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The Exploration of Spatial Strategies on Social Construction in Shenzhen

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Abstract
Shenzhen is a unique city in China where 70% of people come from outside of the city. In fewer than three decades, Shenzhen has gone from a no-name town of tens of thousands to a prototypical fast-growth city of millions of people. Rapid urbanization has brought out rapid economic development; however, social development has been ignored and is lagging far away behind economic development. This paper explored the social problems of Shenzhen, such as: uneven distribution of public facilities, lack of intensive utilization of resources; lack of urban distinction, and an immature social management system. According to the social problems in Shenzhen, this paper researched successful social sustainable cases of the San Francisco Bay Area, Hong Kong and Singapore, etc., and proposed spatial development goals of social construction in Shenzhen: "Promoting the coordinated economic, cultural, social, and ecological development, and building a harmonious city so that a variety of people from everywhere can live a happy life here." Furthermore, this paper suggested several development strategies, including "offering a variety of different spaces and services for various people," "activating stock spaces," "focusing on the community level," and "innovating institutional mechanisms." This is a turning point in the planning and social field; urban planning used to only focus on space planning but has evolved into also focusing on social issues. Moreover, this paper brought in social ecology research methods and explored the establishment of social and ecological assessment systems for urban planning. For example, besides the Environmental Impact Assessment, the Social Impact Assessment of urban renewal should be also considered; this would, for example, explore how demolition reconstruction could lead to fragmentation of social networks in an area.

Keywords: Shenzhen, Social Development, Spatial Strategies, Social Impact Assessment

Introduction

Located in the south of Guangdong Province along the coast of the South China Sea, it is part of the Pearl River Delta Region, in between Guangzhou and Hong Kong. Its progress in the past twenty years has been astounding. Shenzhen once was a small town with a population less than 30,000, but now is a modern city with a population that exceeds 15 million. In less than 30 years, Shenzhen has made significant progress that many cities would had made in several hundred years, which is a typical example of fast growing cities .

Shenzhen's GDP is the third highest in China. Shenzhen's GDP totaled CNY 820.1 billion in 2009, with its GDP per capita reached to US$13800, which is the first city of mainland China to have its GDP per capita surpassed US$10,000. It holds on as China's top export city for 17th year. In 2008, the city's financial income has risen to more than 80 billion, the third highest in China.

The city's population density is the highest in China. Shenzhen's population has grown significantly, and the city's population density is the highest in China.
By 2009 the resident population reached to 89.1 million（total amount would be more than 140 million when including mobile population ）， with household population of 23 million, consisting only 26% of the resident population.

Shenzhen is a unique city in China where 70% of people come from outside of the city. Rapid urbanization has brought out rapid economic development; however, social development has been ignored and is lagging far away behind economic development.

The 18th CPC national congress and the third plenary session of the 18th central committee of the communist party of China have committed important work arrangement to improve people's wellbeing, reaching a consensus to coordinating development of the economy and society. Strengthening the Construction of Society is an important Goal and Requirement of the 18th Chinese Communist Party and The Third Plenary Session of the 18th CPC Central Committee, is the country to promote the "people oriented" new urbanization and the implementation of the depth of urbanization in Shenzhen. Shenzhen is also facing the social transformation and urban transformation, to achieve "a stable growth of quality, sustainable and comprehensive development" of the basic guarantee. Social construction must be based on urban space as the basic carrier; space development should also include social construction as the goal and important content. How to find the combination of social construction and spatial planning to ensure that the city's social construction polices and measures to be implemented, is the problem need to seriously explore and solve.

Social construction relatively lags behind economic growth after 30 years' rapid economic development of Shenzhen. The gather of massive floating population brings up problems such as the shortage of infrastructure, social contradictions increasingly prominent. Consequently, we commence on "study on spatial strategy of Shenzhen social construction" project in order to make urban planning function better, and to improve the spatial resource allocation of social construction. Shenzhen experienced more than 30 years of rapid economic development, social construction is lagging behind in economic development, a large number of floating populations, bringing problems like the relative shortage of public infrastructure, social contradictions have become increasingly prominent.

Contents

Firstly, we analyze the social construction from three aspects: theoretical perspective, policy perspective and case study perspective. We category social construction into two groups: one is referring to space, the other group is not.

Then, we choose the space concerning social construction as our study object. From the theoretical interpretation——the connotation of social construction differs greatly in different institutional systems and stages of development. Social construction include expand employment opportunities, urban environment and urban features and social security, Science and technology, Culture and education, Building a social safety net, Protection of disadvantaged groups, Health, Clean, Efficiency and energy conservation, and Enhanced accountability to service providers.

From Policy Interpretation——Strengthening the Social Construction in Improving People`s Livelihood and Managing Innovation. Social construction includes employment (increase income, public security prevention and control system, social security system), science education and career, housing security, social assistance for special groups, urban and rural community construction and social management.

From Case Study——Urban development is to allow the public to be fair, inclusive, happy to live in the city. 《New York Planning》 Committed to equity – creating opportunities for all; 《The Spatial Development Strategy of Greater London》 Emphasizing inclusion and eliminating discrimination; 《Hongkong2030：To provide a better quality of life》. Implement the concept of sustainable development, and strive to provide a better quality of life by equitably meeting the social, economic and environmental needs of this generation and future generations.

Increase the quality of employment opportunities, ensure high-quality medical services, protection of history and culture, meet the diverse needs of the population, affordable housing, building a comprehensive community, maintain quality open space, and improve sports and leisure facilities.

Inclusion, Social Construction include Culture, Education, Health ;Public safety; Social assistance; Social Security; Community building; Social management; House insurance; Employment. Social construction space: Living space; Employment space; Culture, Education, Health; Public space; Public safety; Social assistance

And then, the project analyses Shenzhen’s spatial current situation and existing problems of social construction, and it also confirm the important role that Shenzhen’s urban planning plays in social construction.

One is that, the rapid development under the combined conglomeration structure, the spatial overlapping of different social classes, has promoted the multi-culture fusion.

Under the group structure, different social strata living, the employment space cascades staggered, promoted the multicultural fusion.

The same development group gathered the original residential villas, industrial areas, old and new residential areas and old and new business district, etc. , in different social strata of space, ‘get what they want’, showing small scale mixed state, promote the integration of urban multiculturalism.

The next is that, the planning has covered all range of service facility. A social service network is established gradually through the effective carrying out of the planning.

Priority planning education, health care, transportation, transportation, social pension and other public facilities；Revised 《Shenzhen Urban Planning Standards and Guidelines》，Clear allocation of public service facilities standards. Formulate 《Annual Implementation Plan for Recent Construction and Land Use Planning》 to protect the supply of land for people’s livelihood projects；Trough 《Implementation of Public Infrastructure Planning 》to gradually promote the implementation of various types of social service space planning.

The third is, it legalizes the construction of urban planning, perfects the supervision over social construction’s planning and implement.

Promote the legalization of spatial planning and construction; improve the supervision and implementation of social construction planning.

Formulate 《Regulations of Shenzhen Municipality on Urban Planning》，Through the establishment of the city planning committee system and public participation system, standardize the city planning, approval and revision procedures；Improve the planning management and implementation of the construction management of social supervision mechanism. Vigorously promote the community planners system, establish and improve the city planning and grass-roots communities of daily communication mechanism.

It further analyses the existing problem of social construction’s spatial arrangement. The first is the arduous task of covering the historical deficit left by rapid urbanization. The existing problems of the Spatial Layout of Social Construction: To make up for the rapid urbanization of the historical legacy of the task is still very arduous. There is a big gap between Shenzhen per capital social service space indicators and domestic advanced cities. Facilities supply is still in the primary stage of basic services such as basic education and health services. Questionnaire reflects the doctor and school is the highest concern of the people of Shenzhen.

The second is the serious imbalance in the social service facility resource allocation; A serious imbalance in the allocation of social service facilities. From the large space level, the scale of social service facilities on the differences reflected in the original SAR difference between inside and outside. The original SAR public facilities construction land accounted for 7.2% of total, serving a population of 3.54 million, while outside the SAR accounted for less than 3%, serving more than 6.82 million people. Uneven community size, using the same configuration standards, results in uneven distribution of social services facilities in the community and service population mismatch.

The third is, the further social differentiation of social space becomes a hidden danger of social conflicts; Social spatial differentiation of the trend is obvious, leaving hidden dangers of social contradictions；Low-income groups for the living and employment space have been compressed. With the upgrading of industrial structure, the improvement of urban functions and the implementation of urban beautification movement, the original SAR has a tradition and modern blend, the coexistence of multiple social forms of the situation is broken, especially residential space has become high-end, mansion, aristocratic tend. Residential space show high-grade residential areas, common area, villages and factory dormitories and other rich and poor class differentiation and isolation. Spatial separation and loneliness caused by isolation, lack of identity and other social problems led to Shenzhen, most of the urban and community space environment did not feel the "home feeling" and "sense of belonging".

The fourth is the existing dual contradictions of social service spatial resource shortage and its inefficient utilization. Social service space resource shortage and the use of inefficient coexistence of contradictions；The existing facilities, whether it is education, health care, pension or housing, have different levels of waste of resources. Cultural and sports facilities: Facilities use efficiency is generally not high, Guanshanyue Art Museum, the number of annual visits around 100000, when Hexiangning Museum is just not more than 80000. Medical and health facilities: When large hospitals are overcrowded, primary health care institutions are deserted, and even difficult to survive. Educational facilities: Nearly 2% of the state-run schools have an average class size of over 55, while about 14% of them have an average class size of less than 35. Pension facilities: The social pension facility occupancy rate is 18%, a large number of them are idle; Luohu and Nanshan welfare center waiting for the elderly a total of about 1700 people.

The fifth is, the urban characteristic has not been shown in the urban space construction yet. The existing problems of the Spatial Layout of Social Construction is lack of urban distinction；On the base of these, we study and draw from New York, San Francisco Bay district, San Francisco Bay district (diversified development), The Greater London district, (The Greater London district emphasize "social toleration and elimination of discrimination"), Queensland, The greater Vancouver and Hong Kong (Hongkong2030：better life quality), and Singapore (Singapore social security system).

The research has proposed the development goal of Shenzhen's social construction. That is to promote a coordinating development between urban economies, culture, society, and ecology.

Spatial Development Goal: "Promoting the coordinated economic, cultural, social, and ecological development, and building a harmonious city so that a variety of people from everywhere can live a happy life here." "Better city, better life. "

Space Development Strategies: Offering a variety of different spaces and services for various people; activating stock spaces; focusing on the community level; building city's characteristics; innovating institutional mechanisms.

Project Innovation

Analyzed and interpreted city from a social ecology perspective, provide various social services meeting different needs.

This project is a spatial policy research characterizes in cutting through from a society construction perspective, carrying out in all aspects and targeting in strengthening social construction. It no longer limited within a certain specific project (e.g. education facility), instead, it takes culture, education, sport, sanity, public space and social welfare as an entity and carries out a systematic spatial strategy research around it.

This project has implemented the work arrangement committed by the 18th CPC national congress and the third plenary session of the 18th central committee of the communist party of China. It changed the traditional research mechanism, which the

The second feature of the project is that has analyzed and interpreted city from a social ecology perspective which is a creative method in urban planning; it takes the city as a complex social ecology system, taking human demand into consideration, researching on a balanced relationship between human, construction and nature system, so as to formulate the self-adjusting and positive cycling abilities of social ecology system.
Innovation Point 1：Analyze and interpret city from a social ecology perspective. Build social-stability-and-ecological-harmony-based urban spatial structure. To improve function decentralization of city center, focus on developing city-group centers by rationally organizing office space, residential space and traffic space and realizing job-housing balance in these centers. Reasonably distribute housing land, industrial land and etc. to shorten commuting distance and to reduce commuting time. Study on features of people working, living and amusing to form public activity center system of the whole city.

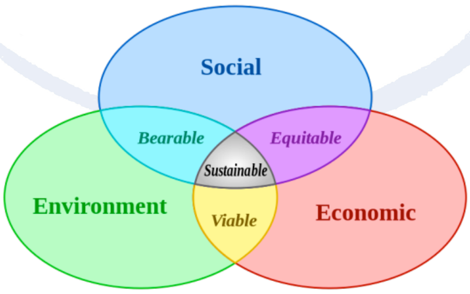

Figure 1: Social, environment, economic sustainability

We held an assessment over Shenzhen's conglomeration spatial structure, and we think that the original special zone's cluster function is incomplete which has broken the inner balanced relationship. As a result, we propose a key emphasis in perfecting the cluster's collocation function, to construct a more steady social ecology system.

Through tracking Shenzhen urban village's renovation, we find it that the tear down-reconstruction way of renovation has broken the social ecology chain and the symbiotic relationship between different crowds. A social ecology assessment system should be established in order to evaluate the social ecology impact of the reconstruction before deciding whether the project should be approved.

Build social-relation-based urban renewal evaluation system. Shenzhen has been speeding up the pace of urban renewal since 2009 by removing and reconstructing urban villages to improve the quality of living environment and urban space. However, this can lead to some social issues such as damage to social ecological environment and self-organization mechanism. For example, cheap labor, such as cleaners and shoemakers, is forced out because of the reconstruction of Gangxia Village and the rising living cost.

Lacking of consideration on social and ecological mechanism and inadequacy of urban planning and practicing has caused a lot of social issues. The government sometimes has to realize urban planning by taking some actions, including land requisition and demolition of current buildings, removal of a whole urban village, public housing construction on non-agricultural construction land that used to be residential land , reconstruction of urban villages and so on, that may probably change the original social ecological system and trigger social problems.

We suggest that related types of planning, such as district planning and detailed planning, especially planning that involves interested party, should build a planning pre-estimate system and a planning practice social ecological evaluate system that are aimed at pre-estimating the planning and evaluating its influence on social ecological environment. Form an evaluation commission consisting of interested party and related government department to evaluate planning proposals. Build a planning practice hearing system to allow local people and interested party express their demands looking for a better way to improve the planning.

The third feature of the project is that it coordinates urban planning assignment on the base of a higher social construction target. According to Shenzhen’s development stage and people’s physical demand, we insist that social construction and urban planning work should be arranged on a higher base for a higher target. Not only to solve the existence needs, but also to satisfy the living demands, and further to presume the well-being life quality.

