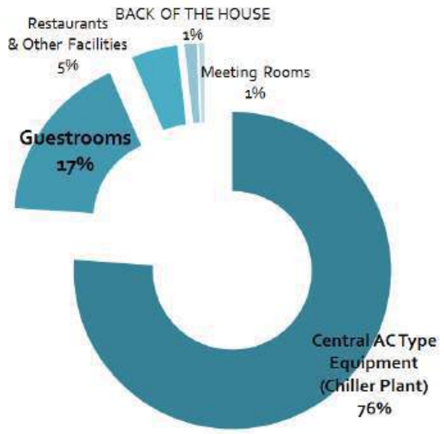
4.1.1 The characteristics of electricity utilization in air conditioning system

The results found that the hotel using central air conditioning system (RAVINDRA BEACH RESORT & SPA) has the most electrical consumption in Chiller Plants which accounted for 76.1% of total electricity utilization in air-conditioning system, which sent cooling to several local areas that most for guestrooms, followed by restaurants and other facilities.
Unlike other three hotels (THE GREENPARK HOTEL RESORT, SUNSHINE GARDEN RESORT and SUNSHINE HOTEL & RESIDENCES) with using split type air conditioning system that the most annual electricity consumption is utilized for guestrooms (rank#1) which accounted for 90.7-96.7% of total electricity utilization in air-conditioning system followed by restaurants and other facilities

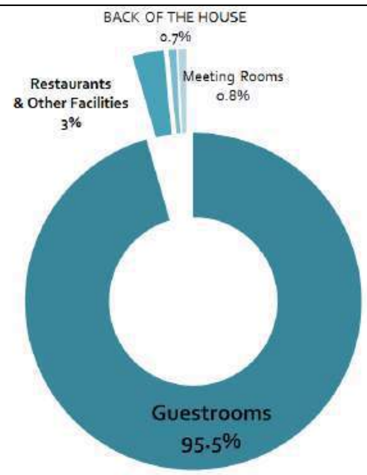
(rank#2) and meeting rooms (rank#3). Except SUNSHINE HOTEL & RESIDENCES that its rank#3 utilization is BACK OF THE HOUSE as shown in Table 5

Table 5: The characteristics of electricity utilization in air conditioning system

<table>
<tr><td>



</td><td>



</td></tr>
<tr><td>1. RAVINDRA BEACH RESORT & SPA
(Central air conditioning system)</td><td>2. THE GREENPARK RESORT
(Split type air conditioning system)</td></tr>
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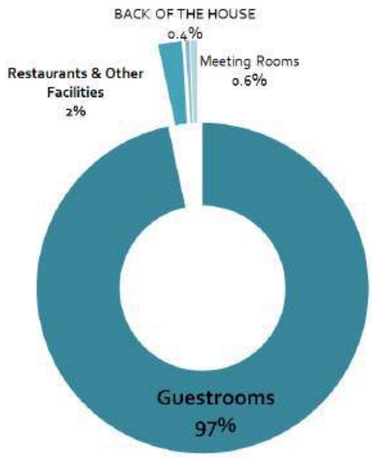

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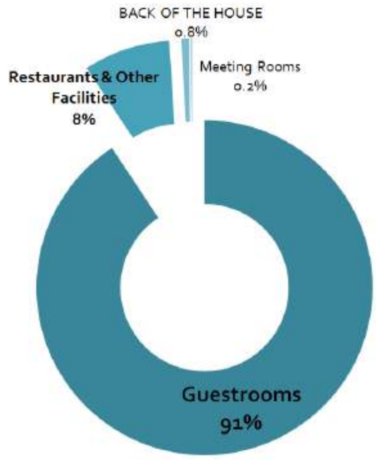


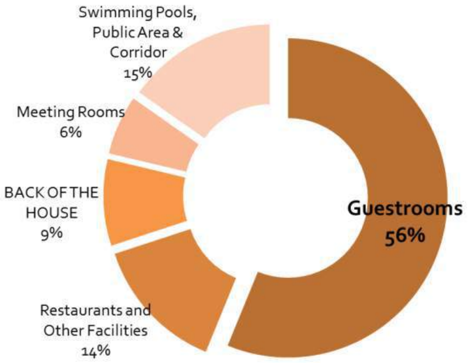
</td></tr>
<tr><td>3. SUNSHINE GARDEN RESORT
(Split type air conditioning system)</td><td>4. SUNSHINE HOTEL & RESIDENCES
(Split type air conditioning system)</td></tr>
</table>

4.1.2 The characteristics of electricity utilization in lighting system

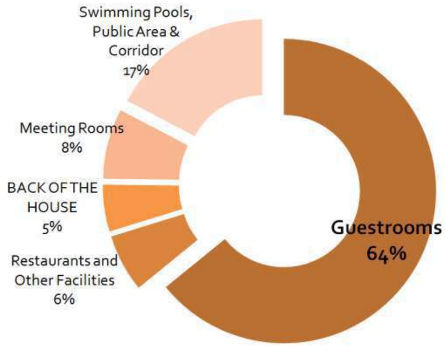
The results showed that all sampled hotels have the most electricity utilization in lighting system for illuminate the guestrooms which accounted for 56.2 - 80.7% of the total electricity utilization in lighting system. Following by 'Swimming Pools, Public

Area & Corridor' (rank#2) which accounted for 11 - 15.3% of the total electricity utilization in lighting system, 'Restaurant and Others Facilities' (rank#3). Except THE GREENPARK RESORT that that its rank#3 utilization is 'Meeting Rooms' as shown in Table 6

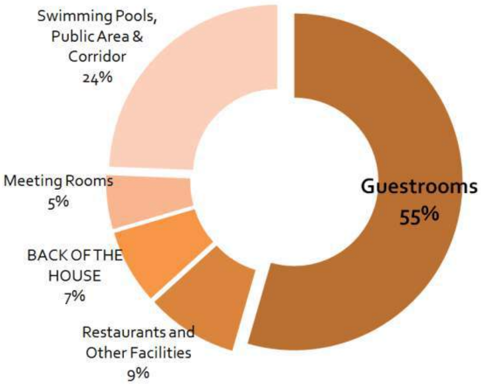
Table 6: The characteristics of electricity utilization in lighting system



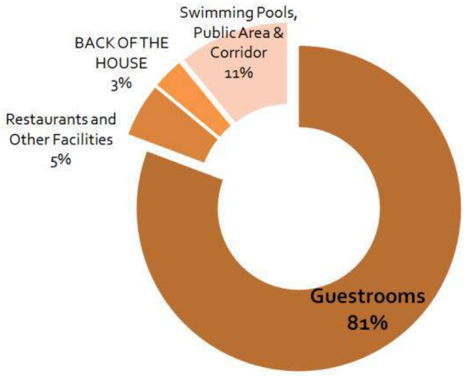
1. RAVINDRA BEACH RESORT & SPA



2. THE GREENPARK RESORT



3. SUNSHINE GARDEN RESORT



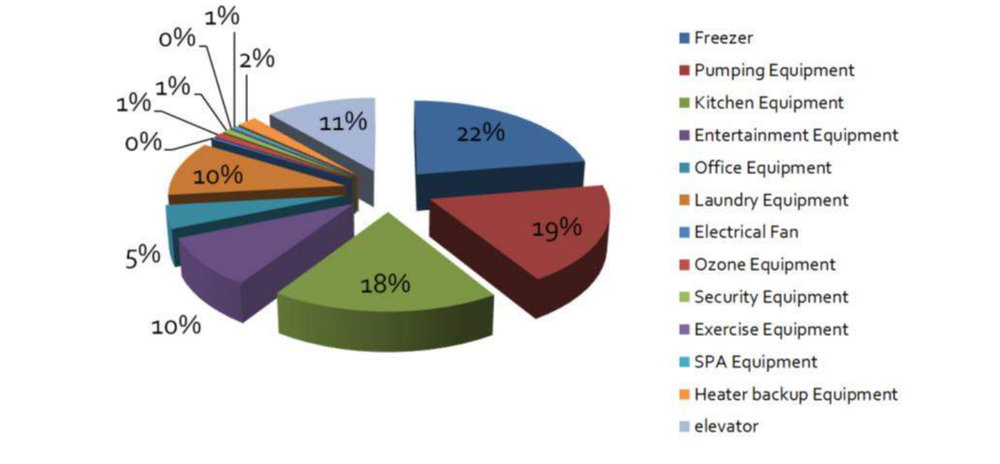
4. SUNSHINE HOTEL & RESIDENCES

4.1.3 The characteristics of electricity utilization in electric-mechanical system

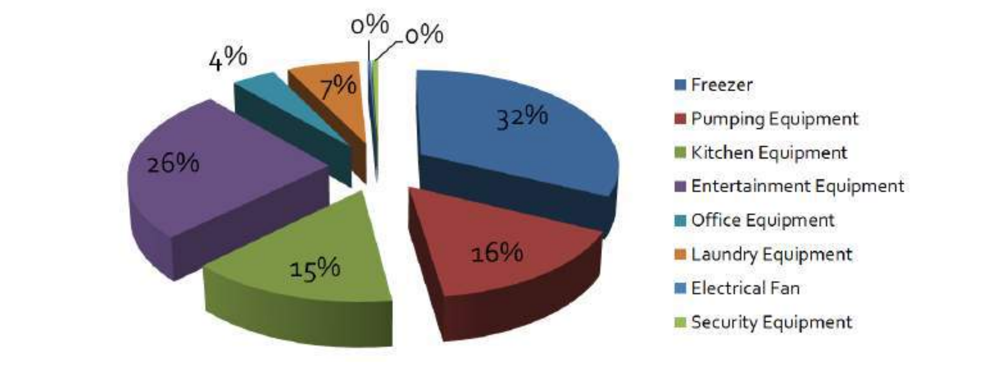
The results can be classified the types of electric-mechanical equipment in sampled hotel into 13 types including refrigeration equipment, pumping equipment, kitchen equipment, entertainment devices, office equipment, laundry equipment, electric fans, ozone equipment, security equipment, fitness equipment, spa equipment, heater backup equipment and elevators. All sampled hotels have the most electricity utilization in electric-mechanical system for refrigeration equipment especially in restaurants and guestrooms. And also notice that all sampled hotels have high electricity utilization in electric-mechanical system for pumping equipment, kitchen equipment, entertainment devices and elevators, etc. The details are shown in Table 7

Table 7: The characteristics of electricity utilization in electric-mechanical system