Innovation Point2：provide various social services meeting different needs

Figure 2: Meet happiness more than basic needs

Combining this orientation, we proposed the "basic utility and improving utility" social facility allocation standard to provide multiple space and service for different crowds.

Provide various social services meeting different needs. Advanced Utilities: New aging community; New education and training facility; New medical facility; New leisure serving facility. Basic Utilities: Cultural facility, educational facility, sports facility and sanitary facility; Caring facility: shelter for wanderers, lunatic asylum. Develop new aging community. According to the difference in aging people's self-care ability, develop various kinds of aging communities, such as retirement community for active adults, daily assisting community and special care community, with different managing modes and for-profit modes.

Develop new education and training facility. Develop elementary career education and training into residential communities through community colleges and other training institutions.

Develop new medical facility. Relying on tourism resources, develop medical tourism serving facility with the subject of medical care and recovery and recuperation.

Develop new leisure serving facility. Develop new leisure serving facility containing culture, sport, entertainment, leisure, shopping and catering industries.

And we insist to cultivate a more diverse and inclusive feature for the coastal city Shenzhen. Develop characteristic of a subtropical coastal city. Raise the percentage of living coastal line from 25% to 30%. Develop waterfront area toward service hinterland; create more waterfront space with more activities. Develop characteristic of subtropical coastal city through streetscape design, park landscape design, architecture design, city sculpture and artistic creation and so on.

The forth feature is that it transfers its focus to the grassroots level and the community. According to investigate method of sociology, we have visited many communities and issued questionnaires all over the city to investigate on citizens' comments on community and their spatial needs. Through the research, we point out that: Allocate the social service spatial resource according to community population scope. Shenzhen used to hold the same allocation standard in different community, however, the biggest community population scope is 1000 times of the smallest one, resulting in the mismatching community service facility allocation and actual service population.

We propose that the social service facility should be allocated according to the actual population. The scale and type of all kinds of facilities should be allocated while regarding the actual local population.

Considering the existing community service facility shortage and its ineffective utility, we encourage communities to construct more public service complex.

Planning and constructing community scale public service complex can integrate the functions maximally and facilitate the compound use of space resource. Also, the recycle use of community service space can be assured through the spatial management cover different time schedules.

The fifth feature of this project is the innovating mechanism of social construction spatial resource allocation. Considering the opacity and low utility efficiency, we call for coordinating the commonweal property management and reinforcing the public function of government service.

Relying on big data management, we integrate the medical, recreation and sport, education, population and social management resource information, so as to promote the sharing of social spatial resource, as well as to found an information platform of citizens' service space.

Project Effect

Influences on related function departments: during the research, we further discussed issues with NDRC (national development and reform commission), civil affairs bureau, and tourist administration and so on. As a result, we have achieved a high degree of consensus in aspects such as the main idea of the project, reinforcing the leading function of planning and the future work focus.

The research outcome has been put into the article "Shenzhen social construction strategy research", issued in social work brief report, and received highly regards and agreement from deputy secretary of Shenzhen. Another article "draw from national and international experience, perfect Shenzhen's social spatial construction supporting system" has been issued in the strategy reference held by municipal policy research administration. These have offered key strategic basis for work arrangement of social construction.

At present, Shenzhen planning territory committee has reached the agreement with social work committee to work on the implement of project and the specific working schedule.

Next, Shenzhen planning territory committee will further take part in the "knit mesh project" held by social work committee, realizing the "integrate the public resource sharing& release resource to the public" strategy, pushing forward the construction of information platform of social construction.

The Impact within Planning field: this project has invited socialists, Shenzhen sunshine family integrated service center, Shenzhen housing estate assessment development center and Pinshan new district urban construction limited company, etc. to have discussion on the topic "spatial solution of social construction".

We held three seminars, inviting urban planning professors, socialists, urban planning officers and American anthropologist to join the discussion on the project outcome and the relations between social construction and spatial planning.

Also, we held academic salon on the topic "spatial planning& social management", discussing some practical problems come up when implementing the planning, sharing the problem solutions and experience, after which we drew generalities and valuable strategic suggestions from different cases to drive the reform. The planning target, overall strategy, etc. have been included in new urbanization planning outline.

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China' Sustainability on Economy and Energy using DEA Assessment

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Abstract
From the "13th five year" plan, China now is directing to transit to the green economy for not only relying on GDP performance, but also ensuring the environmental protection. It is crucial to have the energy plan, which can build up safe, efficient and sustainable energy strategy systems. This study discusses the concept of Undesirable Congestion (UC) under natural disposability and Desirable Congestion (DC) under managerial disposability and links them with Returns to Damage (RTD) and Damages to Return (DTR). RTD and DTR are newly derived from a conventional concept of Returns to Scale (RTS). This study compares between RTD under UC and DTR under DC and applies the proposed methodology to 30 Chinese provinces on their economic and energy planning for sustainable development. Three important findings are identified: First, the Chinese government has historically paid attention to the economic development, but ignoring environmental protection. Second, there was an increasing trend in improving the economy and environment. Finally, China focused on large provinces especially municipalities in terms of energy policy concerns. Thus, Chinese government should consider the privatization from public to private energy firms. It can not only improve the energy management and monitoring by government, but also increase the economic efficiency in market so that GDP can be increased. In further, the increased economic growth can better the economic imbalance of China.

Keywords: Energy, Congestion, Industrial Policy

Introduction

China is the most rapidly developed country in past 10 years in terms of economy. At the same time, the air pollution problem became a major concern for its neighbor countries. The rapid economic development comes along with the air pollution in history. For example, the United of Kingdom in last century. The great smog events caused 12,000 fatalities according to most recent report. Later the relationship of air quality and health led to several changes in practices and regulations. It costs so many years' governance to improve the air quality.

In order to avoid the irreversible outcome from rapid economic development and duplication of UK's development mistake, China should seek social sustainability on economy and environment before the air quality goes worse. And the energy planning plays an important role in controlling air pollutions.

In this study, the social sustainability, based upon our empirical measurability by mathematical programming, implies "a synchronized development of both (a) economic prosperity for reducing the level of poverty and enhancing the standard of living and (b) environmental protection for reducing the level of pollution". The components of such social sustainability are discussed within the conceptual framework of natural disposability and managerial disposability, respectively, where the concept of disposability implies inefficiency elimination. Note that the natural disposability has a priority order where the first priority is operational (economic) performance and the second priority is environmental performance. An opposite priority is found in managerial disposability. Thus, the concept of social suitability will be discussed and measured within our analytical capability. Therefore, this study does not consider qualitative aspects (e.g., culture, law, politics and philosophy) regarding the social sustainability.

DEA environmental assessment can be used to overcome the difficulty on global warming and climate change by combining the technology development with managerial challenges. As an extension of previous studies, this study applies the concept of Undesirable Congestion (UC) and Desirable Congestion (DC) along with its linkage with Returns to Damage (RTD) and Damages to Return (DTR). It is easily imagined that no study has explored RTD under UC and DTR under DC in not only DEA environmental assessment but also production economics. Also in order to overcome the DEA efficiency difficulty, this study equips DEA with an analytical capability for multiplier restriction to improve the measurement reliability on RTD under UC and DTR under DC.

The methodology has been applied to energy planning in China. The economic imbalance and serious environmental pollution are found. In order to control air pollutions and better development, Chinese government should promote the privatization in near future as the policy implication.

Literature Review

The development of DEA was due to the contributions of Professor W.W. Cooper. See Glover and Sueyoshi (2009) and Ijiri and Sueyoshi (2010) on his contributions of

Professor Cooper in DEA development. An important feature of the previous DEA studies is that they have developed methodological frameworks of DEA, but lacking a conceptual framework for its environmental assessment. The first article, which has discussed the conceptual framework such as natural and managerial disposability, can be found in Sueyoshi and Goto (2012).

An occurrence of congestion has been widely examined in many previous studies (e.g., Cooper et al, 2001, Sueyoshi and Sekitani, 2008) within a conventional framework of DEA. It is impossible for this study to apply their approaches to discuss the occurrence for environmental assessment because their approaches did not consider the output separation to desirable and undesirable categories. Furthermore, their approaches did not separate the occurrence into UC and DC.

Most of Chinese energy firms have been operating under public ownership. Sueyoshi and Goto (2012) that has documented the ownership portion of three Chinese petroleum companies. Public agencies on environmental protection usually have a difficulty in monitoring and controlling public companies because their governances are connected to each other. To terminate such a political linkage, the privatization of public firms, in particular energy firms, is necessary for Chinese future. See a series of studies (e.g., Sueyoshi, 1991, 1997, 1998, 1999; Sueyoshi et al., 2010) on privatization whose performance changes have been measured by DEA.

Methodology and methods

This study considers that there are n DMUs (Decision Making Units: corresponding to an organization to be evaluated). The *j*-th DMU ($j = 1, .., n$) uses a column vector of inputs (X_j) in order to yield not only a column vector of desirable outputs (G_j) but also a column vector of undesirable outputs (B_j), where $X_j = (x_{1j}, x_{2j}, .., x_{mj})^T$, $G_j = (g_{1j}, g_{2j}, .., g_{sj})^T$ and $B_j = (b_{1j}, b_{2j}, .., b_{hj})^T$. Here, the superscript "*T*" indicates a vector transpose. These column vectors are referred to as "production factors" in this study. It is assumed that $X_j > 0$, $G_j > 0$ and $B_j > 0$ for all $j = 1, .. , n$, where all components of the three vectors are strictly positive.

The data ranges for adjustment are determined by the upper and lower bounds on inputs and those of desirable and undesirable outputs. These upper and lower bounds are specified by

$$R_i^x = (m+s+h)^{-1}\left(max\left\{x_{ij} \mid j = 1,\cdots,n\right\} - min\left\{x_{ij} \mid j = 1,\cdots,n\right\}\right)^{-1}$$
$$R_r^g = (m+s+h)^{-1}\left(max\left\{g_{rj} \mid j = 1,\cdots,n\right\} - min\left\{g_{rj} \mid j = 1,\cdots,n\right\}\right)^{-1} \text{ and}$$
$$R_f^b = (m+s+h)^{-1}\left(max\left\{b_{fj} \mid j = 1,\cdots,n\right\} - min\left\{b_{fj} \mid j = 1,\cdots,n\right\}\right)^{-1}.$$

To examine the occurrence of UC under natural disposability, this study proposes the following model that maintains equality constraints (so, no slack variable) on undesirable outputs:

$$
\begin{aligned}
&\text{Maximize } \xi + \varepsilon_s[\sum_{i=1}^{m} R_i^{x-} d_i^{x-} + \sum_{r=1}^{s} R_r^g d_r^g] \\
&\text{s.t.} \quad \sum_{j=1}^{n} x_{ij}\lambda_j + d_i^{x-} = x_{ik} \qquad (i = 1, .., m), \\
&\sum_{j=1}^{n} g_{rj}\lambda_j - d_r^g - \xi g_{rk} = g_{rk} \qquad (r = 1, .., s), \\
&\sum_{j=1}^{n} b_{fj}\lambda_j + \xi b_{fk} = b_{fk} \qquad (f = 1, .., h), \\
&\sum_{j=1}^{n} \lambda_j = 1, \\
&\lambda_j \geq 0 \ (j = 1, .., n), \ \xi : URS \\
&d_i^{x-} \geq 0 \ (i = 1,..,m) \ \& \ d_r^g \geq 0 \ (r = 1,..,s).
\end{aligned} \qquad (1)
$$

Model (1) drops slack variables related to undesirable outputs (B) so that they are considered as equality constraints. The other constraints regarding inputs and desirable outputs are considered as inequality because they have slack variables in Model (1). Model (1) has the following dual formulation:

$$
\begin{aligned}
&\text{Minimize} \quad \sum_{i=1}^{m} v_i x_{ik} - \sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} + \sigma \\
&\text{s.t.} \quad \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r g_{rj} + \sum_{f=1}^{h} w_f b_{fj} + \sigma \geq 0 \quad (j = 1, ..,n), \\
&\sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} = 1, \\
&v_i \geq \varepsilon_s R_i^x \qquad (i = 1, .., m), \\
&u_r \geq \varepsilon_s R_r^g \qquad (r = 1, .., s), \\
&w_f : URS \qquad (f = 1, .., h) \ \& \\
&\sigma: URS.
\end{aligned} \qquad (2)
$$

An important feature of Model (2) is that the dual variables (w_f: URS for $f = 1, .., h$) are unrestricted in their signs because the constraints on undesirable outputs are expressed by equality (no slack) in Model (1). The dual variables are often referred to as “multipliers” in the DEA community.

A unified efficiency score of the k-th DMU under natural disposability becomes

$$
UEN(UC) = 1 - [\xi^* + \varepsilon_s(\sum_{i=1}^{m} R_i^x d_i^{x-*} + \sum_{r=1}^{s} R_r^g d_r^{g*})] = 1 - [\sum_{i=1}^{m} v_i^* x_{ik} - \sum_{r=1}^{s} u_r^* g_{rk} + \sum_{f=1}^{h} w_f^* b_{fk} + \sigma^*], \qquad (3)
$$

which incorporates a possible occurrence of UC. All variables used in Equation (3) are determined on the optimality of Models (1) and (2). The equation within the parenthesis, obtained from the optimality of Models (1) and (2), indicates the level of unified inefficiency under natural disposability. The unified efficiency in the case, or $UEN(UC)$, is obtained by subtracting the level of inefficiency from unity.