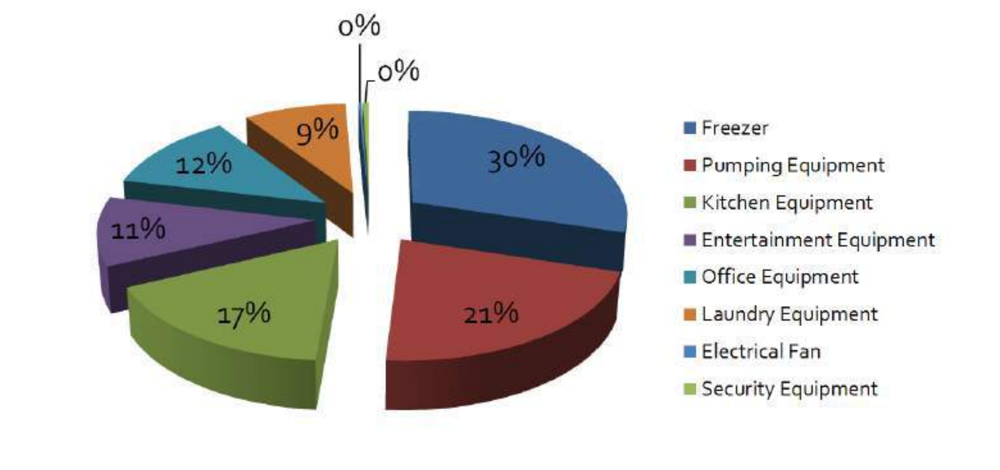
1. RAVINDRA BEACH RESORT & SPA



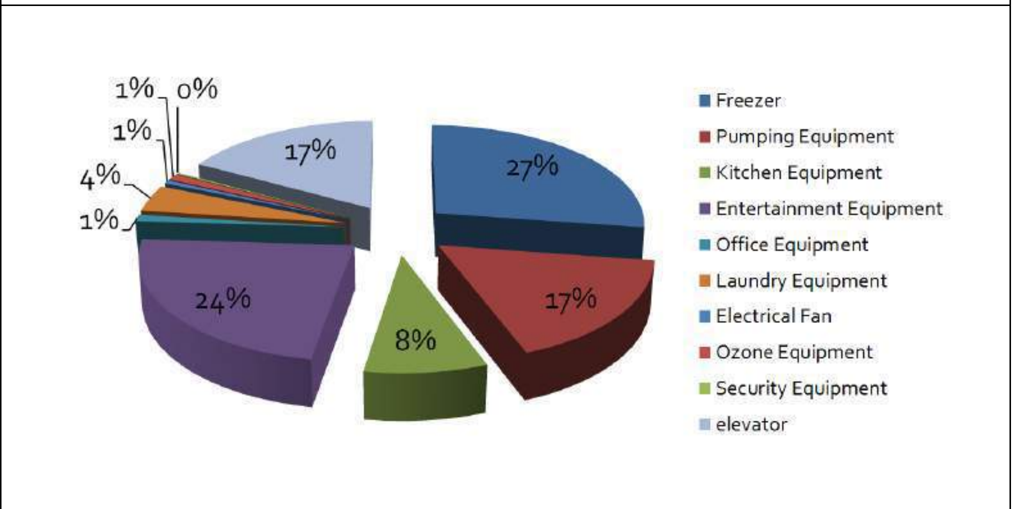
2. THE GREENPARK RESORT



3. SUNSHINE GARDEN RESORT



4. SUNSHINE HOTEL & RESIDENCES



4.2 Potentials of energy conservation

By comparing the standard electricity utilizations of all sampled hotels. It was found that the hotel with most areas in usable, air-conditioned space and using central air conditioning system (RAVINDRA BEACH RESORT & SPA) has the minimum index value of electrical consumption in air conditioning system to air-conditioned area equal to72.36 kWh/m^2/year. Unlike other three hotels (THE GREENPARK RESORT, THE SUNSHINE GARDEN RESORT, SUNSHINE HOTEL & RESIDENCE) with using split type air conditioning system that have this value equal to 89.92, 103.67 and 136.21 kWh/m^2/year, respectively and these are not exceed 172 kWh/m^2/year which is the average of reference index value by Department of Alternative Energy Development and Efficiency (DEDE). The maximum value of lighting density power is lower than 12 W/m^2. In addition, Energy Use Intensity (EUI) is not exceed 117 kWh/m^2/year which is considered the standard of Thailand Energy Conservation Promotion Act as shown in Table 8

Table 8: Potentials of energy conservation

Lists	RAVINDRA BEACH RESORT & SPA	THE GREENPARK RESORT	SUNSHINE GARDEN RESORT	SUNSHINE HOTEL & RESIDENCE	The reference value from the DEDE.
The proportion of air-conditioned space per area (%)	49.78%	33.71%	29.30%	75.27%	67%
Electrical Consumption for air conditioning system (kWh/m2/year)	72.36	89.92	103.67	136.21	Average 172
Electrical Consumption for lighting system (kWh/m2/year)	10.04	3.19	3.13	11.88	Average 34.7
Lighting Power Density (W/m2)	3.84	1.16	0.96	2.99	Average 7. Standard 12
Energy Use Intensity (EUI) (kWh/m2/year) (Actual power consumption)	91.63	38.82	33.87	116.83	Average 173.2 Standard 117

Recommendation

The results from this research study can also use as guidelines for designing 4-star beach resort hotels, Chonburi province, Thailand which controlled the operation of business and hotel facilities in related to the sampled hotels in this research. To achieve the potentials of energy conservation follow by the Energy Conservation Promotion Act B.E.2535 (1992), including the proposal of guidelines for selecting the appropriate use of air conditioning system, and futures studies on electrical budget plan for economics feasibility.

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Whether to Invest in Smart Technology or Elsewhere – a Decision Support Tool

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Abstract
Most small-scale industries and household complexes in developing countries face a financial dilemma regarding installation of energy saving technologies like smart lighting. Given an initial capital, it is often not clear whether to invest it in such technologies or elsewhere that gives better returns on investment. For example, if the users of the building are sufficiently energy aware to turn off their personal appliances and lights before leaving a room, it can be argued that the initial capital is better invested elsewhere.

We introduce a tool that helps concerned decision makers compare the savings due to installation of smart technologies against alternative investment avenues.

Keywords: Building Occupancy, Energy Awareness, Networks of Stochastic Timed Automata, Statistical Model Checking

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1. Introduction

Non-renewable energy sources are depleting at an alarming rate today. It is therefore necessary to conserve energy. One major area where a lot of energy is wasted is household and office electrical power. Modern homes have several power consuming appliances like fans, bulbs, etc. that are left switched on even when not in use. One way to avoid this kind of power wastage is to equip homes and offices with smart technologies like smart lighting systems that switch off when not in use. But such smart technologies require capital investment. For households and offices with limited budgets, it is not easy to decide whether to invest in such technologies or somewhere else that gives higher returns.

The energy awareness of the users of the building plays a major role in this decision. If the average user is responsible enough to switch off devices most of the times when they are not in use, it can be argued that the investment is better made elsewhere. It is therefore desirable to have a tool that gives a quantitative justification of such decisions.

In this paper, we combine building occupancy simulation techniques with statistical model checking tools for probabilistic timed systems to arrive at such justifications. While a straightforward stochastic simulation can yield some interesting observations, statistical model checking can provide more accurate answers to complex queries. Model checking involves description of the system in a mathematically precise language, the specification of requirements in an appropriate system of logic and automatically checking if the model satisfies the specified requirements. Statistical model checking is a technique that provides answers faster, albeit at the expense of accuracy, as opposed to symbolic/numerical approaches that are accurate but computationally expensive. In this paper, we use Networks of Stochastic Timed Automata (NSTA) for modeling the system, weighted Metric Interval Temporal Logic (MITL) to specify our requirements regarding energy savings, and the UPPAAL Statistical Model Checker to do the model checking.

Specifically, our approach answers the following question: Given (i) an initial capital of P units of money required for smart technology (such as smart lighting and smart heating systems) (ii) a rate r of return on an alternative investment plan, (iii) the average energy awareness of the users (measured as the probability switching off power when not in use, averaged over all users), and (iv) the building occupancy profile (obtained through occupancy simulation techniques reported in literature), should P be invested in smart technologies or in the alternative plan?

The paper is organized as follows. Section 2 gives a brief overview of the various concepts, techniques and tools used in this work. Section 3 explains the model checking approach and discusses the results. Section 4 gives a brief description of a simulations based approach and a comparison with results from the model checking approach.

2. Preliminaries

Our work uses concepts from different areas of research. We briefly discuss each in turn. The reader is encouraged to refer to the relevant citations for details.

2.1 Building Occupancy

Building occupancy simulation has attracted considerable interest in the recent past (Liao and Barooah (2010), Richardson et al (2008), Page et al (2008), Wang et al (2011)). It has applications in predicting energy consumption patterns in the buildings, performance analysis of HVA systems etc. Page et al (2008) showed an algorithm to generate a time series of the state of presence of occupants within a specific zone of a building, given the transition probabilities of the model corresponding to arriving, leaving and staying in the zone. Wang et al (2011) handled occupant movement as a Markov process, and generated the location for each occupant at discrete time instants. In addition, they used the concept of *events* during the day, that decides which stochastic transition matrix is appropriate to generate the movement pattern at a given point in time. For example, the transition matrix for an event *ComingToOffice* will differ from the matrix for the event *GoingHome*. The locations of the users are noted after each k-minute interval, which we call a *time-step* in this paper, throughout a full working day. An integral step in our approach is generation of such an occupancy profile, and we use a similar method for the purpose.

2.2 Networks of Stochastic Timed Automata

Networks of Stochastic Timed Automata (NSTA) are essentially stochastic finite automata augmented with real valued clock variables. Uppaal-SMC is a popular statistical model checker that supports modeling as NSTA and weighted MITL as the

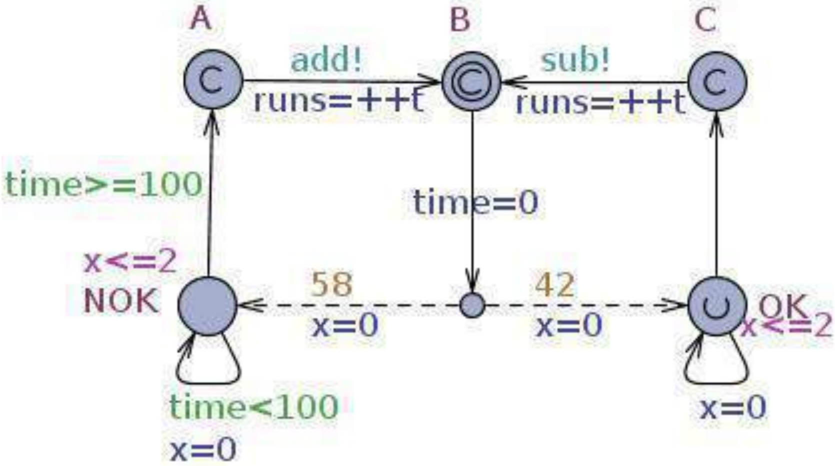

Figure 1. Example of an NSTA Model [Source: UPPAAL SMC Demo]

query language. For the sake of brevity, we introduce only some salient features of NSTA through an example. The queries that we ask of the model will be translated into English as well for convenience. The reader is encouraged to read the UPPAAL-SMC tutorial (David et al, 2015) and the references therein for details regarding NSTA and weighted MITL.

An NSTA essentially consists of a finite number of *locations* connected by labeled directed edges between them, together with (clock) constraints that govern the movement between the locations along the edges. Transitions between locations are enabled upon satisfaction of constraint(s) on clock values and/or integers. Figure 1 shows an example graphically. *time* and *x* are clock variables. Synchronization variables *add* and *sub* are used for communication between various components of the system.

The label *"x<=2"* stands for an *invariant* condition meaning that the system cannot remain in this location when the clock *time* exceeds 2. A guard (e.g. the " *time>=100*" label on the edge going from location labeled *NOK*) on the other hand, determines the earliest the automaton can make transition along the edge. Non-clock variables can be updated, and the clock variables reset along the edges. For example, *runs=++t* is an update on the integer variable *runs,* and the updates *x=0* and *time=0* are clock reset operations. The dashed edges represent the probability with which the system can transit from one location to any location. The numbers of the dashed edges represent the probability ratio with which a particular transition may take place. For example, in this scenario, the system can go from the location *B* to location *NOK*, or to location *OK*, with probabilities, 58/(58+42) and 42/(58+42), respectively.

3. Methodology

The main idea behind our approach can be broadly described as follows:

1. Consider a building with of *m* rooms and a user community of size *n*. For each user U_i of the building, we create the time sequence of occupancy in various rooms. As mentioned previously, this is done using existing agent based building occupancy simulation techniques that model the movement of each person as a Markov process as in Wang et al (2011). (We use a time-step size *k*=10 and the events *GoingHome*, *WalkAround*, and *ComingToOffice*. We consider a building of three rooms, with a total user community of six, each potentially assigned to an initial room.)

2. User U_i turns off personal appliances with the probability p_i when leaving a room. Thus, p_i quantifies the energy awareness of user U_i. In this work, we assume every user has an average energy awareness $(\sum p_i)/n$. Had smart technologies been installed, the appliances would have been necessarily turned off for the interval the user remains out of the room. Therefore, if smart technologies are installed, energy savings occur precisely during the intervals when the user leaves the room forgetting to turning off personal devices and lights.

3. This saving is compared against the returns of the alternative investment.

3.1 Statistical Model Checking Approach

3.1.1 Modeling the System

The system is modeled as a parallel composition of three timed automata: *Timer*, *Person*, and *Control*. We explain each automaton in detail. But before that, we list below important data structures used:

pid: variable to identify each user
rid: variable to identify each room
ts: integer variable denoting *time-step*.
numTimeSteps: constant denoting the total number of time-steps in one working day.
morning: variable denoting the time at which the first event ends.
evening: variable denoting the time at which the second event ends.
night: variable denoting the time at which the third event ends.
room[pid]: variable to denote the current location of user *pid*.

roomPat[pid][rid][ts]: 3-dimensional array capturing the occupancy data for each user pid, in room rid, at time-step ts. roomPat[pid][rid][ts] is 1, if user *pid* is in room *rid* at time-step *ts*.
ePat[pid][rid][ts]: 3-dimensional array capturing the energy pattern for each user pid, in room rid, at time-step ts. ePat is 1, if user *pid* is consuming energy in room *rid* at time-step *ts*, remains 1 if the user forgets to switch off the power before leaving the room, and is set to 0 otherwise.
movementMatrix: data structure representing the probabilities of movements of the users from one room to another.
sincere[pid][ts]: denotes whether or not the user *pid* switched off the power before leaving room at time-step ts.