An important advantage of Model (1) is that it can incorporate prior information as side constraints for multiplier restrictions. For example, DEA environmental assessment usually divides an observation on each production factor by the average in order to avoid a case where a data set with a large magnitude dominates the other data sets with a small magnitude in DEA computation. Therefore, such a data manipulation is important for DEA to enhance the computational reliability. As a result, all the observations used in this study are unit-less, so indicating the importance of each production factor. Along with the data adjustment, it is possible for us to incorporate addition side conditions on production factors by the following manner:

Inputs: $-1 \le v_{i'}/v_i \le 1 \; (i' > i = 1, .., m)$. (4)

Desirable outputs: $-1 \le u_{r'}/u_r \le 1 \; (r' > r = 1, .., s)$. (5)

Undesirable outputs: $-1 \le w_{f'}/w_f \le 1 \; (f' > f = 1, .., h)$. (6)

Model (2), equipped with Equations (4)-(6), becomes as follows:

$$\begin{aligned}
&Minimize && \sum_{i=1}^{m} v_i x_{ik} - \sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} + \sigma \\
&s.t. && \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r g_{rj} + \sum_{f=1}^{h} w_f b_{fj} + \sigma \ge 0 && (j = 1, .., n), \\
& && \sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} = 1, \\
& && v_i \ge \varepsilon_s R_i^x && (i = 1, .., m), \qquad (7) \\
& && u_r \ge \varepsilon_s R_r^g && (r = 1, .., s), \\
& && w_f : URS && (f = 1, .., h), \\
& && \sigma : URS, \\
& && -1 \le v_{i'}/v_i \le 1 && (i' > i = 1, .., m), \\
& && -1 \le u_{r'}/u_r \le 1 && (r' > r = 1, .., s) \; \& \\
& && -1 \le w_{f'}/w_f \le 1 && (f' > f = 1, .., h).
\end{aligned}$$

The level of $UEN(UC)$ is determined by

$$UEN(UC) = 1 - [\sum_{i=1}^{m} v_i^* x_{ik} - \sum_{r=1}^{s} u_r^* g_{rk} + \sum_{f=1}^{h} w_f^* b_{fk} + \sigma^*],$$

(8)

where all the dual variables are identified on the optimality of Model (7). Equation (8) is different from Equation (3) because the side constrains (4)-(6) are additionally incorporated into Model (7). Here, it is important to note that Equation (8) is different from Equation (3) because the former incorporates the proposed multiplier restriction, or Equations (4)-(6), while the latter does not have such additional constraints. Therefore, the two models produce different *UEN(UC)* measures.

After computing Model (7), a possible occurrence of UC is determined by the following rule along with the assumption that Model (7) produces a unique optimal solution (i.e. unique projection and a unique reference set):

(a) if $w_f^* < 0$ for some (at least one) f, then "strong UC" occurs on the k-th DMU,
(b) if $w_f^* > 0$ for all f, then "no UC" occurs on the k-th DMU, and
(c) In the others, including $w_f^* = 0$ for some (at least one) f, then "weak UC" occurs on the k-th DMU.

It is important to note that if $w_f^* < 0$ for some *f* and $w_{f'}^* = 0$ for the other *f'*, then both strong UC and weak UC may coexist on the k-th DMU. In that case, this study considers it as an occurrence of the strong UC on the DMU.

RTD Measurement under a Possible Occurrence of Undesirable Congestion (UC)

Let the dual variables of the k-th DMU, obtained from Model (7), be v_i^* $(i = 1, 2, .., m)$, u_r^* $(r = 1, 2, .., s)$, w_f^* $(f = 1, 2, .., h)$ and σ^* on the optimality. Then, the estimated supporting hyperplane on the k-th DMU is expressed by

$$\sum_{r=1}^{s} u_r^* g_r = \sum_{i=1}^{m} v_i^* x_i + \sum_{f=1}^{h} w_f^* b_f + \sigma^* , \qquad (9)$$

which is characterized by $\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r g_{rj} + \sum_{f=1}^{h} w_f b_{fj} + \sigma,\ j \in R_k$, where R_k is a reference set for the k-th DMU, and $\sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} = 1$.

The degree (Dg) of RTD, or DgRTD, under a possible occurrence of UC, on the k-th DMU by

$$\begin{aligned} DgRTD(UC) &= (\sum_{f=1}^{h} w_f^* b_f) / (\sum_{r=1}^{s} u_r^* g_r) \\ &= (\sum_{f=1}^{h} w_f^* b_f) / (\sum_{i=1}^{m} v_i^* x_i + \sum_{f=1}^{h} w_f^* b_f + \sigma^*) \qquad (10) \\ &= 1/[1+(\sigma^* + \sum_{i=1}^{m} v_i^* x_i)/(\sum_{f=1}^{h} w_f^* b_f)] \end{aligned}$$

As mentioned previously, this study assumes that Model (7) has both a unique projection of an inefficient DMU onto an efficiency frontier and a unique reference set for the DMU.

The type of RTD is classified by the following rule on the k-th DMU:

(a) Increasing RTD $\Leftrightarrow$ There exists an optimal solution of Model (7) that satisfies all $w_f^* > 0$ ($f = 1, .., h$) and $\sigma^* + \sum_{i=1}^{m} v_i^* x_i < 0$,

(b) Constant RTD $\Leftrightarrow$ There exists an optimal solution of Model (7) that satisfies all $w_f^* > 0$ ($f = 1, .., h$) and $\sigma^* + \sum_{i=1}^{m} v_i^* x_i = 0$,

(c) Decreasing RTD $\Leftrightarrow$ Any optimal solution of Model (7) that satisfies all $w_f^* > 0$ ($f = 1, .., h$) and $\sigma^* + \sum_{i=1}^{m} v_i^* x_i > 0$,

(d) Negative RTD $\Leftrightarrow$ any optimal solution of Model (7) that satisfies $w_f^* < 0$ for at least one $i \in \{1, K, m\}$, and

(e) No RTD $\Leftrightarrow$ All other cases excluding (a) to (d).

Difference between UC and RTD: The type of UC is identified by the sign of dual variables (w_f^*). The type of UC is classified into the three categories. Meanwhile, these measures related to RTD are determined by not only the sign of dual variables (w_f^*) but also the sign of $\sum_{i=1}^{m} v_i^* x_i + \sigma^*$. The type of RTD is classified into the five categories. Figure 7 visually classifies the type of RTD under a possible occurrence of UC.

At the end of this section, it is necessary to summarize three concerns related to Model (7) and Equation (10) as well as the proposed RTD classification. First, Model (7) assumes a unique solution, so implying no occurrence on multiple projections and multiple reference sets. Second, Equation (10) is effective on only efficient DMUs, not inefficient ones. In the case of inefficiency, Equation (10) needs to incorporate a projection onto an efficiency frontier by eliminating slacks from the observed production factors. Finally, the type of RTD is determined by measuring the upper and lower bound of $\sum_{i=1}^{m} v_i^* x_i + \sigma^*$. The proposed approach is just an approximation method for the RTD measurement for our descriptive convenience. Figure 1 visually classifies an occurrence of UC and RTD classification (source: Sueyoshi and Yuan (2016)).

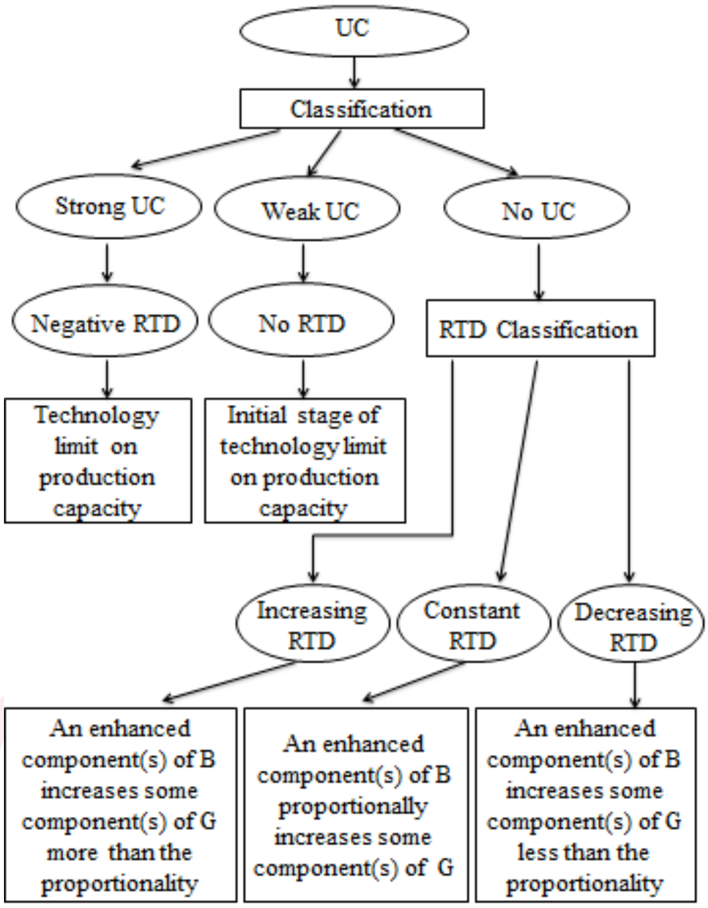

Figure 1: RTD under UC

Source: Sueyoshi & Yuan (2016).

A Possible Occurrence of Desirable Congestion

This study can identify an occurrence of Desirable Congestion (DC) under managerial disposability. To examine the occurrence, this study proposes the following model that maintains equality constraints (so, no slack variable) on desirable outputs:

$$
\begin{aligned}
&Maximize \quad \xi + \varepsilon_s \left[\sum_{i=1}^{m} R_i^x d_i^{x+} + \sum_{f=1}^{h} R_f^b d_f^b \right] \\
&s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j - d_i^{x+} = x_{ik} \quad (i = 1, .., m), \\
&\qquad \sum_{j=1}^{n} g_{rj}\lambda_j - \xi g_{rk} = g_{rk} \quad (r = 1, .., s) \\
&\qquad \sum_{j=1}^{n} b_{fj}\lambda_j + d_f^b + \xi b_{fk} = b_{fk} \quad (f = 1, .., h), \\
&\qquad \sum_{j=1}^{n} \lambda_j = 1, \\
&\qquad \lambda_j \ge 0 \ (j = 1, .., n),\ \xi : URS,\ d_i^{x+} \ge 0 \ (i = 1,..,m), \\
&\qquad and \ d_f^b \ge 0 \ (f = 1,..,h).
\end{aligned} \qquad (11)
$$

Model (11) drops slack variables related to desirable outputs so that they are considered as equality constraints. The other groups of constraints on inputs and undesirable outputs maintain slacks so that they can be considered as inequality constraints. For example, $\sum_{j=1}^{n} x_{ij}\lambda_j - d_i^{x+} = x_{ik}$ is equivalent to $\sum_{j=1}^{n} x_{ij}\lambda_j \geq x_{ik}$ for all i. The description on input slacks is also applicable to undesirable outputs. Model (11) has the following dual formulation:

$$
\begin{aligned}
\text{Minimize} \quad & -\sum_{i=1}^{m} v_i x_{ik} - \sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} + \sigma \\
\text{s.t.} \quad & -\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r g_{rj} + \sum_{f=1}^{h} w_f b_{fj} + \sigma \geq 0 \quad (j = 1, .., n), \\
& \sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} = 1, \\
& v_i \geq \varepsilon_s R_i^x \quad (i = 1, .., m), \\
& u_r: URS \quad (r = 1, .., s), \\
& w_f \geq \varepsilon_s R_f^d \quad (f = 1, .., h) \ \& \\
& \sigma: URS.
\end{aligned}
$$

(12)

An important feature of Model (11) is that the dual variables (u_r: URS for $r = 1, .., s$) are unrestricted in their signs because Model (11) drops slack variables related to desirable outputs.

A unified efficiency score, or $UEM(DC)$ of the k-th DMU, with a possible occurrence of DC, under managerial disposability is determined by:

$$UEM(DC) = 1 - [\xi^* + \varepsilon_s[\sum_{i=1}^{m} R_i^x d_i^{x+*} + \sum_{f=1}^{h} R_f^b d_f^{b*}]] = 1 - [-\sum_{i=1}^{m} v_i^* x_{ik} - \sum_{r=1}^{s} u_r^* g_{rk} + \sum_{f=1}^{h} w_f^* b_{fk} + \sigma^*], \quad (13)$$

where all variables are determined on the optimality of Models (11) and (12). The equation within the parenthesis, obtained from the optimality of Models (11) and (12), indicates the level of unified inefficiency under managerial disposability. The unified efficiency is obtained by subtracting the level of inefficiency from unity.
As discussed on Model (7), Model (6) can incorporate prior information as follows:

$$
\begin{aligned}
&Minimize \quad -\sum_{i=1}^{m} v_i x_{ik} - \sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} + \sigma \\
&s.t. \quad -\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r g_{rj} + \sum_{f=1}^{h} w_f b_{fj} + \sigma \geq 0 \quad (j = 1, .., n), \\
&\sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} = 1, \\
&v_i \geq \varepsilon_s R_i^x \quad (i = 1, .., m), \\
&u_r : URS \quad (r = 1, .., s), \\
&w_f \geq \varepsilon_s R_f^b \quad (f = 1, .., h), \\
&\sigma : URS, \\
&-1 \leq v_{i'}/v_i \leq 1 \quad (i' > i = 1, .., m), \\
&-1 \leq u_{r'}/u_r \leq 1 \quad (r' > r = 1, .., s) \ \& \\
&-1 \leq w_{f'}/w_f \leq 1 \quad (f' > f = 1, .., h).
\end{aligned}
$$

(14)

The level of *UEM(DC)* is determined by

$$
UEM(DC) = 1 - [-\sum_{i=1}^{m} v_i^* x_{ik} - \sum_{r=1}^{s} u_r^* g_{rk} + \sum_{f=1}^{h} w_f^* b_{fk} + \sigma^*],
$$

(15)

where all the dual variables are identified on the optimality of Model (14). Equation (15) is different from Equation (13) because Model (15) incorporates the additional side constrains (4)-(6). Thus, Equations (15) and (13) produce different *UEM(DC)* measures.

After solving Model (14), this study can identify a possible occurrence of DC, or eco-technology innovation, by the following rule under the assumption on a unique optimal solution (i. e. unique projection and a unique reference set):

(a) if $u_r^* < 0$ for some (at least one) r, then "strong DC" occurs on the k-th DMU,

(b) if $u_r^* > 0$ for all r, then "no DC" occurs on the k-th DMU and

(c) In the others, including $u_r^* = 0$ for some (at least one) f, then "weak DC" occurs on the k-th DMU.

Note that if $u_r^* < 0$ for some r and $u_{r'}^* = 0$ for the other r', then the weak and strong DCs coexist on the k-th DMU. This study considers it as the strong DC, so indicating technology innovation on undesirable outputs. It is important to note that $u_r^* < 0$ for all r is the best case because an increase in any desirable output always decreases an amount of undesirable outputs. Meanwhile, if $u_r^* < 0$ is identified for some r, then it indicates that there is a chance to reduce an amount of undesirable output(s). Therefore, this study considers the second case as an occurrence of DC.

DTR under Desirable Congestion (DC)

Let the dual variables of the k-th DMU, obtained from Model (14), be v_i^* (i = 1, 2, .., m), u_r^* (r = 1, 2, .., s), w_f^* (f = 1, 2, .., h) and σ^*. Then, an estimated supporting hyperplane on the k-th DMU is specified by

$$\sum_{f=1}^{h} w_f^* b_f = \sum_{r=1}^{s} u_r^* g_r + \sum_{i=1}^{m} v_i^* x_i - \sigma^* . \qquad (16)$$

The equation is characterized by $-\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r g_{rj} + \sum_{f=1}^{h} w_f b_{fj} + \sigma,\ j \in R_k$, where R_k is a reference set of the k-th DMU, and $\sum_{r=1}^{s} u_r g_{rk} + \sum_{f=1}^{h} w_f b_{fk} = 1$.

This study assumes that Model (14) has both a unique projection of an inefficient DMU onto an efficiency frontier and a unique reference set for the projected DMU. Then, the degree (Dg) of the DTR, or DgDTR, is measured by

$$\begin{aligned} DgDTR &= \Big(\sum_{r=1}^{s} u_r^* g_r\Big) / \Big(\sum_{f=1}^{h} w_f^* b_f\Big) \\ &= \Big(\sum_{r=1}^{s} u_r^* g_r\Big) / \Big(\sum_{i=1}^{m} v_i^* x_i + \sum_{r=1}^{s} u_r^* g_r - \sigma^*\Big) \qquad (17) \\ &= 1/\Big[1 - \Big(\sigma^* - \sum_{i=1}^{m} v_i^* x_i\Big) / \Big(\sum_{r=1}^{s} u_r^* g_r\Big)\Big] \end{aligned}$$

Consequently, the type of DTR is classified by the following rule on the k-th DMU:

(a) Increasing DTR $\Leftrightarrow$ There is an optimal solution of Model (14) that satisfies all $u_r^* > 0$ $(r = 1, .., s)$ and $\sigma^* - \sum_{i=1}^{m} v_i^* x_i > 0$,

(b) Constant DTR $\Leftrightarrow$ There exists an optimal solution of Model (14) that satisfies all $u_r^* > 0$ $(r = 1, .., s)$ and $\sigma^* - \sum_{i=1}^{m} v_i^* x_i = 0$,

(c) Decreasing DTR $\Leftrightarrow$ There is an optimal solution of Model (14) that satisfies all $u_r^* > 0$ $(r = 1, .., s)$ and $\sigma^* - \sum_{i=1}^{m} v_i^* x_i < 0$,

(d) Negative DTR $\Leftrightarrow$ There is an optimal solution of Model (14) that satisfies $u_r^* < 0$ for at least one $r \in \{1, K, s\}$, and

(e) No DTR $\Leftrightarrow$ All other cases excluding (a) to (d).

All the concerns discussed for the measurement of RTD are applicable to DTR. However, it is important to add that the type of DTR is determined by measuring the upper and lower bound of $\sigma^* - \sum_{i=1}^{m} v_i^* x_i$. The proposed approach is just an approximation method for the DTR measurement.

Difference between DC and DTR: The occurrence and type of DC are identified by the sign of dual variables (u_r^*). The type of DC is classified into three categories. Meanwhile, these measures related to DTR are determined by not only the sign of dual variables (u_r^*) but also the sign of $\sigma^* - \sum_{i=1}^{m} v_i^* x_i$. The type of DTR is classified into five categories. Figure 2 visually classifies an occurrence of DC and DTR classification (source: Sueyoshi and Yuan (2016)).

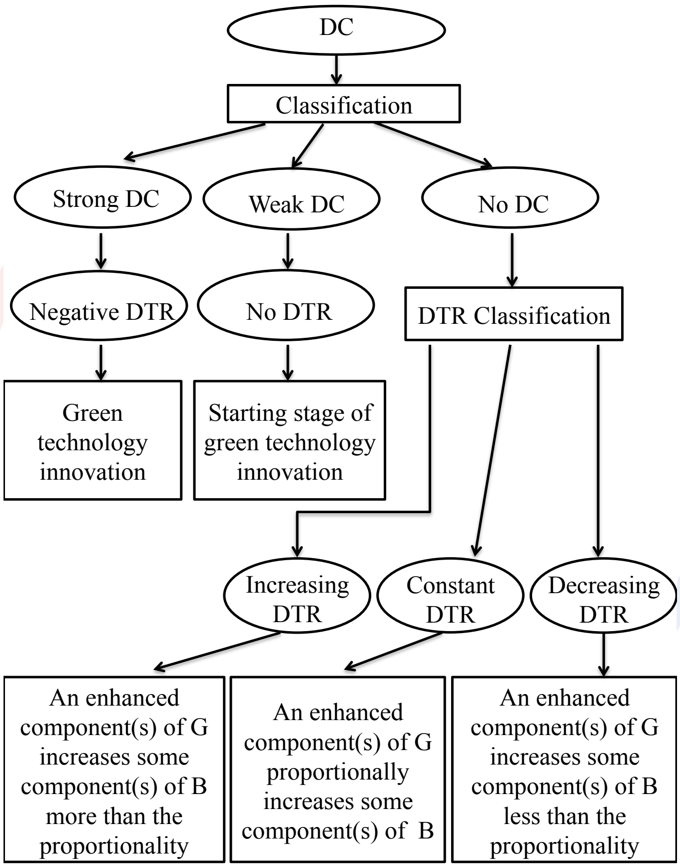

Figure 2: DTR under DC

(a) Source: Sueyoshi & Yuan (2016).

Table 1: UEN of 30 provinces in 2005-2012

Province	2005	2006	2007	2008	2009	2010	2011	2012	Average
Beijing	0.7740	0.8195	0.7357	0.7897	0.7873	0.9096	1.0000	1.0000	0.8520
Tianjin	0.5571	0.4960	0.5445	0.5750	0.5010	0.6266	0.7702	0.7866	0.6071
Hebei	0.5017	0.5389	0.6147	0.6837	0.7173	0.7415	0.7850	0.8164	0.6749
Shanxi	0.2961	0.2871	0.3177	0.4214	0.3761	0.4642	0.5132	0.5457	0.4027
Inner Mongolia	0.3789	0.3720	0.4673	0.5851	0.5702	0.6448	0.6219	0.5480	0.5235
Liaoning	0.4242	0.4235	0.4716	0.5135	0.5442	0.5978	0.6774	0.6928	0.5431
Jilin	0.5274	0.5044	0.5227	0.5441	0.5974	0.5804	0.6782	0.7162	0.5839
Heilongjiang	0.4123	0.4260	0.4330	0.4720	0.4760	0.5092	0.6127	0.6910	0.5040
Shanghai	0.6876	0.7400	0.7431	0.8518	0.7897	0.9096	1.0000	1.0000	0.8402
Jiangsu	0.7211	0.7515	1.0000	0.9409	0.9433	1.0000	1.0000	1.0000	0.9196
Zhejiang	0.6282	0.6625	0.7262	0.8731	0.9029	0.9969	0.9917	1.0000	0.8477
Anhui	0.7940	0.6694	0.6753	0.6955	0.7565	0.8102	0.9057	0.9422	0.7811
Fujian	1.0000	1.0000	1.0000	0.9214	1.0000	0.8846	0.9379	1.0000	0.9680
Jiangxi	1.0000	0.9522	1.0000	1.0000	0.9692	0.9484	0.9625	1.0000	0.9790
Shandong	0.6265	0.7537	0.7749	0.8577	0.8776	0.9126	0.9602	1.0000	0.8454
Henan	0.6101	0.5930	0.6589	0.7728	0.7662	0.8296	0.8880	0.9353	0.7567
Hubei	0.4922	0.4724	0.5280	0.6600	0.6557	0.7380	0.8808	1.0000	0.6784
Hunan	0.6575	0.7200	0.7992	0.8445	0.8841	0.9264	0.9788	1.0000	0.8513
Guangdong	0.6505	0.7503	0.8674	0.8986	0.8706	0.9745	1.0000	1.0000	0.8765
Guangxi	0.9603	0.8102	0.8511	1.0000	1.0000	0.9733	1.0000	1.0000	0.9494
Hainan	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9939	1.0000	0.9992
Chongqing	0.3696	0.3540	0.3944	0.4358	0.4468	0.4810	0.5751	0.5860	0.4553
Sichuan	0.4983	0.4752	0.5922	0.6274	0.5865	0.6618	0.7331	0.7452	0.6150
Guizhou	0.4980	0.4531	0.4493	0.4860	0.5329	0.5378	0.5091	0.6297	0.5120
Yunnan	0.5112	0.4611	0.5655	0.6535	0.6508	0.6243	0.7422	0.7637	0.6215
Shaanxi	0.3570	0.3080	0.3213	0.3693	0.3786	0.4102	0.4745	0.5029	0.3902
Gansu	0.3826	0.3080	0.3551	0.3331	0.2897	0.2902	0.3550	0.3756	0.3362
Qinghai	1.0000	0.3536	0.4523	0.3618	0.2963	0.3445	0.3598	0.3849	0.4441
Ningxia	1.0000	0.7704	0.4602	0.4696	0.4156	0.3903	0.3800	0.3544	0.5301
Xinjiang	0.3110	0.2384	0.2743	0.2644	0.2779	0.3168	0.3299	0.3225	0.2919
Average	0.6209	0.5822	0.6199	0.6634	0.6620	0.7012	0.7539	0.7780	0.6727

(a) UEN scores of thirty provinces during eight years from 2005 to 2012 use a pooled data set (240 = 30 x 8 observations).
(b) The increasing UEN from 2005 to 2012 indicated the improving performance in terms of economy.
(c) Source: Sueyoshi & Yuan (2016).

Table 2: UEM of 30 provinces in 2005-2012

Province	2005	2006	2007	2008	2009	2010	2011	2012	Average
Beijing	0.2860	0.2814	0.3158	0.4127	0.4209	0.4369	0.4853	0.5205	0.3950
Tianjin	0.3500	0.3362	0.4245	0.5002	0.4762	0.4687	0.4923	0.4557	0.4380
Hebei	0.5039	0.5531	0.6542	0.7209	0.7420	0.7530	0.8175	0.8328	0.6972
Shanxi	0.4873	0.4855	0.5463	0.6631	0.6472	0.7991	0.9162	1.0000	0.6931
Inner Mongolia	0.5109	0.5053	0.6483	0.8569	0.8708	1.0000	1.0000	0.9794	0.7965
Liaoning	0.4488	0.4452	0.5201	0.5345	0.5846	0.6885	0.7134	0.7396	0.5843
Jilin	0.4695	0.4808	0.5025	0.5607	0.5542	0.6066	0.6342	0.6573	0.5582
Heilongjiang	0.4154	0.4646	0.4629	0.5011	0.5112	0.5767	0.6254	0.7013	0.5323
Shanghai	0.4901	0.5106	0.5205	0.5452	0.5852	0.6030	0.6181	0.6928	0.5707
Jiangsu	0.5467	0.5622	0.6149	0.6954	0.7901	0.8321	0.9388	1.0000	0.7475
Zhejiang	0.4405	0.4593	0.4971	0.5177	0.5716	0.6255	0.6669	0.7067	0.5607
Anhui	0.6490	0.5836	0.6342	0.6353	0.6849	0.7222	0.7989	0.8909	0.6999
Fujian	0.5776	0.5814	0.6686	0.6636	0.7800	0.8859	0.9377	1.0000	0.7619
Jiangxi	0.4404	0.4708	0.5063	0.5320	0.5652	0.5504	0.5765	0.5997	0.5302
Shandong	0.6960	0.8981	0.8225	0.8942	0.9282	1.0000	1.0000	1.0000	0.9049
Henan	0.5575	0.5689	0.6053	0.7217	0.7407	0.7714	0.8446	0.8820	0.7115
Hubei	0.3793	0.3934	0.3927	0.4736	0.5180	0.5714	0.6552	0.7416	0.5156
Hunan	0.3586	0.4098	0.4710	0.5365	0.6023	0.6773	0.7349	0.8110	0.5752
Guangdong	0.7110	0.8390	0.8234	0.9089	0.9582	0.9855	0.9932	1.0000	0.9024
Guangxi	0.5795	0.6108	0.6589	0.7753	0.8580	0.7340	0.7844	0.8568	0.7322
Hainan	0.9044	0.9979	1.0000	0.8868	1.0000	1.0000	0.9729	1.0000	0.9703
Chongqing	0.3066	0.3397	0.3562	0.3797	0.3988	0.4345	0.5522	0.5618	0.4162
Sichuan	0.3824	0.4187	0.4890	0.5400	0.5948	0.7692	0.8560	0.8977	0.6185
Guizhou	0.5192	0.4863	0.4821	0.5048	0.5702	0.5768	0.5948	0.7067	0.5551
Yunnan	0.4944	0.4683	0.5855	0.6855	0.7120	0.6837	0.7902	0.8225	0.6552
Shaanxi	0.3866	0.3533	0.3919	0.4583	0.5039	0.5487	0.6523	0.6998	0.4994
Gansu	0.2551	0.2339	0.3027	0.2946	0.3325	0.3541	0.4056	0.4888	0.3334
Qinghai	0.3845	0.3611	0.3559	0.3710	0.3097	0.3493	0.3908	0.4381	0.3700
Ningxia	0.3886	0.3715	0.3971	0.4346	0.4243	0.4783	0.4929	0.4352	0.4278
Xinjiang	0.3446	0.2763	0.3295	0.3186	0.3393	0.3976	0.4346	0.4946	0.3669
Average	0.4755	0.4916	0.5327	0.5841	0.6192	0.6627	0.7125	0.7538	0.6040

(a) UEM scores of thirty provinces during eight years from 2005 to 2012 use a pooled data set (240 = 30 x 8 observations).
(b) All provinces showed the increasing trend in UEM during the eight years. This indicated that the Chinese government put effort on environmental protection, but still not efficient.
(c) Source: Sueyoshi & Yuan (2016).