A. The *Timer* Automaton

The Timer Automaton (Figure 2) maintains the time-step for each event and in the end, computes the energy if smart technology is used. The automaton works as follows:

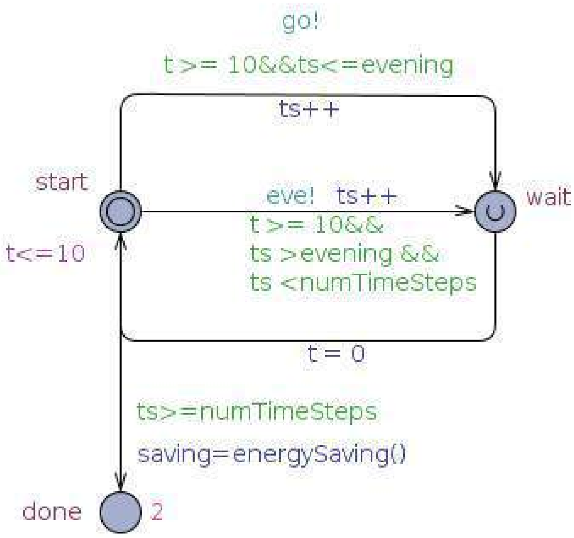

Figure 2. Timer Automaton

The automaton moves from its initial *start* location to the *wait* location at the end of each 10-minute *time-step*. This is ensured by the guard $t \geq 10$ and the invariant $t \leq 10$. A synchronization signal "go" is sent to the *Person* automaton to indicate that the occupant can change location as determined by the probability distribution over the outgoing edges. There is one more guard on the edge going from *start* to *wait*: *ts<numTimeSteps*, which indicates that this automaton will run only till the number of time-steps equivalent to one day observations. When *ts* becomes equal to or exceeds *numTimeSteps*, the automaton moves from the *start* location to the *done* location. At this point, an internal function is invoked that calculates the energy that would have been saved during the day if smart technologies had been installed.

B. The *Person* Automaton

This automaton (Figure 3) models the movement of the occupants from one location to another. There are 3 rooms, and an *outside* location. Each occupant starts from outside (represented by the *Outside* location) and moves into the room assigned to them after receiving the *go* signal from the *timer* automaton. The guard *ts<evening*

ensures that this transition happens only before the last event, i.e. evening. The update *roomPat[pid][0][ts]* = 1 updates the room occupancy info of room0 in the matrix *roomPat* which basically captures the occupancy profile of each occupant at each time-step. This captures the first event - *ComingToOffice*. The next event is *WalkAround* in which the occupants move from one room to another based on the probability of movements. The *go* signal from the *timer* automaton sets this event in motion, and the automaton moves to the location *WalkAround* from either of the three locations viz. *Room0, Room1, or Room2*. From this location, the automaton either transits to location *LeaveRoom* or *RemainInside* based on the probability weights on the dashed-edges (2/5 and 3/5, here). These weights are directly taken from the movement matrix discussed earlier, and represented as ratio of weights. Now based upon which room the occupant was in before leaving his room, the automaton transits to either location A, or B or C. From each of these locations, the automaton transits to either of the locations *Room0* or *Room1* or *Room2* depending again, on the probability weights.

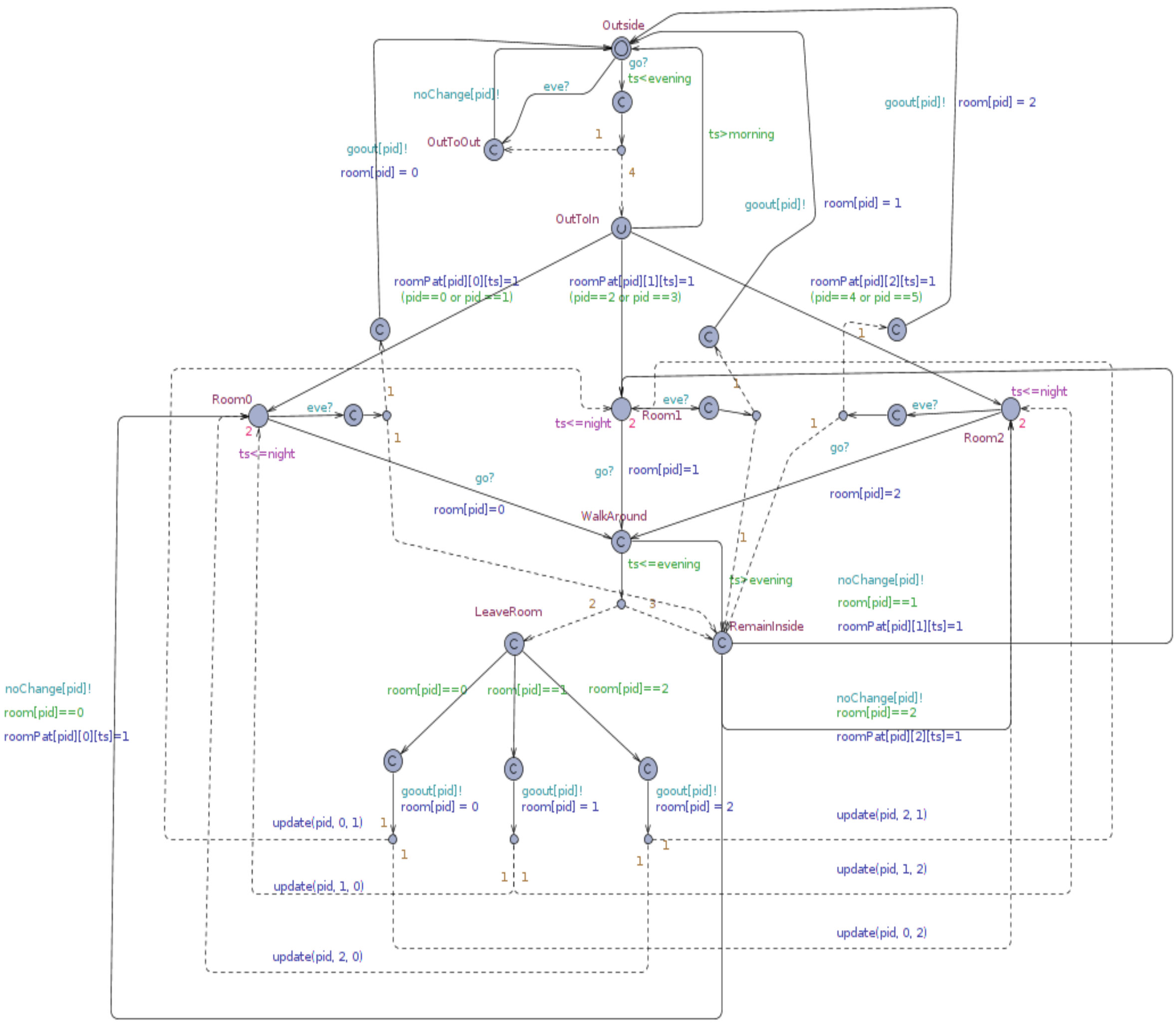

Figure 3. Person Automaton

This transition sets out the signal *goout[pid]* to the control automaton indicating that the person is leaving the room. The update function *update(pid, x, y)* is called to update the occupancy matrix indicating that the person has moved from room x to room y. The guard *ts≤evening* on the edge going out from *WalkAround* ensures that walk-around happens no later than evening, after which the occupant has to go home or remain inside the room. If the automaton moves to the location *RemainInside* from the location *WalkAround*, then it will transit to the location it was earlier in. This is ensured by the guard room[pid] == x, checking if the person was in room x earlier or not. This is indicated by the signal *noChange* to the control automaton. Along the transition from *RemainInside* to either of the locations representing the rooms, *roomPat* array is updated to denote that person is still in that room by setting *roomPat[pid][x][ts]* to 1. The last event is *GoingToHome*. The signal *eve* received from the timer automaton captures this event.

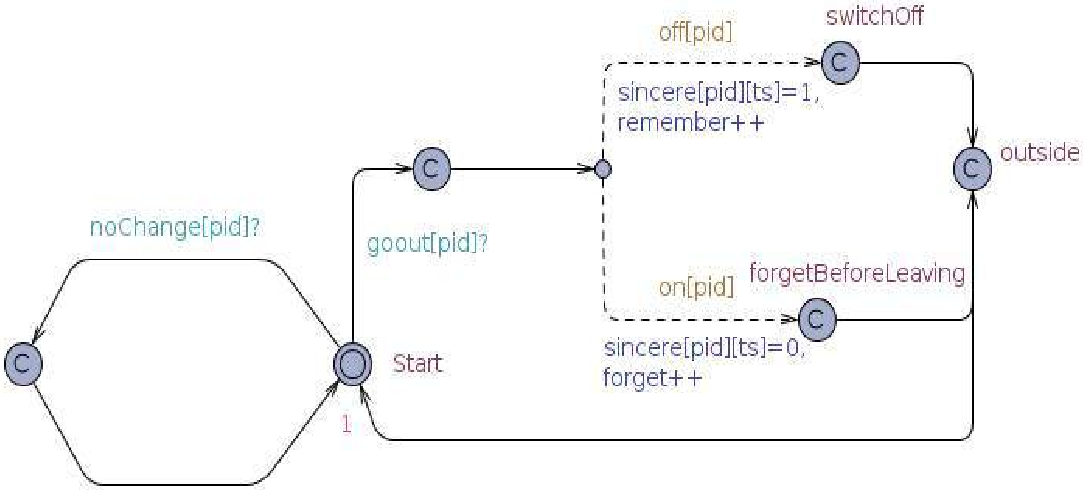

Figure 4. Control Automaton

The automaton upon receiving the *eve* signal, moves to either *Outside* or *RemainInside* location denoting that the person has gone home or has remained inside the room he was in. If the person goes out, then the signal *goout* is sent to the control automaton, and the *noChange* signal is sent if he stays inside his room. The loop between the locations *Outside* and *OutToOut* is to indicate that all the events are over and the person stays outside. This is achieved through the synchronization channels *eve* and *noChange*.

C. The *Control* Automaton

The *control* automaton (Figure 4) basically deals with the energy part of our problem, that is, it updates the energy pattern array that stores the information about the energy consumption by the occupants at each time-step in each room. The automaton works as follows. Initially the automaton is in the start location and then it moves to either the *switchOff* or *forgetBeforeLeaving* based on the energy awareness of the occupant indicated by *off[pid]* and *on[pid]*. In either case the sincerity array *sincere[pid][ts]* is updated to indicate if the power being utilized was switched off or not. Again, the probabilities of switching off or leaving it on are represented by the probability weights, *off[pid]* and *on[pid]*. These three automata together represent the system.

3.1.2 Model Checking the System

As described earlier, model checking is done by expressing the properties to be checked in the form of weighted MITL queries. Figure 5 describes is a snapshot of the statistical parameters set in UPPAAL-SMC for the experiments. Table 1 describes some important queries and their results.