Table 3A: Classification of UC, DC, RTD and DTR of 30 provinces in eight years

Province	2005				2006				2007				2008			
	UC	RTD	DC	DTR	UC	RTD	DC	DTR	UC	RTD	DC	DTR	UC	RTD	DC	DTR
Beijing	W	No	W	No	W	No	W	No	W	No	W	No	No	D	W	No
Tianjin	W	No	W	No	W	No	W	No	W	No	W	No	No	D	W	No
Hebei	No	D	S	N	No	I	S	N	No	D	S	N	No	D	S	N
Shanxi	No	I	W	No	No	I	W	No	No	I	W	No	W	No	W	No
Inner Mongolia	W	No	W	No	W	I	S	N	W	No	W	No	W	No	W	No
Liaoning	No	I	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Jilin	No	D	S	N	No	I	S	N	No	I	S	N	No	I	S	N
Heilongjiang	No	I	S	N	No	I	S	N	W	No	S	N	No	D	S	N
Shanghai	W	No	W	No	W	No	W	No	W	No	W	No	W	No	W	No
Jiangsu	No	D	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Zhejiang	No	D	S	N	No	D	S	N	W	No	S	N	S	N	S	N
Anhui	No	D	S	N	No	D	S	N	No	I	S	N	No	I	S	N
Fujian	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
Jiangxi	No	D	S	N	W	No	S	N	W	No	S	N	No	D	S	N
Shandong	No	D	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Henan	No	D	S	N	No	D	S	N	W	No	S	N	W	No	S	N
Hubei	W	No	S	N	No	D	S	N	W	No	S	N	W	No	S	N
Hunan	No	D	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Guangdong	W	No	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Guangxi	W	No	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Hainan	W	No	W	No	No	I	W	No	W	No	W	No	S	N	S	N
Chongqing	W	No	S	N	W	No	W	No	W	No	S	N	W	No	S	N
Sichuan	W	No	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Guizhou	W	No	W	No	W	No	W	No	W	No	W	No	W	No	No	I
Yunnan	W	No	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Shaanxi	No	I	S	N	No	I	S	N	No	I	S	N	No	I	S	N
Gansu	No	I	W	No	No	D	W	No	No	I	S	N	W	No	S	N
Qinghai	No	I	W	No	No	I	W	No	S	N	W	No	No	I	W	No
Ningxia	W	No	W	No	S	N	W	No	W	No	W	No	W	No	W	No
Xinjiang	W	No	W	No	W	No	W	No	W	No	W	No	W	No	S	N

(a) W stands for weak, S stands for strong, N stands for negative, I stands for increasing, D stands for decreasing.

(b) Most provinces in east coast China and four municipals belonged to no or weak in UC and decreasing or no in RTD and even though Hainan had weak or no UC, but increasing RTD in year 2006, 2010 and 2012. Therefore, the Chinese government should invest and develop Hainan in terms of economy.

(c) Most of the central provinces had weak or no UC with no or decreasing RTD except Hubei.

(d) Even though some of the northeast and north provinces had some no UC with increasing RTD before 2008, all of the provinces had weak or no UC with no or decreasing RTD.

(e) Even if the UC of all western provinces such as Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang is weak or no, all of them had no UC with increasing RTD. The Chinese government should reinforce the development of western China.

(f) Most provinces all over the China including east coast China, central China, northeast and north China have strong potential to reduce the pollutions with green technology innovation because they have strong DC with negative DTR The Chinese government should invest green technology to provinces in east coast, central China, northeast and north China, as well as Xinjiang in western China.

(g) There are two types of provinces having weak DC with no DTR, which indicates the low level of potential for pollution mitigation. One type is big municipals such as Beijing, Tianjin and Shanghai. The other type is western China.

(h) Source: Sueyoshi & Yuan (2016)

Table 3B: Classification of UC, DC, RTD and DTR of 30 provinces in eight years

Province	2009				2010				2011				2012			
	UC	RTD	DC	DTR	UC	RTD	DC	DTR	UC	RTD	DC	DTR	UC	RTD	DC	DTR
Beijing	No	D	W	No	W	No	W	No	No	D	W	No	W	No	W	No
Tianjin	No	D	W	No	W	No	W	No	W	No	W	No	No	D	W	No
Hebei	No	D	S	N	No	D	S	N	W	No	S	N	W	No	S	N
Shanxi	W	No	W	No	W	No	S	N	W	No	S	N	W	No	S	N
Inner Mongolia	W	No	W	No	W	No	S	N	W	No	S	N	W	No	S	N
Liaoning	No	D	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Jilin	No	I	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Heilongjiang	No	D	S	N	No	D	S	N	No	D	S	N	No	D	W	No
Shanghai	S	N	W	No	S	N	W	No	No	D	W	No	No	D	W	No
Jiangsu	S	N	S	N	W	No	S	N	No	D	S	N	No	D	No	D
Zhejiang	S	N	S	N	S	N	S	N	S	N	S	N	W	No	S	N
Anhui	No	I	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Fujian	S	N	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Jiangxi	W	No	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Shandong	No	D	S	N	No	D	S	N	No	D	S	N	W	No	S	N
Henan	W	No	S	N	W	No	S	N	W	No	S	N	W	No	S	N
Hubei	No	D	S	N	W	No	S	N	S	N	S	N	S	N	S	N
Hunan	W	No	S	N	W	No	S	N	W	No	S	N	No	D	S	N
Guangdong	W	No	W	No	S	N	S	N	W	No	S	N	No	D	S	N
Guangxi	No	D	S	N	No	D	S	N	No	D	S	N	No	D	S	N
Hainan	W	No	W	No	No	I	S	N	No	D	W	No	No	I	S	N
Chongqing	W	No	S	N	W	No	S	N	No	D	S	N	W	No	S	N
Sichuan	No	D	S	N	No	D	W	No	No	D	S	N	No	D	S	N
Guizhou	W	No	W	No	W	No	W	No	W	No	W	No	No	I	W	No
Yunnan	W	No	S	N	W	No	S	N	W	No	S	N	No	D	S	N
Shaanxi	No	I	S	N	No	I	S	N	No	I	S	N	No	I	S	N
Gansu	No	I	S	N	No	I	S	N	No	I	S	N	No	I	W	No
Qinghai	No	I	W	No	No	I	W	No	No	I	W	No	No	I	W	No
Ningxia	W	No	W	No	No	I	W	No	No	I	W	No	W	No	W	No
Xinjiang	W	No	S	N	W	No	S	N	W	No	S	N	No	I	S	N

(a) W stands for weak, S stands for strong, N stands for negative, I stands for increasing, D stands for decreasing.
(b) See the notes (b)–(g) in Table 3A.
(c) Source: Sueyoshi & Yuan (2016).

Discussion

This study obtains a data set from National Bureau of Statistics of the People's Republic of China (http://www.stats.gov.cn/tjsj/). Using the data set, this study examines thirty provinces of China including four well-developed municipalities directly under the central government, which are Beijing, Shanghai, Tianjin and Chongqing, but excluding Tibet, Hong Kong and Macau because of our limited data accessibility on the three regions during 2005–2012. This study utilizes four desirable outputs: Gross Regional Product (GRP), value-added of the primary industry, the secondary industry and the tertiary industry, three undesirable outputs: PM10, SO_2 and NO_2, five inputs: investment in energy industry, coal consumption, oil consumption, natural gas consumption and electricity consumption.

Table 1 summarizes the UEN(UC) scores of the thirty provinces. The increasing trend of UEN(UC) from 2005 to 2012 indicated an improving trend in terms of their regional economies. Besides Beijing, most of the provinces with a high level of UEN(UC), were found in the east coast of China. They were Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi, Hainan, Jiangxi and Hunan. In Chinese history, the east coast was first developed due to convenient connection with other countries. Then, the central China, including Anhui, Henan and Hubei provinces exhibited UEN(UC) at the level of about 0.7. In a descending order, the northeast and northern China, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin and Heilongjiang had UEN were rated from 0.4027 to 0.6749, being about 0.5 on average. The worst part of China in terms of economic performance was western China including Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. The average UEN(UC) of these provinces was only about 0.35. In particular, the UEN(UC) of Xinjiang exhibited 0.2919 in the magnitude.

Table 2 summarizes the degree of UEM(DC) on thirty provinces during eight years. All provinces showed an increasing trend in UEM(DC) during the eight years. This indicated that the Chinese government put effort on environmental protection, but being still not efficient. Specifically, most of the east coast provinces with good economic performance still performed best in their environment protection such as Shandong, Jiangsu, Fujian, Guangdong, Guangxi and Hainan. As mentioned previously, large provinces such as Beijing, Shanghai and Zhejiang performed poorly on environment protection but with good performance on economy. The UEM(DC) of northeast and north provinces was about 0.6 on average. The UEM(DC) of western China was about 0.4 on average.

Table 3A and 3B summarizes UC, RTD, DC and DTR on the thirty provinces. In 2005 and 2012, many Chinese provinces were rated as weak or no in UC and no or decreasing RTD. See Beijing. The result indicated an economic growth limit on those provinces. Exceptions could be found in Liaoning, Shaanxi, Gansu and Qinghai, which exhibited no UC and increasing RTD. They had an economic growth potential. In contrast, most of Chinese provinces were rated as strong in DC and negative in DTR, so indicating that they had a potential to reduce the level of air pollution by eco-technology development. Exceptions found could be municipalities such as Beijing, Tianjin and Shanghai, for example. They were rated weak UN and no DTR, so implying that they did not have a potential to improve the level of air pollution by eco-technology at that time.

The Chinese government has long paid attention to the rapid economic development, but not making a major policy effort to reduce its air pollution. As a result, the current level of environment was not good enough to attain the status of social sustainability. Moreover, regional imbalance still exists in China. The east coast provinces developed the best with the highest level of UEN(UC) and UEM(DC), followed by the central, northeast and north regions, which was close to Beijing. The worst performance on both economy and environment protection was still western provinces after the western developing programs. Most of resources in China were mainly allocated to large cities, especially the Chinese capital Beijing. The northeast and north regions have performed insufficiently even though they are so close to Beijing. Because of the rapid development on economy in large cities such as Beijing and Shanghai, even if the Chinese government tried to improve their environment protection, the pace could not catch up with their pollutions creations in air.

From the perspective of the international concern on climate change, it is necessary for us to raise another serious policy issue on China. As first discussed by Sueyoshi and Yuan (2015), the Chinese government has structurally a limited governance capability to reduce the amount of CO_2 emission. Sueyoshi and Yuan (2016) discussed that the government should allocate resources to small provinces so that China can reduce the industrial and regional imbalances. Also, large provinces need strict regulation on traffic control and a fuel mix shift from coal combustion to natural gas and renewable energies. This study focused more on energy planning and the role of government.

We know that the central government has previously proposed many environmental plans, but local governments have not maintained enough governance capabilities to monitor and control the amount of GHG emission in provinces. The reason is that energy firms are usually under public ownership, being able to call "China Inc." It is easily envisioned that local governments do not have the monitoring power to reduce the level of GHG emissions that have been produced by public companies in energy sectors and other industrial sectors. Therefore, the Chinese government should consider the privatization. The government should transfer the public ownership to private ownership and only conduct the monitoring function. The government can do a better job in regulation if there is no interest conflict. In other words, if any private energy firm violates the law or regulation, the government can punish the firm seriously without harming the government's benefit or revenue. Once the firms realize that they may lose huge profit in risk even face bankruptcy, no firm will take the risk to violate the law or regulation in energy planning. Also historical result of privatization tells us that privatization consistently improves efficiency in competitive industries. The more competitive the industry is, the greater improvement in profitability and output. The increased economic growth can further benefit the income imbalance of China.

Conclusion

This study discussed the concept of UC under natural disposability and DC under managerial disposability from their economic and methodological implications on social sustainability development. Considering the two groups of disposability concepts, this study compared between RTD under UC and DTR under DC. These new scale measures (i.e., RTD and DTR) can be considered as extended concepts of Returns to Scale (RTS) and Damages to Scale (DTS).

This study applied the methodology to Chinese economic and environmental assessment for its future economic and energy planning for social sustainability development. This study identified three important concerns: First, the Chinese government had historically paid attention to the economic prosperity, but not paying serious attention on air pollution prevention. Second, there was an increasing trend in improving the two components (i.e., economic and environmental performance) for social sustainability. Third, the economic and energy policy concerns had been focused upon well-developed municipalities (e.g., Beijing and Shanghai), not small provinces, in China. Therefore, the privatization is necessary for central government of China (i.e., from public to private energy firms). It can not only improve the energy management and monitoring by government, but also increase the economic efficiency in market so that GDP can be increased. In further, the increased economic growth can better the economic imbalance of China.

In conclusion, it is important to note that this study is based upon the work of Sueyoshi & Yuan (2016). It is hoped that this study makes a contribution in DEA environmental assessment. We look forward to seeing future extensions as discussed in this study.

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Urban Logistics Planning of Kho Chang Port Island Trad Province, Thailand

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With the potentiality of Thailand in being ASEAN's logistics center, the past and present governments have given emphasis on this matter. Many strategies and projects have been continuously initiated to promote Thailand to be the logistics and transport hub of the region, be it land, sea, or air. One of the projects that is fully supported and given large budget allocation is the Phase 1 of the Special Economic Zone in five bordering provinces (Tak, Mukdahan, Srakaew, Trad, and Songkhla). Presently, the Trad Special Economic Zone Project is one of the projects with much progress.

As for sea transportation, Laem Chabang Port is aimed to be the major port of the country as it facilitates good access for sea-land transportation and thus it enjoys a success as being international deep-sea port. However, an obstacle occurs in facilitation of transshipments between ocean liners and feeders as the Port is not a destination of major goods in ASEAN, neither does it locate in the world's liner routes. As ocean liners will only land at the Port when there are shipments sent to Thailand, Laem Chabang Port thus has small number of ocean liners. Instead of the Port, large number of transshipment activities, both for bulk cargos and container ships, take place in the Gulf of Thailand 24 hours a day near islands and along the coast in Sriracha, Chonburi, Rayong, as well as around Koh Samed Island and Koh Sichang Island. Not only cause pollution to the sea, these activities are also against the sea transportation network principles within the Gulf of Thailand.

Aware of this problem and the importance of the Special Economic Zone development, especially in the sea border area, the Logistics and Supply Chain Management Program, Chulalongkorn University thus initiated the research "Urban Logistics Planning: Koh Chang Port Island, Trad Province, THAILAND", and organized the Academic Workshops by cooperating with naval officers and architectural, engineering, logistics, and marine transportation students. A Prototype Master Plan was made in order to test and study for an effective marine logistics development and support with less impact on the natural environment and the communities. On the transshipment port study and comparison, to have examples from both the eastern and western world, the Singapore Port and Hawaii Port in the United States have been used as case studies. This Research is part of Chulalongkorn University's "Waterfront Development Project (WFD. In order to achieve a perfect and sustainable development of Thailand, the study area covers significant activities on ports, transshipments, sea tourism, and sea border security.

1. Introduction

This issue is aimed at understanding key issues of configuration of urban structure of Kho Chang Port Island in case of its evolution and effectiveness of urban realm base on recent theories and debates. The investigation, limited by time, focuses on Singapore Port and Hawaii Port where some of them were chosen for case studies.

Research question

"What is a sustainable planning and design of the Kho Chang Port Island master plan suitable for urban community and Navy security perception?"

Aim and Objectives

1. To study projects owned by the Government, the Royal Thai Navy, and the surrounding communities; and set up a development framework of Koh Chang Port Island project, Trad Province, THAILAND in order to mitigate the impact on the urban areas.

2. To study the regional network and city plan in the related areas in line with the Special Economic Zone (SEZ) development plan of Thai Government.

Merit of the Proposed Research

1. For creating an innovation of urban logistics planning in academic perception. It will be useful for both learning of Urban Logistics Planning and Environmental Management in terms of port city.

2. For creating urban structure prototype of navy and port city which might be useful for professional perception in Urban Logistics Planning and for consideration of port and urban control in city in future.

Value of the research and its significance

1. The research methodology employed illustrates the trend of the various research processes and investigation of the urban logistics planning of port city approach. There may be examples involving other research or urban logistics studies which may be conveniently adapted and applied to further demonstration and highlight individual areas of interest in connection with the urbanization process.

2. The facts/information obtained and the methodology employed in the research process can bring together the ideas or concepts involving other port city settlements. These processes can then be adapted to use in the port city management including the possible expansion of existing settlements. Such knowledge and information processes can serve a useful and valid purpose in helping to develop the principles of port city.

3. The determination of a perceptive substance is useful in terms of appropriate or assessing the possibilities of the existence of port city in Thailand for developing and redesign the specific principles for use in actual generic cases.

2. Research Methodology

Urban Planning and Design Analysis

1. Site analysis

2. Analysis of sea traffic and transport in the Gulf of Thailand (Internet search)
    1. Cargo ship routes
    2. Tourist ship routes
    3. Fishing boat routes

3. Location Planning, Zoning, and Master Plan
    1. Navy Port
    2. Commercial Port
    3. Port Hinterland

Master Planning

Master plan is a future principle plan or a pilot policy containing sub-plans that are in conformity. For master plan preparation, first of all goals must be set up and then the budget, organization, and function will be incorporated in the plan. To obtain such information, related people or operators can be further interviewed.

1. GIS Analysis Koh Chang Port Island

Figure 1: Koh Chang Port Island: Master Plan Analysis

2. Zoning

The main objective of Koh Chang Port Island is aimed at tourism, sea freight transportation, and sea bordering security. The development of bordering port towns concerns with both short- and long-distance sea freight transport, as well as international freight transport of some types of goods. The development area is divided into 4 zones as following:

1. Navy and Multi Propose Zone
2. Logistics and Supply Chain Zone
3. Sea Freight Factory Zone
4. Commercial, Business, Tourist Zone

Professional meeting and discussion to decide and planning for the necessary components need for Koh Chang Port Island by reduce any unclear and useless function for the operation in the study model.

3. Testing and Evaluating of Master Plan

3.1 Potential Surface Analysis (PSA) (Harvard university, 1969)

PSA is a technique for location assessment and analysis of the Seaport using the overlay mapping principle. This technique needs the Spatial Data and Attribute Data obtained from the Geographic Information System (GIS). PSA technique is divide area into grid table for put score in the area, this will analyses the potential of existing land use with indicators.

3.2 Space Syntax (University College of London; Hiller and Hanson, 1984)

Space Syntax is a theory on the components of space. Using the Space Syntax together with the Geographic Information System, models of the connectivity and urban morphological analysis can be made. The Space Syntax analysis helps in understanding the relations, and cause and effect of the city planning and utilization. The integration measurement of each component to the total system is calculated from the depth distance of each line against the total network. The density of the city is shown in various colors, the hot tone like red represents the area where there are highest natural movement and traffic with high integration value and easily accessible. On the contrary, the blue color represents the less traffic area with low integration value and difficult to access. In this analysis, the red area is the area where there are lots of activities, or a commercial area. The blue area is the area where there are less activities, peaceful and suitable for living.

3.3 Public Participation Workshop

Public Participation Workshop for commenting that Koh Chang Port Island to community and environments. (Environment effected and Navy Port effected) The conclusion will show how to establish and plan Sustainable Koh Chang Port Island and its operation affect to area surrounding and the region by the point of view of the public participation.

Environmental Engineering Issues

Environmental Engineering Issues	**Urban Areas Affected**
1. Port Waste Management 2. Dredging 3. Dredging Disposal 4. Dust 5. Noise 6. Air Quality 7. Bunkering 8. Hazardous cargo 9. Port Development (land related) 10. Ship discharge (bilge)	P1: Port and connecting areas P2: Communities and Villages P3: Natural Tourism P4: Conservation places P5: Coastal beach and fishing areas

Table 1: The Top-10 European Environmental Engineering Issues

The Top-10 European Environmental Engineering Issues, periodically ESPO and EPF undertake a survey of European Environmental Engineering to evaluate the progress made in environmental management, and to identify the Top Ten sustainable management issues. (ESPO Survey 2004) The academic workshop was established in 2015

Navy Port Operation Issues

Navy Port Operation Issues	**Urban Areas Affected**
1. Aim and Objective of Navy Port 2. Navy Port Zoning 3. Navy Port Combat Equipment and Capacity 4. Quality of Navy Supporting Office 5. National Security Issues 6. Effect of Navy Port to Urban Structure 7.Targeted Attacks Location 8. Business Related Issues 9. Industrial Related Issues	P1: Port and connecting areas P2: Communities and Villages P3: Natural Tourism P4: Conservation places P5: Coastal beach and fishing areas

Table 2: The Navy Port Operation Issues

4. Analysis of Koh Chang Port Island:

In term of Potential Surface Analysis; Land use of Koh Chang Port Island will be in good condition while transportation network are excellence condition. Infrastructure, Accessibility of Cargo and Commercial zones are in very good condition; moreover it showed that Koh Chang Port Island had high potential of those cases in term of overall city network. In term of Low-income access and Land ownership, Koh Chang Port Island keep fairly condition, while Open space and Green Area system of the city are in excellence condition.

In term of Space Syntax Software Analysis: connectivity and Global Integration of Koh Chang Port Island keep quality of planning and design in world class development level with high standard of planning.

Analyzing of the design and planning of Koh Chang Port Island, Trad Province, Thailand will assist Thailand to be the center of marine logistics in the near future.

1. POTIENTAIL SURFACE ANALYSIS		2. SPACE SYNTAX CONCEPT	
1. Land Use	4	1. Connectivity	4
2. Transportation Network	5	2. Global Integration	4
3. Infrastructure	3	Full Score 10 marks	8
4. Cargo Zone Accessibility	3		
5. Commercial Zone Accessibility	4		
6. Low-Income Zone Accessibility	3		
7. Open space System	4		
8. Green Area System	4		
Full Score 40 marks	26		

Table 3: Koh Chang Port Island Analysis 2016

Conclusion from the interview of academics and general people, via video conference and voice recording, in regard to the upgrading of the Koh Chang Port Island to be the Navy and Deep sea Port, most interviewees have positive responses on the development. In their opinions, the Koh Chang Port Island will facilitate transportation of both the sea freight and tourists. The people, business owners, and investors will enjoy increasing benefits. Due to the fact that the region is already the tourist areas with lots of tourism activities, the Koh Chang Port Island will therefore help accelerate the economy and tourism in the region. The growth and prosperity will increase job opportunities for locals and attract labors from outside. However, some local wisdom and culture may unavoidably be affected. The freight and tourist travelling will be a lot easier though a negative impact may also occur.

5. Conclusion

From the urban logistics Plan above, the corporation among Government and Private Sector are needed to determine Urban Logistics Strategy as Main National Plan in the near future. Koh Chang Port Island Plan is as a handbook to introduce Logistics Framework, moreover, the successful and efficiency implementation is in regarding on corporation field practice of the organizations concerned. Logistics planning, intelligent technology IT, scenarios simulation and computerization software will assistant them to complete Koh Chang Port Island operation with high potential and sustainable.

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DEA Environmental Assessment on Industrial Sectors in the United States

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Abstract
To evaluate corporate sustainability, we should address not only operational performance but also environmental performance because people care more about environment protection than before. They prefer to purchase green products in nowadays. This study proposes "DEA environmental assessment" for measuring how to invest for eco-technology innovation to prevent industrial pollutions as a major research concern. The proposed approach incorporates the analytical capability on an occurrence of zero and negative values in a data set. We pay attention to both successful companies with positive net incomes and unsuccessful companies with negative net incomes in a short-term horizon. This study finds that US energy sectors may be not attractive in terms of a short-term horizon because of stricter governmental regulation on their operations and environment mitigations than other industrial sectors. Therefore, the energy sectors need a long-term horizon to attain a high level of corporate sustainability by investing eco-technology innovation for pollution mitigation.

Keywords: Energy, green technology innovation, corporate sustainability

Introduction

Climate change and global warming has been a major concern for all countries. In long-run consideration, environmental protection plays a more important role for sustainable development for all countries. Therefore, all corporates should pay attention to environment pollutions in their production lines. This study evaluates the operational and environmental performance of different industrial sectors in the United States. The evaluation results could be different in short-run and long-run consideration.

The US government conducts various regulation changes for prevent industrial pollutions. Also public people care more about the living conditions. Then, all companies should adjust their business strategies for sustainable development. Obviously, environmental protection requires a large investment and the companies cannot gain any direct benefit from the investment in short-run. However, the environmental investment will improve efficiency and competitiveness through innovation for companies. For example, TESLA is very popular in car industry due to “green” design without producing any emissions even though the price is high. This indicates that modern corporations in all industrial sectors have to consider the environmental protection to enhance the performance for sustainable development in short-run and long-run.

DEA environment assessment has been applied to many issues for social sustainability. The difficulty to analyze the corporate sustainability is the negative or zero values. Previous works only considered the successful companies, but the result cannot reflect the reality of the industrial sectors. This study applies the DEA approach, which can measure the data with positive, zero and negative values.

Applying the methodology to US industrial sector data, we find the fact that the technology innovation investment in the low-tech industries including energy sector can improve their unified performance as a short-run concern, but cannot improve the unified performance for high-tech industries. Also the energy firms may be not attractive in terms of net income in short-run because of strict governmental regulation and need to attain a high level of corporate value by investing technology innovation for pollution mitigation in long-run.

Literature review

A holistic methodology, or Data Envelopment Analysis (DEA) was used to evaluate the performance of companies for their corporate sustainability in many previous studies. For example, Sueyoshi and Wang, 2014a, Sueyoshi and Wang 2014b, Sueyoshi and Yuan, 2015a.

As mentioned above, the difficulty of analyzing corporate sustainability is handling the negative or zero values in data sets. Therefore, Wang et al. (2014) analyzed the corporate sustainability in U.S. industrial sectors only for successful companies with positive net incomes.

Technology innovation can solve various environmental problems so that we can obtain the corporate sustainability. See Sueyoshi and Yuan, 2016a, 2016b.

This study applies the advanced DEA methodology (see Sueyoshi and Yuan, 2015b) to handle negative or zero values in US industrial sectors for corporation sustainability.

Methodology and methods

This study considers that there are n DMUs (Decision Making Units: corresponding to an organization to be evaluated). The *j*-th DMU ($j = 1, .., n$) uses a column vector of inputs (X_j) in order to yield not only a column vector of desirable outputs (G_j) but also a column vector of undesirable outputs (B_j), where $X_j = (x_{1j}, x_{2j}, .., x_{mj})^T$, $G_j = (g_{1j}, g_{2j}, .., g_{sj})^T$ and $B_j = (b_{1j}, b_{2j}, .., b_{hj})^T$. Here, the superscript "*T*" indicates a vector transpose. These column vectors are referred to as "production factors" in this study. It is assumed that $X_j > 0$, $G_j > 0$ and $B_j > 0$ for all $j = 1, .. , n$, where all components of the three vectors are strictly positive.

The data ranges for adjustment are determined by the upper and lower bounds on inputs and those of desirable and undesirable outputs. These upper and lower bounds are specified by

$$R_i^x = (m+s+h)^{-1}\left(max\left\{x_{ij}\ \middle|\ j = 1,\cdots,n\right\} - min\left\{x_{ij}\ \middle|\ j = 1,\cdots,n\right\}\right)^{-1}$$

$$R_r^g = (m+s+h)^{-1}\left(max\left\{g_{rj}\ \middle|\ j = 1,\cdots,n\right\} - min\left\{g_{rj}\ \middle|\ j = 1,\cdots,n\right\}\right)^{-1} \text{ and}$$

$$R_f^b = (m+s+h)^{-1}\left(max\left\{b_{fj}\ \middle|\ j = 1,\cdots,n\right\} - min\left\{b_{fj}\ \middle|\ j = 1,\cdots,n\right\}\right)^{-1}.$$

<u>Unified Efficiency under natural and managerial disposability (UENM)</u>
UENM is used as methodology considering both operational performance and environmental performance.