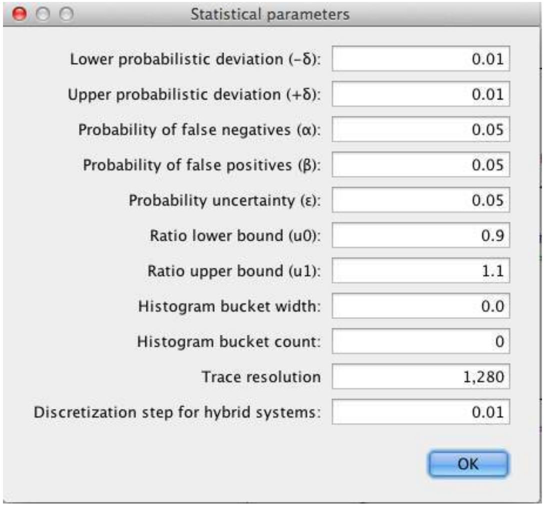

Figure 5. Statistical Parameters set in UPPAAL SMC

Table 1.

weighted MITL Query	Meaning	Result
Pr [≤1000] (saving≥50 and saving ≤100)	Prob. that saving is between 50 and 100	[0.3898, 0.4898]
E[≤1000,100] {max:saving}	What is the expected max. saving within time period 1000 in a total of 100 simulations [With Average Sincerity being 0.7]	E(max:saving) =316.31
Pr([100,600](forget≥remember))	Prob. that the total no. of times occupants forgot to switch off was at least as much as the no. of times they remembered to switch off within time period 100 and 600	[0.9500,1.0000]
E[≤600,100] {max:remember}	What is the expected max. no. of times the occupants remember to switch off within time period 600 in a total of 100 simulations? [With Average Sincerity being 0.3]	E(max:remembe r) =40.96
E[≤600,100] {max:forget}	What is the expected max. no. of times the occupants forget to switch off within time period 600 in a total of 100 simulations? [With Average Sincerity being 0.3]	E(max:forget) =99.51
Pr [≤1000] (saving≥100 and saving ≤150)	Prob. that saving is between 100 and 150 within 1000 time period	[0.0, 0.09738]

4.1 Plain Simulation Approach

The idea behind this approach is similar, and also involves generating the occupancy profile using the method explained of Wang et al (2011). What remains to be done is to generate the energy usage pattern, which captures the information about the state of power (on or off) at each time-step, based on the average level of energy awareness of the occupants. Having obtained the energy pattern matrix, we count those time-steps in which the energy was being consumed without user presence in the room. Based on the occupancy profile and the energy profile thus generated, we have the energy savings as depicted in Figure 6.

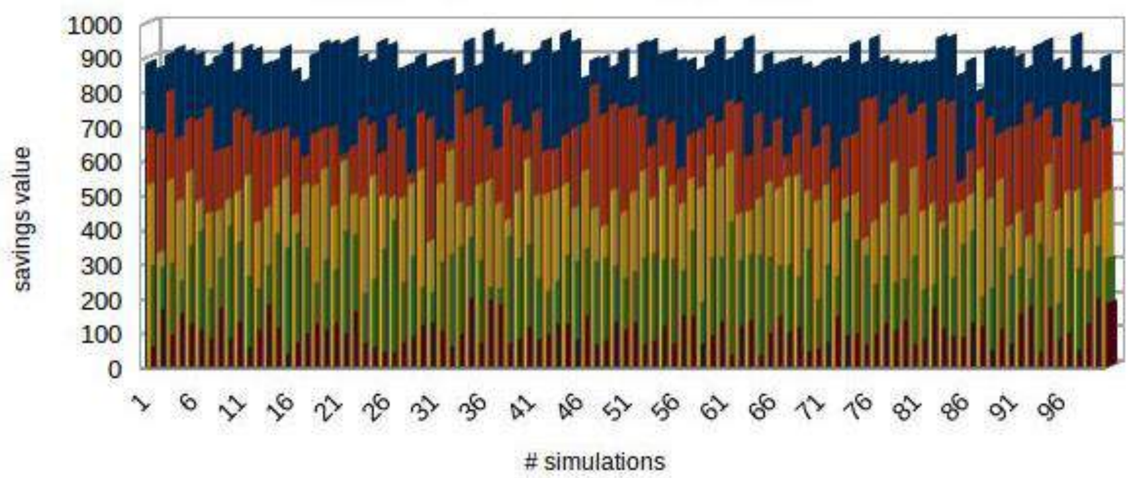

Figure 6. Energy Saved (in time-steps)

This figure depicts one-day savings in terms of the total number of time-steps in which the occupant forgot to switch off the power they were using just before leaving the room. The x-axis is the simulation number, and the y-axis is the savings in time-steps. The graph is plotted with different values of average sincerity level or energy awareness of the occupants. As is clear from the plot, energy savings is quite high when the avg. sincerity level is less. But as the sincerity level increases, the energy saved decreases, which is as expected. Following is a rough translation of energy savings into monetary savings:

Considering, an initial investment = INR 5000[1] x 3 rooms = INR 15000
Cost per unit power 1 kWh = INR 5
No. of units consumed = (Watt x Hour) / 1000
Average wattage per device: 20 W (Assumed)
One time-step = 10 minutes = 10/60 hour
Average One Day Savings = INR (20 * No. of time-steps/6)*5/1000 = time-steps/60.

Table 2 draws a comparison between the investment in smart technology and elsewhere. The savings in time-steps are obtained by averaging the energy saved over 100 runs of the program with varying energy awareness indicated by the first column. '*y*' means that money should be invested in smart technology because the savings thus obtained would exceed that obtained by investing money elsewhere with rate of return on investment being *r*; and '*n*' indicates that it should be invested in the other alternative. Table 3 compares the values for energy saved (in time-steps) using the two approaches.

[1] Rough estimate based on information available on http://goo.gl/RoYm5H

Table 2

Avg. Sincerity *p*	**1 day savings (time-steps)**	**5 year savings (INR)**	**r=6%**	**r=8%**	**r=10%**
0.1	901.14	27409.675	y	y	y
0.3	694.24	21116.467	y	n	n
0.5	502.61	15287.721	n	n	n
0.7	299.05	9096.104	n	n	n
0.9	103.56	3149.95	n	n	n
1.0	0	0	n	n	n

Table 3

Avg. Sincerity p	**Plain Simulation**	**Model Checking**
0.1	901.14	965.68
0.3	694.24	766.32
0.5	502.61	536.71
0.7	299.05	316.31
0.9	103.56	105.36
1.0	0	0

Acknowledgements

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Training Onshore Failure Rate to Offshore Cost Effectiveness Analysis in Condition Monitoring System

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Abstract
Offshore wind energy is a fast growing technology within the marine energy sector. In contrast to onshore, offshore wind farms require larger installation and incur higher O&M costs due to the challenges of the marine environment. In this context condition monitoring systems have an important role to play in reducing maintenance costs.

The high initial cost of condition monitoring systems motivates this analysis of the cost effectiveness of such technology O&M cost data are commercially sensitive and generally protected by the wind industry, especially for offshore operations. Component failure rates are essential for modelling wind turbine O&M costs but very little offshore failure rate data available in the public domain.

With cooperation of the operator of the largest onshore wind farm in the UK and that of a large Swedish offshore wind farm, three years of operational data records have been made available for this research. With wind and wave parameters extracted from the database and set as inputs to a cost model is has been possible to compare the O&M cost of reactive maintenance with condition based maintenance. The cost model available uses empirical failure rate based on onshore data and so will not fully represent the offshore situation as failure rates are expected to affected by offshore operational conditions. To overcome this limitation, a mathematical translation of failure rate from onshore to offshore is applied to the operational data. The way this translation is calculated is sensitive to the way the relevant probability distributions are represented and improved curve fitting approaches have been explored.

Keywords: Wind Energy, Offshore, Cost Effectiveness, Failure rate, Reliability

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Introduction

Driven by the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), adopted in Kyoto, Japan on 11th December 1997 and entered into force on 16th February 2005, the European Union (EU) in 2005 assigned an 8% CO_2 reduction target for the year 2008 to 2012, and it is one of the few parties which have committed to further reductions for 2013-2020 with a 20% binding figure. (United Nations, 2014) The United Kingdom, as one of the member country in EU, has exceeded the initial target, ending up with 12.5% reduction for 2008-2012. The UK has also assigned further 19% reduction for the next 8 year run. Much of this success has been due to the rapid growth of wind energy, and in recent years much of this has been offshore. In 2014, 16.9GW of new power generating capacity was installed in the EU, with wind power having the largest share with 11.8GW, accounting for 43.7% of all energy installed, followed with Solar PV of 8GW accounting for 29.7%. These two renewable energy generation methods account for 73.4% of the entire annual installed power capacity, as shown in Figure 1. Since 2000, the annual renewable capacity additions have been 24.7-34.6GW, 8-10 times higher than what was in 2000. The net growth of European wind power since the year 2000 is 116.8GW (EWEA, 2015)

The high quality of the offshore wind resource together with a reduced sensitivity from a public planning perspective accounts for the present political support for offshore wind development. 2,488 turbines are now installed offshore and grid connected, making a cumulative total of 8,045.3MW in 74 wind farms in 11 European countries. A further 2.9GW of capacity will be added when 12 on-going projects complete. This will bring the cumulative capacity in Europe to 10.9GW. Nearly half of the final investment decisions in 2014 were billion-euro projects. The industry raised €3.14 billion of non-recourse debt in 2014, which was the highest level in its history. The UK has the largest amount of installed offshore wind capacity with 4.5GW, counting for 55.9% of European installations, as shown in Figure 2.

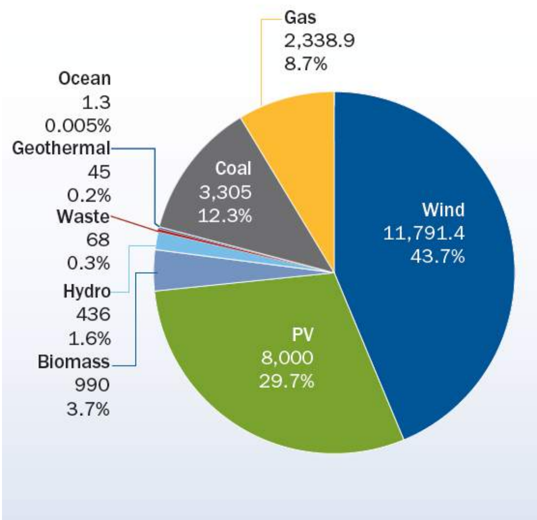

Figure 1: share of new power capacity installations in EU (MW), (EWEA, 2015)

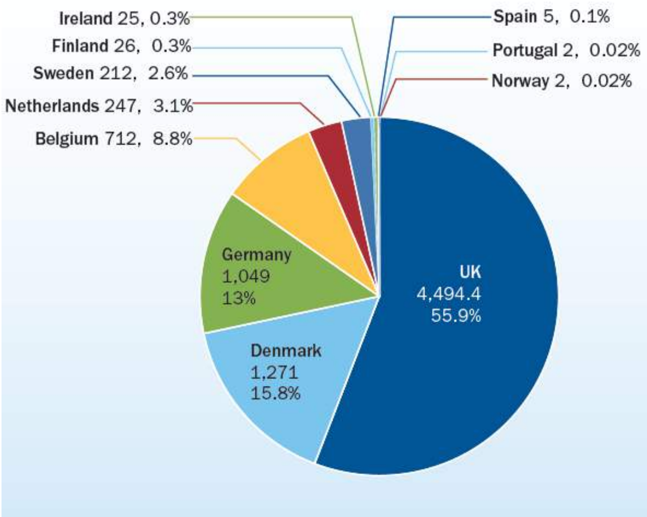

Figure 2: Installed Cumulative Capacity by country in the EU (MW), (EWEA, 2015)

Compared to onshore, offshore wind has the advantage of generally higher mean wind speed, less temporal variation and lower turbulence. In addition there is a reduced negative impact on the landscape and noise is a less critical issue. On the other hand, some of these advantages come at a cost. The low disturbence to human population is the result of a substantial distance between the offshore wind farm and shoreline where the port of operation and maintenance (O&M) centre is located. The marine conditions restricts access for maintenance which depend on the prevailing wind and wave conditions. This characteristic of offshore wind farm operations motivates the interest in condition monitoring.

Compared to reactive maintainence, condition based maintenance is based on data providing the real time condition of the certain turbine subsystems or components. The O&M team can arrange the maintainence considering both component condition and vessel access. In this way, major failures of the turbine can often be circumvented; at the same time, the cost of maintainece should reduce due to a more effective maintenance regime.

For quantifing the cost effectiveness of O&M, and condition monitoring in particular, failure rate is a key input. However, offshore component failure rate data is not publically available as it has been commercially protected by manufacturers and operators. This results in failure rate data in the public domain being very limited, especially for offshore. Three years of operational data records have been made available for this research through bi-lateral research agreements.The onshore data come from the largest British onshore wind farm, and the offshore data come from a large Swedish offshore wind farm. This enables the translation of componet failure rates from onshore to offshore. The translation considers the ambient conditions in terms of wind speed and temperature.

Failure rate translation

The failure rate translation allows calculation of offshore failure rates from onshore data. The core calculation is for the ratio of the expectation of the failure rate, offshore to onshore. The expectation of the failure rate is dependent on the prevailing environment. As described in the introduction, the most relevant environmental factors are the wind speed and the temperature. Therefore the wind speed and temperature time series data are taken from both on and offshore sites.