UENM under variable RTS and DTS (UENM$_v$): the radial formulation under natural and managerial disposability leads to model (1) as below:

$$
\begin{aligned}
& Maximize\ \xi + \varepsilon_s [\sum_{i=1}^{m^-} R_i^x d_i^{x-} + \sum_{q=1}^{m^+} R_q^x d_q^{x+} + \sum_{r=1}^{s} R_r^g (d_r^{g+} + d_r^{g-}) + \sum_{f=1}^{h} R_f^b d_f^b \\
& s.t. \quad \sum_{j=1}^{n} x_{ij}^- \lambda_j + d_i^{x-} = x_{ik}^- \quad (i = 1, .., m^-), \\
& \sum_{j=1}^{n} x_{qj}^+ \lambda_j - d_q^{x+} = x_{qk}^+ \quad (q = 1, .., m^+), \\
& \sum_{j=1}^{n} g_{rj}^+ \lambda_j - d_r^{g+} - \xi g_{rk}^+ = g_{rk}^+ \quad (r = 1, .., s), \\
& \sum_{j=1}^{n} g_{rj}^- \lambda_j + d_r^{g-} = g_{rk}^- \quad (r = 1, .., s), \qquad (1) \\
& \sum_{j=1}^{n} b_{fj} \lambda_j + d_f^b + \xi b_{fk} = b_{fk} \quad (f = 1, .., h), \\
& \sum_{j=1}^{n} \lambda_j = 1 \\
& \lambda_j \ge 0 \ (j = 1, .., n),\ \xi : URS,\ d_i^{x-} \ge 0\ (i = 1,..,m^-),\ d_q^{x+} \ge 0\ (q = 1,..,m^+), \\
& d_r^{g+} \ge 0 \ (r = 1,..,s), d_r^{g+} \ge 0 \ (r = 1,..,s)\ \&\ d_f^b \ge 0\ (f = 1,..,h).
\end{aligned}
$$

The level of unified efficiency of the k-th DMU under managerial disposability as follows:

$$
UENM_v = 1 - \left\{ \xi^* + \varepsilon_s \left[\sum_{i=1}^{m^-} R_i^x d_i^{x-*} + \sum_{q=1}^{m^+} R_q^x d_q^{x+*} + \sum_{r=1}^{s} R_r^g (d_r^{g+*} + d_r^{g-*}) + \sum_{f=1}^{h} R_f^b d_f^{b*} \right] \right\}, \qquad (2)
$$

where the inefficiency measure and all slack variables are identified on the optimality of Model (1). The equation within the parenthesis, obtained from Model (1), indicates the level of unified inefficiency. The UENM is obtained by subtracting the level of inefficiency from unity.

UENM under constant RTS and DTS ($UENM_c$): To attain the status of constant RTS and DTS, this study drops the condition ($\sum_{j=1}^{n} \lambda_j = 1$) from Model (1) and measures the level of unified efficiency by

$$UENM_c^* = Equation\ (2),$$

(3)

where the optimal solution is obtained from Model (1) without $\sum_{j=1}^{n} \lambda_j = 1$.

Scale Efficiency Measure under Natural and Managerial Disposability ($SENM$): To examine how each DMU carefully manages its operational size under natural and managerial disposability, this study measures the degree of its scale efficiency by

$$SENM^* = UENM_c^* / UENM_v^*. \qquad (4)$$

Since $UENM_c^* \leq UENM_v^*$, the scale efficiency is less than or equals unity. The higher score in $SENM^*$ indicates the better scale management under managerial disposability.

UENM with Desirable Congestion: UENM (DC)

In order to incorporate an occurrence of DC, or technology innovation for pollution mitigation, this study reformulates Model (1) so that it can measure the unified efficiency with a possible occurrence of DC. The reformulated model becomes as follows;

$$\begin{aligned}
&Maximize\ \xi + \varepsilon_s[\sum_{i=1}^{m^-} R_i^x d_i^{x-} + \sum_{q=1}^{m^+} R_q^x d_q^{x+} + \sum_{f=1}^{h} R_f^b d_f^b] \\
&s.t.\quad \sum_{j=1}^{n} x_{ij}^- \lambda_j + d_i^{x-} = x_{ik}^- \ (i = 1, .., m^-), \\
&\sum_{j=1}^{n} x_{qj}^+ \lambda_j - d_q^{x+} = x_{qk}^+ \ (q = 1, .., m^+), \\
&\sum_{j=1}^{n} g_{rj}^+ \lambda_j + \xi g_{rk}^+ = g_{rk}^+ \ (r = 1, .., s), \\
&\sum_{j=1}^{n} g_{rj}^- \lambda_j = g_{rk}^- \ (r = 1, .., s), \qquad (5) \\
&\sum_{j=1}^{n} b_{fj} \lambda_j - d_f^b = b_{fk} \ (f = 1, .., h), \\
&\sum_{j=1}^{n} \lambda_j = 1, \\
&\lambda_j \geq 0 \ (j = 1, .., n),\ \xi: URS, \\
&d_i^{x-} \geq 0 \ (i = 1,..,m^-),\ d_r^{x+} \geq 0 \ (r = 1,..,m^+), \&\ d_f^b \geq 0 \ (f = 1,..,h),
\end{aligned}$$

The level of unified inefficiency of the k-th DMU under natural and managerial disposability as follows:

$$UENM(DC)_v = 1 - \left\{ \xi^* + \varepsilon_s \left[\sum_{i=1}^{m^-} R_i^x d_i^{x-*} + \sum_{q=1}^{m+} R_q^x d_q^{x+*} + \sum_{f=1}^{h} R_f^b d_f^{b*} \right] \right\}, \qquad (6)$$

where the inefficiency score and all slack variables are identified on the optimality of Model (5). The equation within the parenthesis, obtained from Model (5), indicates the level of unified inefficiency with a possible occurrence of DC. The level of UENM(DC) is obtained by subtracting the level of inefficiency from unity.

The dual formulation becomes as follows:

$$\begin{aligned}
&\text{Minimize} \sum_{i=1}^{m^-} v_i x_{ik}^- - \sum_{q=1}^{m^+} z_q x_{qk}^+ + \sum_{r=1}^{s} u_r^+ g_{rk}^+ + \sum_{r=1}^{s} u_r^- g_{rk}^- - \sum_{f=1}^{h} w_f b_{fk} + \sigma \\
&\text{s.t.} \quad \sum_{i=1}^{m^-} v_i x_{ij}^- - \sum_{q=1}^{m^+} z_q x_{qj}^+ + \sum_{r=1}^{s} u_r^+ g_{rj}^+ + \sum_{r=1}^{s} u_r^- g_{rj}^- - \sum_{f=1}^{h} w_f b_{fj} + \sigma \ge 0 \quad (j = 1, .., n), \\
&\qquad \sum_{r=1}^{s} u_r^+ g_{rk}^+ = 1, \qquad (7) \\
&\qquad v_i \ge \varepsilon_s R_i^x \quad (i = 1, .., m^-), \\
&\qquad z_q \ge \varepsilon_s R_q^x \quad (q = 1, .., m^+), \\
&\qquad u_r^+ \ \& \ u_r^- : URS \quad (r = 1, .., s), \\
&\qquad w_f \ge \varepsilon_s R_f^b \quad (f = 1, .., h) \ \& \\
&\qquad \sigma : URS.
\end{aligned}$$

UENM under constant RTS and DTS ($UENM(DC)_c$): To attain the status of constant RTS and DTS, this study drops the condition ($\sum_{j=1}^{n} \lambda_j = 1$) from Model (5) and measures the level of unified efficiency by

$$UENM(DC)_c^* = \text{Equation (6)}, \qquad (8)$$

where the optimal solution is obtained from Model (5) without $\sum_{j=1}^{n} \lambda_j = 1$.

Scale Efficiency Measure ($SENM$): To examine how each DMU carefully manages its operational size under natural and managerial disposability, this study measures the degree of its scale efficiency by

$$SENM(DC)^* = UENM(DC)_c^* / UENM(DC)_v^*. \qquad (9)$$

Since $UENM(DC)_c^* \le UENM(DC)_v^*$, the scale efficiency is less than or equals unity. The higher score in $SENM(DC)^*$ indicates the better scale management under natural and managerial disposability. The scale efficiency considers a possible occurrence of DC, or technology innovation on industrial pollution.

Investment Rule

After solving Model (7), this study can identify an occurrence of DC, or technology innovation for pollution mitigation, by the following rule along with the assumption on a unique optimal solution (Sueyoshi and Goto, 2014):

(a) if $u_r^{+*} = 0$ for some (at least one) r, then "zero DTR" occurs on the k-th DMU,
(b) if $u_r^{+*} < 0$ for some (at least one) r, then "negative DTR" occurs on the k-th DMU and
(c) if $u_r^{+*} > 0$ for all r, then "positive DTR" occurs on the k-th DMU.

Note that if $u_r^{+*} < 0$ for some r and $u_{r'}^{+*} = 0$ for the other r', then this study considers that the negative DTR (Damages to Scale) occurs on the k-th DMU, indicating a status of DC, or technology innovation for pollution mitigation.

It is indeed true that $u_r^{+*} < 0$ for all r is the best case because an increase in any desirable output always decreases an amount of undesirable outputs. Meanwhile, if $u_r^{+*} < 0$ is identified for some r, then it indicates that there is a chance to reduce an amount of undesirable output(s). Therefore, this study also considers the second case as an investment opportunity because we want to reduce an amount of industrial pollution as much as possible.

Under an occurrence of negative DTR (i.e., $u_r^{+*} < 0$ for at least one r), the effect of investment on undesirable outputs is determined by the following rule:

(a) if $z_q^* > \varepsilon_s R_q^x$ for q in Model (7), then the q-th input for investment under managerial disposability can effectively decrease an amount of undesirable outputs and
(b) if $z_q^* = \varepsilon_s R_q^x$ for q in Model (7), then the q-th input for investment has a limited effect on decreasing an amount of undesirable outputs.

The investment on inputs under managerial disposability is not recommended in the other two cases (i.e., positive and zero DTR) as depicted in the right hand side of Figure 1. Furthermore, this study uses "a limited effect" in the second case. The term implies that if this study drops the data range on the q-th input in Model (7), then there is a high likelihood that z_q^* may become zero. Moreover, $z_q^* > \varepsilon_s R_q^x$ are required for some q, but not necessary for all q.

Finally, it is important to note that the proposed investment classification needs at least two desirable outputs because Model (7) has $ug_k = 1$ in the case of a single desirable output. Even if u is unrestricted, Model (7) cannot produce a negative value on the dual variable, so being unable to identify an investment opportunity. Thus, the investment rule discussed in this study needs multiple desirable outputs.

Results

This study obtains a data set on S&P companies in 2012 and 2013 from the proceeding study of Sueyoshi and Wang (2014) for Carbon Disclosure Project (CDP) and COMPUSTAT. It includes the companies' direct and indirect GHG emission, the investment in carbon mitigation and the corresponding total estimated GHG saving. The data set consists of two desirable outputs: net income and estimated annual CO_2 saving, two undesirable outputs: direct and indirect CO_2 emissions, three inputs under natural disposability: number of employees, working capital and total assets and two inputs under managerial disposability: investment in CO_2 abatement and R&D expense.

Table 1: Unified efficiency measures of industry sectors

Sector	Company type	UENMv	UENMc	SENM	DMUs
Consumer discretionary	Automobiles & Components	0.7463	0.5042	0.7483	6
	Consumer Durables & Apparel	0.5645	0.3034	0.4502	5
	Retailing	0.5532	0.0107	0.0439	2
	Overall	0.6466	0.3510	0.5253	13
Consumer staples	Food, Beverage & Tobacco	0.3259	0.2467	0.6358	9
	Household & Personal Products	0.6096	0.0929	0.2483	4
	Overall	0.4132	0.1994	0.5166	13
Energy	Energy equipment & services	0.5772	0.4855	0.7915	4
	Oil & gas	0.6501	0.4904	0.7895	10
	Overall	0.6293	0.4890	0.7900	14
Health care	Health Care Equipment &	1.0000	0.9161	0.9161	2
	Biotechnology & Life Sciences	0.4176	0.3542	0.8545	11
	Pharmaceuticals	0.6674	0.5553	0.8250	14
	Overall	0.5903	0.5001	0.8438	27
Industrials	Capital Goods	0.7970	0.7757	0.9751	18
	Commercial & Professional	0.1401	0.1360	0.9847	2
	Overall	0.7313	0.7117	0.9761	20
Information technology	Semiconductors & Equipment	0.7127	0.7088	0.9920	20
	Software & Services	0.7703	0.7659	0.9897	19
	Technology Hardware &	0.7481	0.7414	0.9889	12
	Overall	0.7425	0.7378	0.9904	51
Materials	Chemicals	0.9530	0.9525	0.9995	13
	Containers & Packaging	0.9046	0.8961	0.9886	4
	Metals & Mining	0.9133	0.9133	1.0000	2
	Paper & Forest Products	0.9714	0.9714	1.0000	4
	Overall	0.9443	0.9426	0.9977	23

Source: Sueyoshi & Yuan (2015b).

Table 1 summarizes the same unified efficiency scores of the seven industrial sectors, all of which are measured by Model (1). Combining their unified (operational and environmental) performance, for example, the consumer staples industry is inefficient at the level of UENMv (0.4132) on average. The efficiency levels of energy industry are UENMv (0.6293) and UENMc (0.4890). The highest efficiency measures, or UENMv (0.9443) and UENMc (0.9426), can be found in the materials industry. The materials, information technology and industrials sectors consist of the high-ranked group. The health care and energy sectors belong to the middle-ranked group. The consumer directory and consumer staples sectors belong to the low-ranked group. The ranking position of the industrial sectors is consistent with their scale efficiency measures. For example, the materials, information technology and industrials sectors have high SENM measures (0.9977, 0.9904 and 0.9761), respectively.

Table 2 summarizes the unified efficiency scores of UENM(DC)v, UENM(DC)c, SENM(DC) of the seven industrial sectors, all of which are measured by Model (5). The most important feature of the three UENM measures is that they incorporate a possible occurrence of DC, or technology innovation for pollution mitigation. The three efficiency measures increase drastically in consumer discretionary, consumer staples and energy industry sectors in comparing them with the ones of Table 1. Therefore, the unified performance of these industries can be improved significantly by technology innovation. In particular, the unified efficiency measures of the consumer discretionary industry are increased to unity, indicating the status of full efficiency. In contrast, All efficiency scores UENM(DC)v, UENM(DC)c, SENM(DC) decrease in the top four industrial sectors (i.e., materials, information technology, industrials and health care) of Table 1. An exception may be found in SENM(DC) of the material industry in the manner that the SENM is 0.9977 and SENM(DC) is 0.9983.