This is not to say that there are no other factors that influence failure rate, but if that data was available it could be included in a similar manner, e.g. for wind turbulence. For the results presented here, the relationships between failure rate and the selected environmental factors have been obtained based on analysis of data from the UK onshore wind farm covering 3 years of operation. The probability distributions of wind speed and temperature are derived from both on and offshore data. The ratio of expected failure rates on/offshore can be derived for wind speed and temperature, separately.

Failure rate probability

The wind turbine component failure rate probability is an important element in the expectation calculation. According to Bayes' rule (Laplace, 1814), the probability of failure rate dependent on weather condition, P(F|W), is calculated from the product of the probability of weather condition given failure rate, P(W|F), and the annual mean failure rate of the selected turbine component, P(F), divided by the weather parameter distribution, P(W).

$$P(F|W) = \frac{P(W|F) \cdot P(F)}{P(W)} \tag{1}$$

The probability of weather condition given failure rate is the information which can be directly obtained from failure record of the wind turbine operational data, where the failure type, location, date and the corresponding weather statistics are recorded. It is important to note that the value used for wind speed and ambient temperature is the daily mean value since it is accepted that the impact of the environment on failure will not be instantaneous. One day may well be insufficient and in future work, longer averaging periods will be investigated.

Fitting a suitable function to the failure probability distribution

The common approach to estimate curves for the probability density function (PDF) is by using a non-parametric estimate of the density function, such as the Kernel function (Epanechnikov, 1969). Although these fitted distributions look reasonable, as in Figure 3, the tails are not at all precise and this is a problem because for high and low values (in this case of wind speed), P(W|F) is determined by a ratio of the tails of two PDFs.

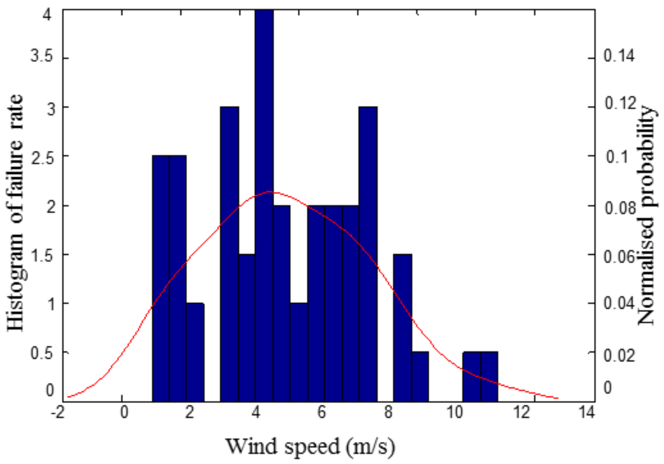

Figure 3. Failure rate histogram and normalized probability Kernel distribution of an onshore drive train system

Because of the limited size of the database, it is difficult to derive smooth and reliable probability distributions. Unexpected spikes occur in the distribution curves which only reflect the data limitations and are not generic. In order to obtain a smoother distribution curve, a procedure of finding a fit to the cumulative probability distribution (CPD) of P(W|F) and then differentiating the result to regain the desired probability distribution function has been applied in this research.

The first fitting function for the CPD in this example is a 2^{nd} order polynomial function. The 2^{nd} order polynomial function has suitable characteristics for of the ascending curve with a flexible tangent. It provides reasonable fitting to the data and is easy to differentiate. The disadvantage is that the curve extends (extrapolates) at the two ends with high-value tangents, which creates significant error in the fitting of the tails to the original curve. This error will have exaggerated impact when differentiation is applied.

An alternative fitting function is the exponential. The most observable nature of the CPD curve is the asymptotic ends towards 0 and 1. The exponential function can be derived to reflect this and this makes the fitting of the tails much more reliable. The disadvantage of exponential fitting is the complexity of the function itself, which increases the difficulty of parameter estimation. The accuracy of the exponential function to the target curve is also slightly lower than for the polynomial function.
Once obtained from the fitting function, the parameters allow algebraic differentiation of the CPD function to give the required PDF function.

Wind speed distribution fit

Figure 4 shows the staircase curve of the CPD dependent on wind speed (blue) with the fitting curves (red and green). The red line shows the exponential function fit, and green dashed line represents the 2^{nd} order polynomial fit. In this figure, the two fitted functions show good agreement with the main body of the staircase CPD curve.

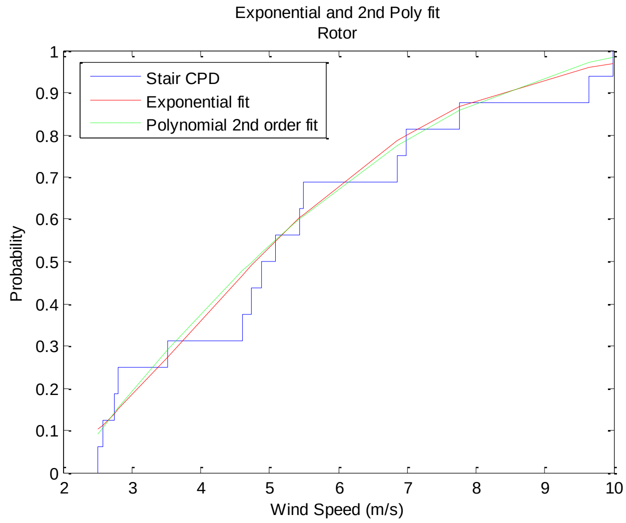

Figure 4: Staircase plot of CPD fitted by 2nd polynomial and exponential function of rotor system in an onshore wind turbine dependent on wind speed

The parameters obtained from the fitting function are substituted into the expression for P(W|F). The failure rate probability function P(F|W) is then calculated based on the Bayes' rule (equation 1). Figure 5 compares the curves from the fitting methods with the original directly obtained failure rate probability function curve. The upper plot presents the non-fitted curve, where a lump at the high wind speed is shown. This lump is likely the result of the limited data record and does not reflect an actual functional relationship. The middle plot shows the P(F|W) calculated from the exponential fitted P(W|F). It retains the basic shape of the long term distribution but avoids the fluctuations in short term. The lower plot presents the P(F|W) calculated from the 2^{nd} polynomial fitted P(W|F). Because of the issues concerned with any extrapolation using the 2^{nd} polynomial function, as stated above, the curve is only calculated within the two vertical bars, which reflect the low and high wind speed values in the original data. In the absence of any other indication, constant value extrapolation has been used outside these limits.

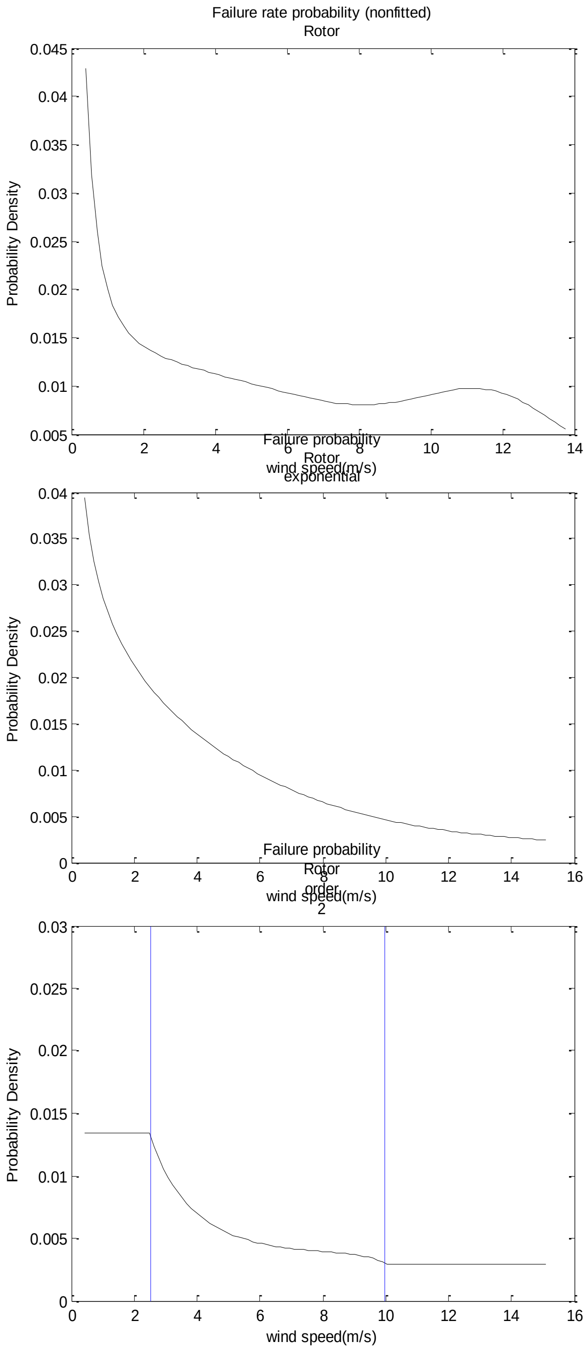

Figure 5: Failure rate PDF with an onshore rotor system non-fitted (upper), exponential fitting function (middle) and 2nd order polynomial fitting function (lower) dependent on wind speed

Temperature distribution fit

The situation for temperature is slightly different. Unlike wind speed, temperature can have a negative value. This is an obstacle to fitting an exponential function to the temperature distribution because of the non-negative-x-value nature of the exponential function. The curves are offset to the right-hand side of the y axis, fit with exponential functions, and shifted back. In this way, the parameters are obtained in the offset stage and put in the PDF calculation.

Figure 6 shows an example of the staircase curve of the CPD dependent on temperature (blue) with the fitting curves (red and green). In this figure, the 2nd order polynomial (green dashed) shows a high-value tangent at the high temperature values. This can be observed at the right hand side of the curve.

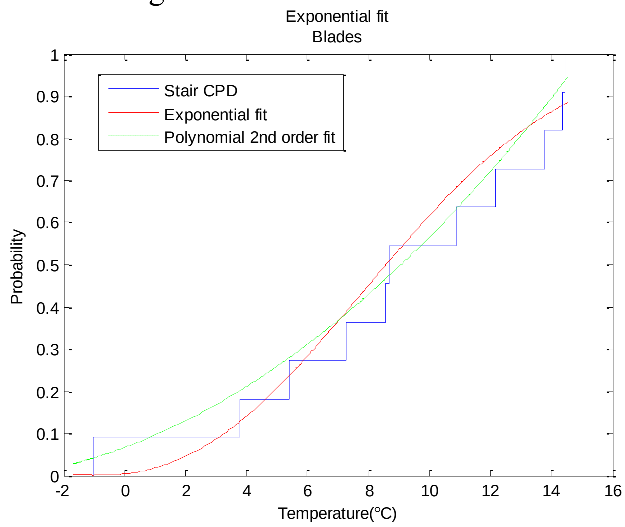

Figure 6: Staircase plot of CPD fitted by 2nd polynomial and exponential function for an onshore wind turbine blade system dependent on temperature

Figure 7 (left) shows the failure rate probability function P(F|W) based on the Bayes' rule. This figure clearly shows the high-tangent nature of the 2nd polynomial function (green dashed line). The high-temperature tail expands far above 1, which of course is not allowed for probability function plot. Ignoring the illogical tails and zooming in on the middle range of temperatures, as shown in the right hand figure, the three methods can be observed agreeing each other to a certain extent. The non-fitted method shows a peak in failure rate at around -4 degree, in some agreement with the 2nd order polynomial method but with a much higher fluctuation; whereas the exponential method shows a peak at around 5-10 degrees. It is not possible to confirm which method is closer to the reality due to a lack of data.

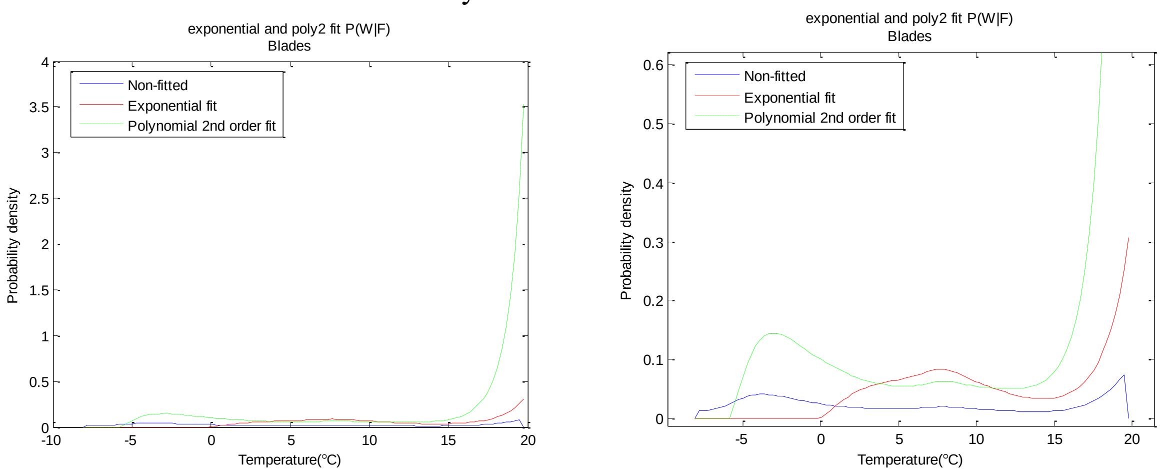

Figure 7: Failure rate PDF with an onshore rotor system non-fitted, exponential fitting function and 2nd order polynomial fitting function dependent on temperature (left) and zoomed-in figure (right)

Cost model

The cost model used in this research is based on statistical analysis of O&M (Feuchtwang & Infield, 2013) specifically for offshore wind. The purpose of the development of this cost model is to access offshore wind turbine maintenance by calculating access probabilities, expected delays and the associated costs using a probabilistic approach. Failure rate of each turbine subsystem is an important input of the cost model. The accuracy of the failure rate directly affects the accuracy of the cost estimation. The final output of the cost model is annual maintenance cost.

This cost model is compared with other four cost models: the ECUME model from EDF; the NOWIcob model from SINTEF Energy; the UiS model from the Univeristy of Stavanger; and the OPEX model from CDT, University of Strathclyde (Dinwoodie & Endrerud, 2015). The comparison uses the same input of a virtual offshore wind farm 45km off the coast of Germany with 8 years of wind and wave data. In this way, the results from the different methods can be compared.

Results

The subsystem failure rates translated from onshore to offshore are listed in Table 1 for the three different fitting methods. The failure rate results are substituted into the cost model. The results of the cost model are shown in Table 2, among which the annual O&M costs are compared with other cost models. Figure 8 shows the comparison in one chart. It shows that the exponential fitted failure rate provides the closest cost results to the other models. The non-fitted and 2nd-polynomial-fitted failure rate has a higher value for the O&M cost.

Table 1: failure rate translation from onshore to offshore for the selected subsystems

			RatioWindSpeed			RatioTemperature			offshore failure rate		
code	onshore failure rate	failure R%	Nonfitted	Poly 2Fitted	ExpFitted	Nonfitted	Poly 2Fitted	ExpFitted	Nonfitted	Poly 2Fitted	Exp Fitted
Generator Assembly27	0.78	7.20%	0.92	0.74	0.63	1.69	0.74	0.52	1.208	0.424	0.255
Gearbox Assembly14	0.56	5.10%	1.00	1.33	0.94	1.04	1.84	1.40	0.579	1.367	0.734
Blades9	0.16	1.50%	1.00	1.01	0.82	1.22	1.06	0.78	0.193	0.170	0.102
Pitch System11	2.32	21.30%	0.87	0.79	0.69	1.26	1.53	0.89	2.551	2.813	1.425
Yaw System18	1.23	11.30%	1.27	0.92	1.04	1.04	2.34	0.88	1.616	2.648	1.135
Rotor Other8	0.01	0.10%	0.94	0.84	0.79	1.25	0.69	1.19	0.008	0.004	0.007
Control & Comms Other	0.05	0.50%	1.26	1.18	1.17	0.95	1.74	1.21	0.061	0.105	0.072
Mechanical Brake15	0.05	0.50%	0.96	0.60	0.74	0.77	3.50	1.18	0.037	0.108	0.045
High Speed Shaft transmi	0.05	0.40%	1.58	1.00	0.95	0.81	3.54	2.49	0.057	0.159	0.107
Main Shaft13	0.03	0.30%	0.90	0.70	0.69	1.26	0.77	1.44	0.036	0.017	0.032
Hydraulic System23	0.13	1.20%	1.09	0.84	0.87	1.46	0.93	0.59	0.206	0.102	0.067
Tower33	0.29	2.70%	1.10	1.28	0.96	0.82	1.34	0.89	0.262	0.499	0.249

Table 2: cost model output with comparison of different methods

WITH DOWNTIME based on		REACTIVE MAINTENANCE: NONFITTED	REACTIVE MAINTENANCE:2ND POLY FIT	REACTIVE MAINTENANCE: EXPONENTIAL FIT
downtime		31.8 days	33.5 days	23.4 days
availability		91.3%	90.8%	93.6%
capacity factor with downtime	Cfd	45.6%	45.3%	46.9%
energy lost	Estot	1273.4 MWh	1344.7 MWh	938.1 MWh
mean power generated over year with downtime	Pmd	1.37 MW	1.36 MW	1.41 MW
total annual energy generated with downtime	Ead	11976.8 MWh	11905.5 MWh	12312.2 MWh
annual revenue with downtime	Rad	1077.9 £k	1071.5 £k	1108.1 £k
revenue lost	srev	114.6 £k	121.0 £k	84.4 £k
annual maintenance cost	ftot	454.1 £k	505.2 £k	343.1 £k
entire wind farm annual maintenance cost		36.3 £m	40.4 £m	27.4 £m
vessel cost	per unit	£0.025 /kWh	£0.026 /kWh	£0.018 /kWh
wage cost	per unit	£0.0016 /kWh	£0.0018 /kWh	£0.0012 /kWh
component cost	per unit	£0.0109 /kWh	£0.0146 /kWh	£0.0089 /kWh
Total O&M cost (w/o revenue loss)	per unit	£0.0379 /kWh	£0.0424 /kWh	£0.0279 /kWh
revenue lost	per unit	£0.0096 /kWh	£0.0102 /kWh	£0.0069 /kWh
Total O&M cost (with revenue loss)	per unit	£0.0475 /kWh	£0.0526 /kWh	£0.0347 /kWh

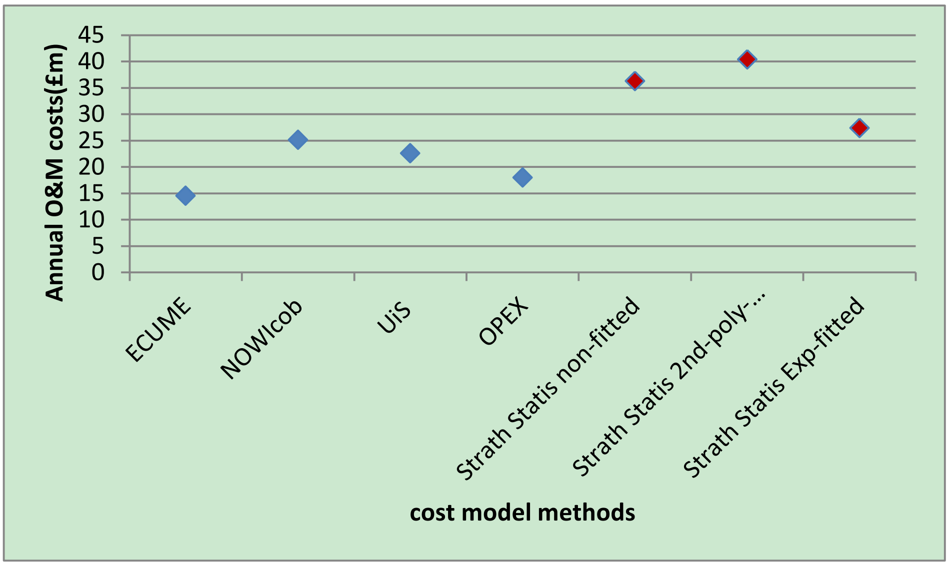

Figure 8: Annual O&M costs for the cost models with different methods

Conclusion

This paper presents an initial analysis that attempts to estimate failure rates for offshore wind turbines based on the onshore values. It applies correction factors dependent on wind speed and temperature to the failure occurrence in the cost model calculation. The correction factors are calculated by comparing the failure rate expectations from on and offshore wind farms. The failure rate probabilities obey Bayes' rule, and a range of fitting functions are applied in an attempt to obtain the probability density functions. The failure PDF is derived from the CPD in order to get a more realistic result. 2nd order polynomial and exponential function are proved to fit the failure rate function in order to give a smoother and more generic function. The fitting functions together with the non-fitted method are used to derive the final costs, and compared with other cost models in the research domain. The comparison of the final O&M costs suggests the exponential fitting method has the closest result with other cost models. However, no final evidence shows which method is the closest to the reality because of the lack of long term failure data in the operational domain.

In future work, the cost model will be applied to assess how the use of condition monitoring systems might reduce offshore wind O&M costs, and how these depend on the characteristics of the offshore sites.

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Eco-efficiency with Social Performance of Fresh Latex Production in the Southern of Thailand

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Abstract
This research modified the eco-efficiency with social performance for evaluating the fresh latex production in the southern of Thailand. The economic, environmental and social performances of nine rubber farms during 2010-2012 were collected to assess the eco-efficiency value and trend. The results presented that chemical consumption and social performance of fresh latex production were the highest and lowest values of eco-efficiencies, respectively. In additional, trends of eco-efficiency with social performance of fresh latex production located in half eco-efficiency in the year 2011 and in half non eco-efficiency in the year 2012 due to the reduction of rubber price. This finding identified that the performance of fresh latex production in the southern of Thailand was strongly affected by social performance. Therefore, the rubber labor cost of fresh latex production should be decreased for proving a better discrimination among rubber farmers.

Keywords: Eco-efficiency; social performance; Fresh latex production; Southern of Thailand.

Introduction

Thailand has been the world leader in natural rubber production as its planting area currently covers over 22,400 km^2 and is still expanding. In 2012, the export value amounted for 336,287 million baht (approximately 10,508 million US dollars) from over 3.6 million tons of various rubber products (1). Most rubber plantation areas are in the South, covering 1,814,345.28 ha, whereas other rubber plantation areas have expanded to the Northeast (455,286.72 ha), Central and East (336,625.28 ha) and Northern regions (96,092.48 ha). Hence, the rubber plantation is the most economical crop species in the southern region [2]. The fresh latex is tapped and collected as a liquid, and then processed to primary rubber products. The fresh latex production is the main primary product of Thai farmer productions (3).

The literature on assessing the sustainable development of agricultural activities frequently invokes the concept of eco-efficiency (5). The term eco-efficiency itself was coined by the World Business Council for Sustainable Development (WBCSD) in their 1993 report (5) and is based on the concept of creating more goods and services while using fewer resources, thereby generating less pollution. The measurement of eco-efficiency is essentially on measuring efficiency with the integration of undesirable outputs that contribute negatively to the environment (6) Applications, challenges and opportune of the general concept to agricultural production systems have recently been presented (7).

Interest in the economic aspects of social performance and in environmental issues is increasingly highlighted in research on eco-efficiency (8). Thus, the main objective of this article is to assess eco-efficiency performance with respect to social performance for the fresh latex production in the Southern of Thailand.

Methodology

Scope of fresh latex production

Fresh latex production refers to latex that is collected trees by farmers, and then transported to rubber processing mills. Ammonia may be added to the latex to prevent coagulation before reaching the mill (9).

Questionnaire Development

The standard questionnaire from National Round Table on the Environment and the Economic (10) and selected eco-efficiency indictor was used to develop the questionnaire in this study. The selected eco-efficiency indicators of fresh latex production were developed by material flow analysis (11) and verified by general eco-efficiency indicator of WBCSD. For social performance indicator, the indicator was selected by literature reviews of sustainable agriculture farm. Finally, this questionnaire was also validated by three same experts before using the field.

Data collection

The rubber farms in Songkhla and Surattani provinces of Southern Thailand were conducted in this study. These two provinces are the important rubber plantation areas which the host various existing rubber farming systems, a developed rubber industry, and many important rubber organizations. Songkhla and Surattani have a total land area of 1,444,302 rai and 1,871,907 rai, repectively. The six rubber farms of Songkhla province and six rubber farms Surattani provinces was randomly selected for collecting data. The upper and lower production rates of 272-283 kg dry rubber/rai/year (12) were included to sample size. The data during year 2010-2012 were collected by using a face-to-face questionnaire.

Eco-efficiency assessment

The social performance was added to modify the original assessment of eco-efficiency values. The modify equation of eco-efficiency with social dimension as a ratio of economic and environment performances with social dimension is expressed in the following equation 1:

$$E = \frac{EV}{\sum En + \sum Es} \qquad 1$$

where, *EV* is an economic indicator in US dollar, *En* is an environmental indicators and *ES* is an social indicators, regarded as environmental and social burdens from activities carried out in the study scope.

The social performance was added to modify the original eco-efficiency trend. The percent variations of the economic and environmental with social indicators, was analyzed following in equation 2:

$$\%VE = \frac{\left(\sum E_i - \sum E_b\right) \times 100}{\sum EV_b} \qquad 2$$

Where % VE_{ns} = Percent variation of economic or environmental with social indicators, ΣEi = Summation of economic or environmental with social indicators of rubber plantation, and ΣEb = Summation of economic or environmental with social indicators of fresh latex production.

Result and Discussion

The general indicators of eco-efficiency from WBCSD (13) and material flow analysis (14-16) were used to develop the eco-efficiency indicator of fresh latex production. In addition, the social performance of fresh latex production was developed by benchmarking of various researches related with sustainable assessment of agriculture. Therefore, eco-efficiency indicators with social performance of fresh latex production are shown in Table 1. The questionnaire of collecting data for fresh latex production was generated from the standard questionnaire from National Round Table on the Environment and the Economic (10) and approved by agriculture, economic and social experts.

Table 1: Eco-efficiency indicators wit social performance of fresh latex production

Indicators	Units
Economic indicator	
- Net sale	Bath
Environmental indicator	
- Chemical consumption	Liters
- Fertilizer consumption	Kilogram
- Energy consumption	kWh
Social indicator	
- Labor cost	Bath

Eco-efficiency value with social performance of fresh latex production

Figure. 1 indicated that net sale in 2011 of fresh latex production was highest value because there was a severe flood occurred in Thailand and covered nearly half the country in water for several months. This flood devastated the agricultural land area and rubber plantation (17). The highest value of eco-efficiency value for fresh latex production was chemical consumption because only ammonia may be added to the latex to prevent coagulation before reaching the mill (18). Furthermore, the lowest value of eco-efficiency for fresh latex production was the social performance because haft of net sale in the southern of Thailand was generally paid to rubber tapping workers. Hence, the problem performance of eco-efficiency value significantly was the social indicator of fresh latex production in the southern of Thailand.

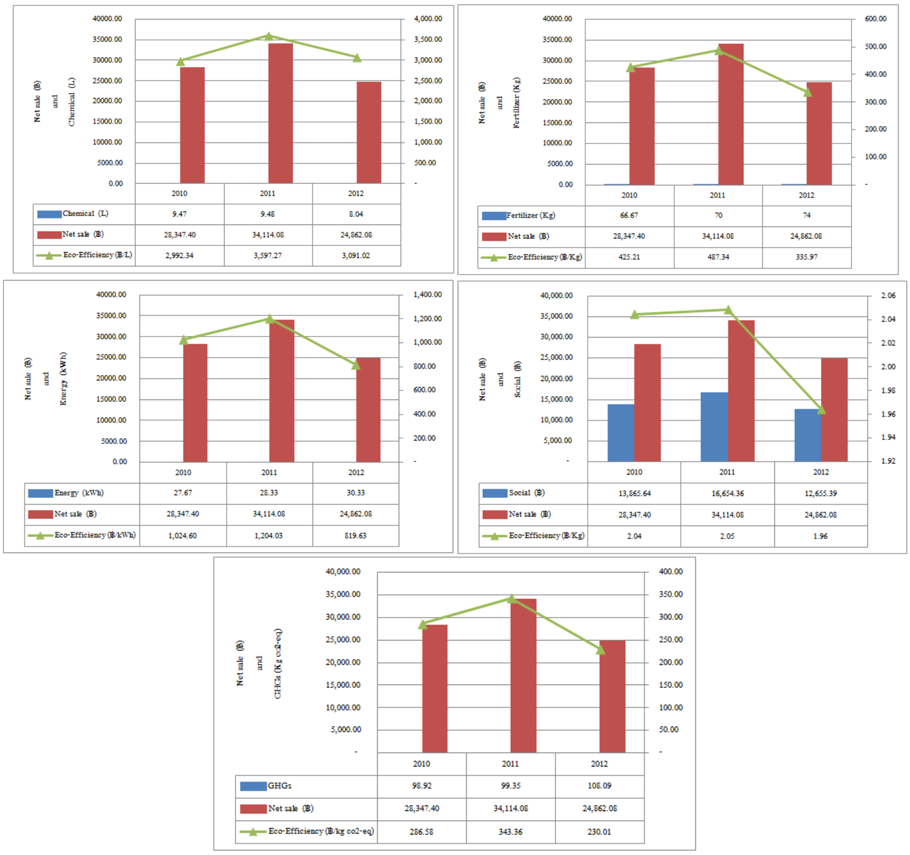

Figure 1: Eco-efficiency values of fresh latex production

Eco-efficiency trend with social performance of fresh latex production

Equation 2 was perform to compute the economic, the normalized environmental and social indicators. Figure. 2 indicated that eco-efficiency trend of fresh latex production in the southern of Thailand located in half eco-efficiency in the year 2011 and half non eco-efficiency in 2012. This result recommended that the eco-efficiency trend with social performance of fresh latex production varied on the stability of rubber price because long run prices stability of perennial crops has added significance in the case of perennial crops due to higher initial investment, longer gestation period and longer economic life (19). Besides, the results mentioned that social performance directly affected to the fresh latex production. Hence, rubber labor cost of fresh latex production in the southern of Thailand would be developing the decreasing approach to increase the profit of fresh latex production.

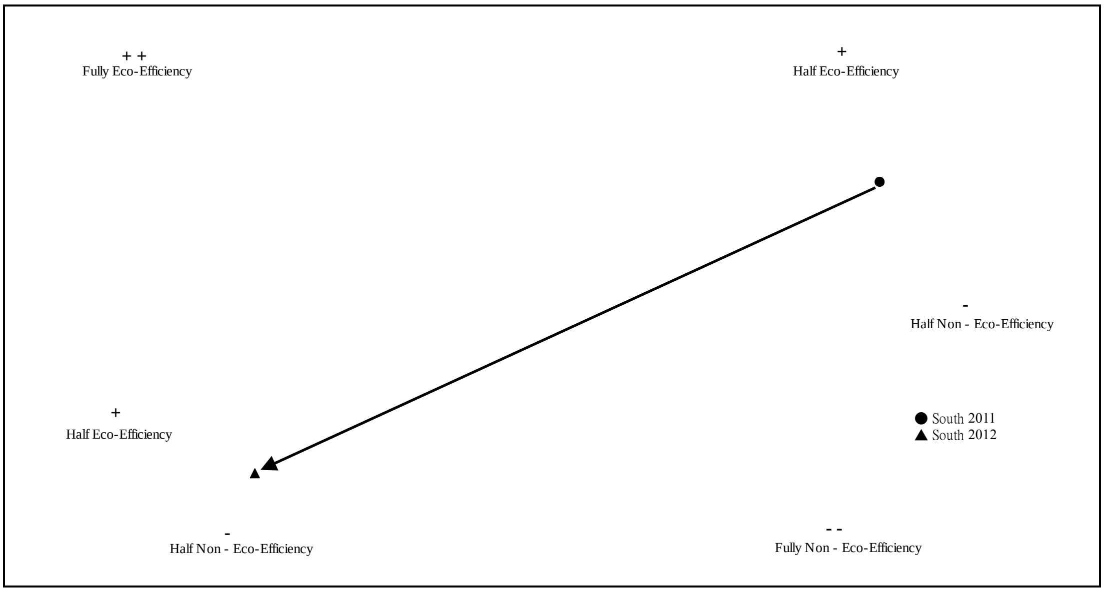

Figure 2: Eco-efficiency trend of fresh latex production

Conclusion

The combination of eco-efficiency and social performance as sustainable tool for evaluating the performance of fresh latex production was performing. Eco-efficiency values of fresh latex production were evaluated by the suggestion from World Business Council for Sustainable Development. The result showed that highest and lowest eco-efficiency values of fresh latex production were the chemical consumption and social performance, respectively. Next, eco-efficiency trend assessment of fresh latex production was plotted by Snapshot graph. The result presented that eco-efficiency trend was dropped from half eco-efficiency in the year 2011 to half non eco-efficiency in the year 2012 due to the decreasing rubber price. These finding recommended that the high potential of eco-efficiency with social performance can be presented the incident of agriculture activities.

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Assessment of Carbon Footprint Organization and Analysis of Appropriate Greenhouse Gas Mitigation Measures: Case Study PTA Factory in Thailand

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Abstract
This research investigated carbon footprint organization and analyzed appropriate greenhouse gas mitigation measures of purified terephthalic acid (PTA) factory in Thailand. The factory has a production capacity about 40% of intermediate petrochemical products in Thailand. PTA is raw materials for producing textiles, plastic bottles, X-ray films and products in the automotive industry, and etc. Two PTA factories are used as case studies. The production capacities of PTA representative factories are around 1,347,000 ton per year.
The results indicated that the carbon footprint organization of PTA factory is average around 216,557 tCO_2e per year. The energy use on average is 1,606 TJ per year. The average carbon intensity of PTA product is 0.3878 CO_2e/ton product. Potential greenhouse gas mitigation measures are mainly energy conservation including using excess steam from steam turbine, replacing Hollow GRP to Hollow FRP, and installing vapor absorption chiller. Mitigation measure that can reduce relative largest greenhouse gas emissions is by renovating steam turbine. Based on a case study, it can reduce electricity appromately 5,100 MWh which is equal 2,958 tCO_2e reduction. Energy inspection and conservation measures should be implemented within the plant continuously for substantial greenhouse gas reduction.

Keywords: purified terephthalic acid, carbon footprint organization, greenhouse gas mitigation

Introduction

Nationally Appropriate Mitigation Actions (NAMAs) become a mandate for counties that ratified the Kyoto protocol. Mainly, each county has to identify and develop greenhouse gas mitigation in their countries. Thailand also prepares how to reduce greenhouse gas emission efficiently in the future. The petrochemical industry has high contribution of greenhouse gas emission and also has high capability to reduce greenhouse gas emissions effectively.

Intermediate petrochemical industry in Thailand produce 16 products and its production capacity average is around 7,003,000 ton (Table 1). Purified terephthalic acid (PTA) factories have a production capacity about 40% of intermediate petrochemical products in Thailand. PTA chemical formula is $C_8H_6O_4$. The appearance is white crystals or powder and solubility in organic solvents.

Table 1: Products of intermediate petrochemical factories in Thailand

No.	Products	Capacity (ton/year)	Percentage capacity
1	Purified Terephthalic Acid	2,787,000	39.80
2	Vinyl Chloride Monomer	900,000	12.85
3	Styrene Monomer	560,000	8.00
4	Bisphenol A	430,000	6.14
5	Propylene Oxide	390,000	5.57
6	Ethylene Glycol	325,000	4.64
7	Cumene	262,000	3.74
8	Methyl Methacrylate	245,000	3.50
9	Acrylonitrile	200,000	2.86
10	Crylohexane	200,000	2.86
11	Phenol	200,000	2.86
12	Caprolactam	130,000	1.86
13	Acetone	124,000	1.77
14	Epichlorohydrin	115,000	1.64
15	Ethylene Oxide	85,000	1.21
16	Pthalic Anhydride	50,000	0.71
		7,003,000	**100.00**

Source: The Petroleum Institute of Thailand (PTIT), 2013.

Process of PTA production include 2 processes (1) Oxidation and (2) Purification that have details of each process as follows Figure 1.

Oxidation starts from the paraxylene to react with oxygen. The reaction takes place under the acetic acid solution and a catalyst. The product of the process is crude terephthalic acid (CTA) in form of Slurry. Reaction is exothermic.

Purification The oxidation process will get rid of contaminants such as 4-carboxy benzaldehyde (4-CBA), which are required to make the amount of contaminants less.

The hydrogenation change the 4-CBA to para-toluic acid, which has the ability to dissolve in water better than CTA. Later, it will crystallize and separate out the impurities.

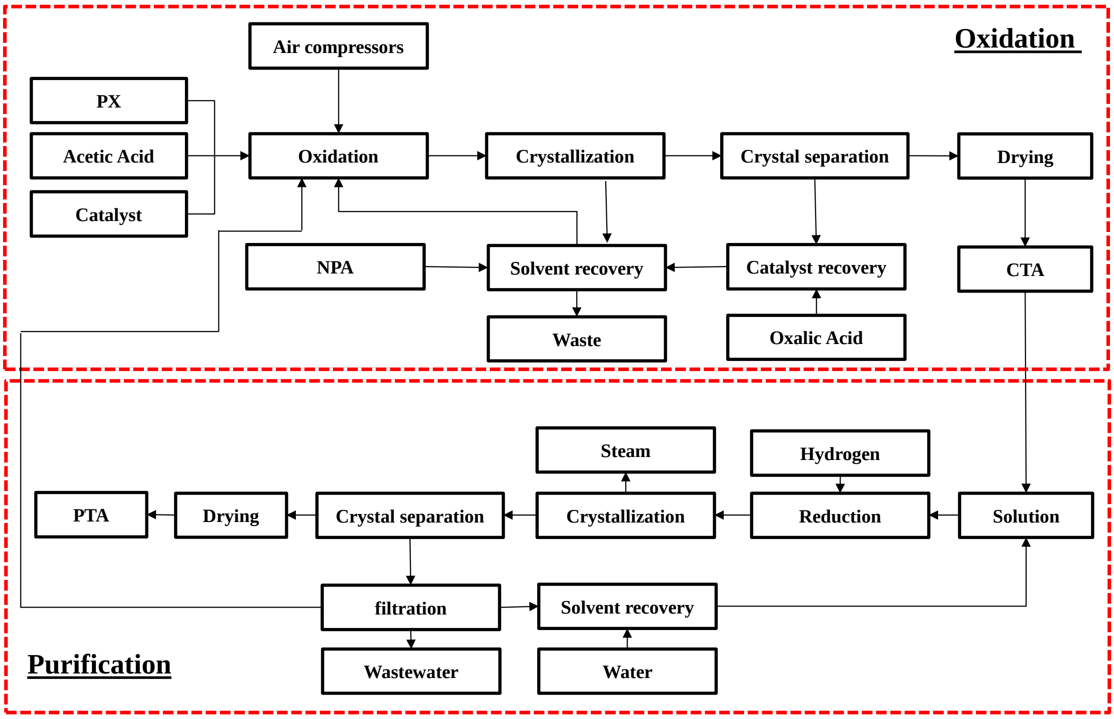


Figure 1: Process of purified terephthalic acid (PTA)

Methodology

Evaluation of greenhouse gas emissions as carbon dioxide equivalent (CO_2e) include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulfur Hexafluoride (SF_6). Sources of greenhouse gas emission are classified into 2 types which are (1) direct greenhouse gas emission (combustion, vent, wastewater treatment, refrigerants, extinguishing and flare) and (2) indirect greenhouse gas emission (purchased electricity and steam). Period for data evaluation was 3 years during year 2011 to 2013.

Two PTA factories are used for carbon footprint organization assessment. Organization boundaries or compilation of resources and absorb emissions of greenhouse gases is defined based on the Operational Control including 2 scopes.

Scope 1: Direct greenhouse gas emissions include activities that contribute to the greenhouse gas emissions from operations, including the production of electricity, heat and steam for internal use or for distribution to external organizations. The combustion of fuel used in equipment and machine owned enterprise control.

Scope 2: Indirect greenhouse gas emissions are activities that contribute to the greenhouse gas emissions from energy import from outside to use in the factory, including the purchase of electricity, heat and steam.

Assessment of carbon footprint organization use basic equation as shown in equation 1.

$$\textbf{Emission = AD x EF} \qquad \textbf{(1)}$$

Emission	=	Emissions of greenhouse gas (t CO_2e)
AD	=	Activity Data (Unit)
EF	=	Emission Factor (t CO_2e/Unit)

Emission factor will primary use domestic EF. If there is not EF within the country, emission factor from the IPCC (Default value) will be used for evaluation. Non CO_2 greenhouse gases will calculate by using equation 2.

$$\textbf{Emission = Emission}_{\textbf{GHG}} \times \textbf{GWP} \qquad \textbf{(2)}$$

Emission $_{GHG}$	=	Emissions of greenhouse gas non CO_2 (t GHG)
GWP	=	Global Warming Potential (t CO_2e/t GHG)

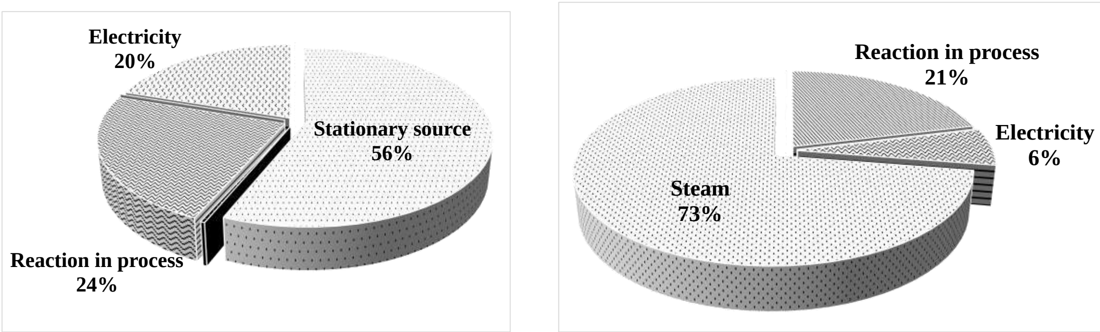
Assessment of reduction the greenhouse gas and energy consumption from energy conservation measures is done from interviewing about the projects and collecting data from factory that were implemented reduce energy consumption and costs in production. Energy conservation measures can classified 2 groups:

1. Development and improvement of production technology.
2. Management and improvement energy efficiency of equipment used in the production process.

The greenhouse gas reduction from case studies from different measures are analyzed compared the reduction ratio of each measure to analyze efficiency of energy conservation measures and provide recommendations as guidelines for further reduction.

Results and discussion

Sources of greenhouse gas emissions from 2 case studies are shown in Figure 2. Factory A has the largest contribution of greenhouse gas from stationary source (Scope 1: direct greenhouse gas emissions), which is natural gas used as fuel to generate steam. However, factory B has the largest contribution of greenhouse gas from purchased steam (Scope 2: Indirect greenhouse gas emissions), used in operating reactor of CTA and PTA process.



Factory A **Factory B**

Figure 2: Assessment sources of greenhouse gas emissions.

The results indicated that the carbon footprint organization of PTA factory is average around 216,557 tCO_2e per year. The energy use on average is 1,606 TJ per year. (Figure 3)

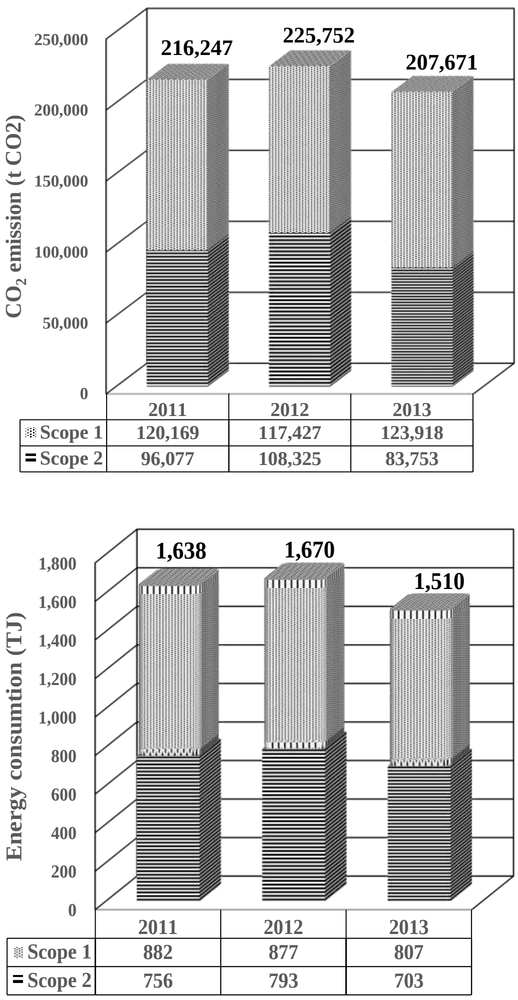
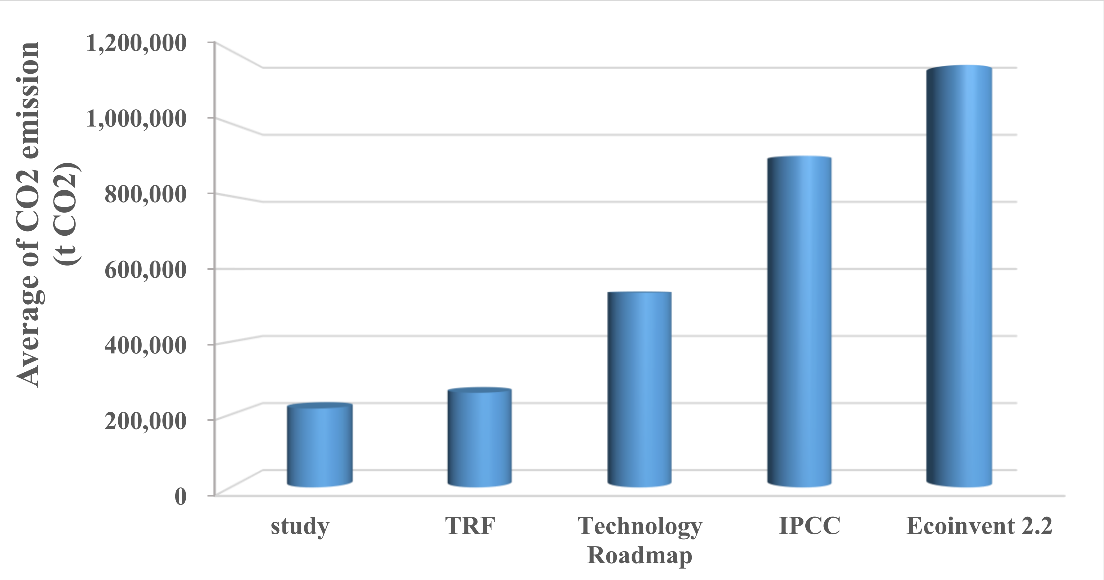


Figure 3: The results of average greenhouse gas emissions and energy consumption.

In addition, to the results from this study when compared with results from other studies (Figure 4) found that greenhouse gas emission of PTA factory in case studies (from Thailand) are less than other studies. However, this comparison does not take into account of the production capacity of each factory. Therefore, the carbon intensity (CO_2/ton PTA) should be used for comparison in the future.

Energy conservation measures implemented in the PTA representative factories were assessed for amount of greenhouse gas reduction and energy consumption each year, as shown in Table 2. Mitigation measures that can reduce relative largest greenhouse gas emissions is by renovating steam turbine. It can reduce electricity appromately 5,100 MWh per project which is equal to reduce 2,958 tCO_2e per project.



Source: TRF (Thailand Research Fund, 2011), Technology Roadmap (International Energy Agency, The International Council of Chemical Associations (ICCA) and Society for Chemical Engineering and Biotechnology (DECHEMA), 2013), IPCC (Intergovernmental Panel on Climate Change, 2006) and Ecoinvent 2.2 (LCA software, IPCC 2007. GWP 100a.)

Figure 4: Comparison of greenhouse gas emissions with other studies.

Table 2: Amount of energy saving and CO_2 equivalent reduction from energy saving measure of PTA factory in Thailand.

Saving	**2011**	**2012**	**2013**
Energy (GJ)	44,970	24,970	3,719
CO2 (t CO2e)	3,169	4,023	513

Conclusion

Carbon footprint organization of PTA representative factories have average greenhouse gas emission 216,557 tCO_2e/year and energy use on average is 1,606 TJ per year. The average carbon intensity of PTA product is 0.3878 CO_2e/ton product. Main source of greenhouse gas are from energy production and utilization which depend on energy sources (own generation or purchase). Energy conservation is recommended measure to effectively reduce greenhouse gas emission. High potential mitigation measures that can reduce relative largest greenhouse gas emissions are by renovating steam turbine which can be implemented practically. However, to increase amount of greenhouse gas reduction, best practice technology (BPT), new technologies or emerging technology should be considered and implemented in the future.

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