Table 2: Unified efficiency measures of industry sectors

Sector	Company type	UENM(DC)v	UENM(DC)c	SENM(DC)	DMUs
Consumer discretionary	Automobiles & Components	1.0000	1.0000	1.0000	6
	Consumer Durables & Apparel	1.0000	1.0000	1.0000	5
	Retailing	1.0000	1.0000	1.0000	2
	Overall	1.0000	1.0000	1.0000	13
Consumer staples	Food, Beverage & Tobacco	0.8180	0.7384	0.8977	9
	Household & Personal Products	0.8173	0.7920	0.9658	4
	Overall	0.8177	0.7549	0.9187	13
Energy	Energy equipment & services	0.8251	0.7858	0.8690	4
	Oil & gas	0.7835	0.6915	0.8507	10
	Overall	0.7954	0.7184	0.8559	14
Health care	Health Care Equipment &	0.8280	0.7888	0.9402	2
	Biotechnology & Life Sciences	0.4650	0.3288	0.6829	11
	Pharmaceuticals	0.5204	0.4138	0.7238	14
	Overall	0.5206	0.4069	0.7231	27
Industrials	Capital Goods	0.5186	0.4788	0.8883	18
	Commercial & Professional	0.6374	0.5762	0.7774	2
	Overall	0.5305	0.4885	0.8772	20
Information technology	Semiconductors & Equipment	0.4151	0.3924	0.9102	20
	Software & Services	0.6608	0.6506	0.9573	19
	Technology Hardware &	0.4181	0.4146	0.9802	12
	Overall	0.5074	0.4938	0.9443	51
Materials	Chemicals	0.7345	0.7342	0.9970	13
	Containers & Packaging	0.6363	0.6362	0.9998	4
	Metals & Mining	0.6054	0.6054	1.0000	2
	Paper & Forest Products	0.9554	0.9554	1.0000	4
	Overall	0.7446	0.7444	0.9983	23

Source: Sueyoshi & Yuan (2015b).

Table 2 indicates that technology innovation may not improve the performance of firms in health care, industrials, information technology, and materials sectors, which have already reached a high level of technology development through spending much money on their engineering capabilities. Therefore, redundant investment on technology innovation cannot continuously improve companies' performance. Hence, the balanced investment on different part of business should be emphasized and promoted. On the other hand, the technology innovation investment can improve the high-tech companies' performance. Because the UENM(DC)v of two company types which are related with high technology (eg, biotechnology & life science, commercial & professional services) increase comparing to UENM in Table 1.

Discussion

Comparing between Tables 1 and 2, two important business implications are indicated. First, the technology innovation investment in the low-tech industries can improve their unified performance if desirable outputs are measured by net income and an amount of CO_2 emission reduction because these industries are the largest emitter among the seven sectors examined in this study and they historically paid more attention on operational performance rather than environment performance. The green investment may increase the amount of net income by enhancing a good corporate image in a short-term horizon. Second, balanced investment on technology innovation should be promoted. The high-tech industries, including health care, industrials, information technology and materials, already paid more attention on environment than economic performance in scale management. Therefore, the investment on technology innovation cannot attain best performance. This green investment on technology innovation may absorb the resources on other parts of business in the companies and it cannot lead to the immediate enhancement of their net incomes. However, technology innovation is a key factor of some sub-industries such as biotechnology and professional services, the green investment on technology innovation is necessary.

Table 3: Investment strategy on industry sectors

Company Name	# of effective investments	Percentage (%)	# of limited investments	Percentage (%)
Consumer discretionary	2	15.38	0	0.00
Consumer staples	2	15.38	0	0.00
Energy	2	14.29	0	0.00
Health care	4	14.81	0	0.00
Industrials	2	10.00	1	5.00
Information technology	11	21.57	2	3.92
Materials	8	34.78	1	4.35
Overall	31	19.25	4	2.48

Source: Sueyoshi & Yuan (2015b).

Table 3 lists effective and limited investment opportunities on the seven industrial sectors. On overall average, 31 observations (19.25%) are rated as effective investments and 4 observations (2.48%) are rated as limited investments in terms of developing corporate sustainability. The energy sector has the fraction (14.29%) of effective investments, rated as the sixth among the seven industrial sectors. This indicates that the energy sector does not exhibit an attractive investment opportunity for developing corporate sustainability in short-run, compared with the other six industrial sectors.

Conclusion

This study has paid attention to both successful companies with positive net incomes and unsuccessful companies with negative net incomes. The analytical capability on an occurrence of zero and negative values was incorporated. Finally, we have obtained the following empirical findings. First, the technology innovation investment in the low-tech industries including energy sector can improve their unified performance as a short-run concern if desirable outputs are measured by net income and an amount of CO_2 emission reduction. Second, balanced investment on technology innovation should be promoted for high-tech industries.

Specifically for energy sector, the energy firms may be not attractive in terms of net income in short-run because of strict governmental regulation on their operations and environment mitigations. The energy sector needs to attain a high level of corporate value by investing technology innovation for pollution mitigation in long-run.

In conclusion, it is important to note that this article is based upon the work of Sueyoshi & Yuan (2015b). It is hoped that this study makes a contribution in DEA environmental assessment. We look forward to seeing future extensions as discussed in this study.

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Performance of a Solar Heating System with Photovoltaic Thermal Hybrid Collectors and Heat Pump

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Abstract

The energy consumption in buildings accounts for a large part of the World's CO2 emissions. Much energy is used for appliances, domestic hot water preparation and space heating.

In solar heating systems, heat is captured by solar collectors when the sun is shining and used for heating purposes. When the solar collectors are unable to supply the heat demand an auxiliary heat source is used. Heat pumps can generate this heat. Liquid/water heat pumps have better performance than air/water heat pumps in cold climates but requires installation of a tubing system for the cold side of the heat pump. The tubes are typically placed in the ground, requires a significant land area and increase the installation cost.

A new system design of a solar heating system with two storage tanks and a liquid/water heat pump is presented. The system consists of PVT collectors that generate both heat and electricity. Heat from the collectors is transferred to a domestic hot water storage tank or to a cold storage tank, which is used as the source for the heat pump. When the heat pump charges the warm storage tank, heat is extracted from the cold storage tank, which then can be reheated by the PVT collectors.

In this system, it is possible to have the high performance of the liquid/water heat pump but without the need to install tubes in the ground. The performance of the system with automated energy discharge over several months is evaluated.

Keywords: Photovoltaic thermal hybrid collector, PVT, energy absorber, heat pump, solar

Introduction

Smarter systems for space heating and domestic hot water preparation are needed to make energy consumption more efficient than it is today (IEA, 2014). Heat pumps generate heat from electricity in an efficient way. Generally liquid/water heat pumps are more efficient than air/water heat pumps (Poppi et al., 2016). Liquid/water heat pumps are typically installed with a tubing system either horizontally or vertically inserted into the ground (Kamel, Fung, & Dash, 2015). This requires space and has significant installations costs.

The system concept presented in this article was with a high efficient liquid/water heat pump in a system with PVT collectors. Instead of connecting the cold side of the heat pump to ground tubes, it was connected to a cold storage tank. The PVT collectors were uninsulated and could work as energy absorbers, which could extract low temperatures heat from the ambient when no solar radiation was available.

Method

System description

The system consisted of three PVT collectors of each 3.1 m^2 (see Figure 1). The solar cells had a net area of 2.37 m^2 of each PVT panel. The PVT panels were produced by RACELL Technologies. The PVT collectors faced south with a tilt of 45° and were installed at the Lyngby campus of Technical University of Denmark near Copenhagen, Latitude 56°N. The collectors were connected to two heat storage tanks located in an indoor test facility. A domestic hot water tank could be heated by the PVT collectors via an internal heat exchanger spiral and the cold storage tank could also be heated by the PVT panels. When the temperature level in the DHW tank dropped below the required comfort value, the heat pump heated it up. As the heat pump charged the domestic hot water tank, energy was extracted from the cold storage, which could then be recharged by the PVT collectors.The installed heat pump was a Vølund F1155. This type of heat pump was designed to cover both a space heating and domestic hot water demand and was therefore oversized for the demonstration system presented in this article. The performance of the heat pump in this system was therefore not evaluated in other ways that it proved the system concept.

Figure 1: PVT collectors on roof.

Automated draw offs of hot water were made three times per day to simulate an actual installation in a house. 1.5 kWh of energy was tapped three times per day at 7, 12, 18 hr. This corresponds to three times approximately 45 liters of water at 48-51 °C when the cold-water inlet temperature was 18-20 °C.

Figure 2 shows a simple diagram of the solar heating system concept.

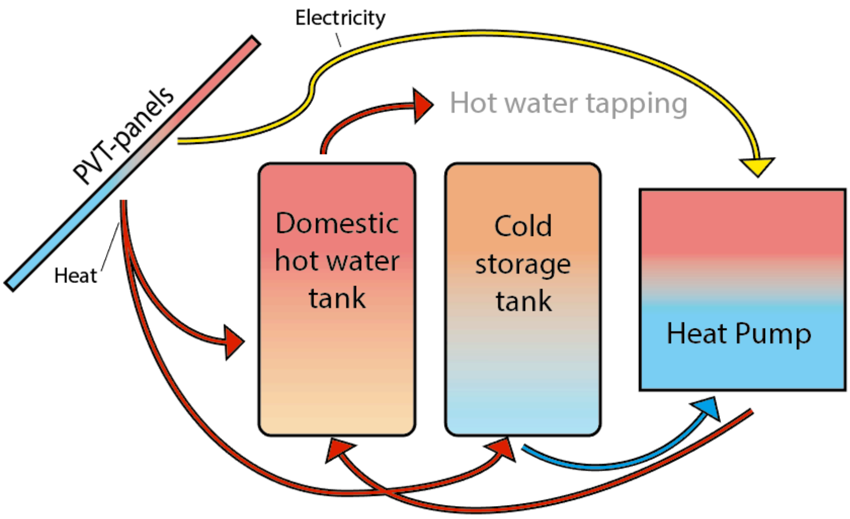

Figure 2: Simple diagram of system with PVT collectors, storage tanks and heat pump.

The PVT collectors were connected to the tanks via 20 m forward and 20 m return copper pipes with at outer/inner diameter of 22/20 mm. The pipes were insulated with Aeroflex with a thickness of 19 mm.

The PVT solar heating system ran continuously subject to real weather conditions for several months with various control strategies implemented to evaluate its performance. Minor changes in sensor placement and set point temperatures for the control of the heat pump were made during the test period to achieve better performance of the system.

Measurements

Absolute temperatures in the tanks, liquid flow temperatures in the pipes, temperature differences, flow rates, electricity generation and electricity consumption at various key locations in the system and ambient were measured and logged. Five junction thermopiles made from thermocouples type TT were used to determine the temperature differences across in- and outlet of the collectors as well as across the hot and cold-water temperatures for the domestic hot water tapping. The total and the diffuse irradiances on the PVT panels were measured by pyranometers, the wind speed was measured with a cup star wind sensor and the infrared radiation exchange between the sky and the collector surface was determined by a pyrgeometer.

The energy flows in the different loops were calculated and accumulated values of selected periods were made to evaluate the performance of the system. The solar energy on the PVT panels accumulated over the periods, were also determined to evaluate the efficiency of the collectors and system.

The PV part of the PVT panels was not in operation in the first periods, when the system was running.

Control system

Figure 3 illustrates sensor location and the control strategy of the thermal part of the solar heating system.

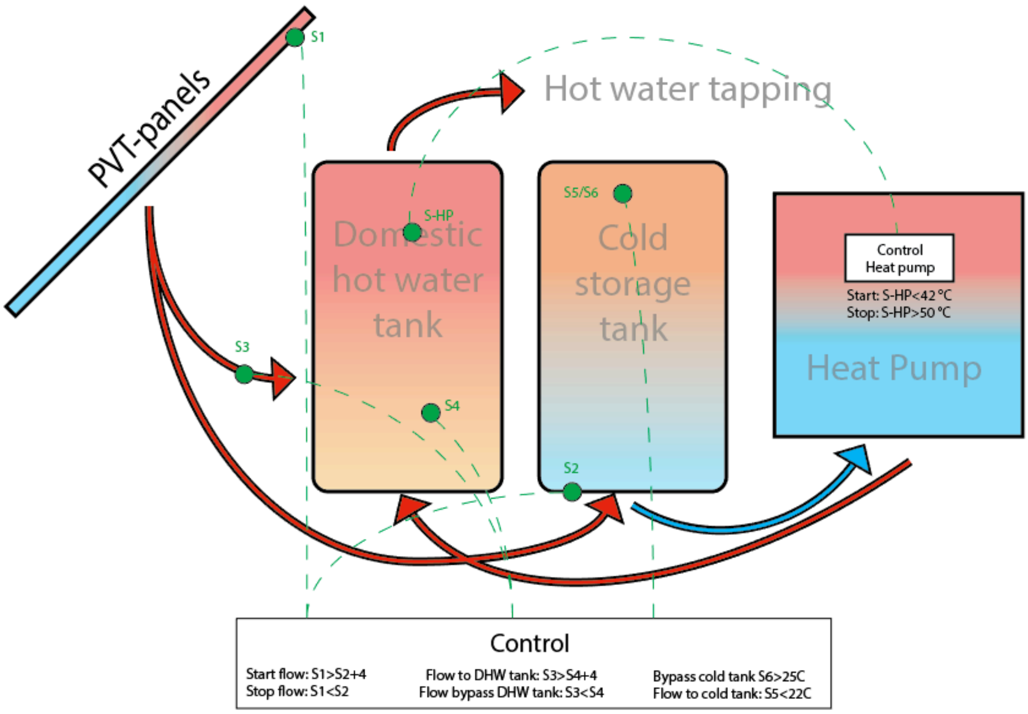

Figure 3: Control strategy and dimensions of system.

When the temperature on the back of the PVT panel near the outlet (S1) was 4 K higher than the bottom of the cold tank (S2) the flow in the collector loop started. The flow ran until the temperature of the PVT panel dropped below the temperature in the bottom of the cold tank. If the temperature in the pipe immediately before the DHW tank (S3) was 4 K higher than in the lower part of the DHW tank (S4), then the flow was directed through the heat exchanger spiral of the DHW tank. When the temperature in the pipe before the DHW tank dropped to the same temperature as in the lower part of the DHW tank, then the flow bypassed the DHW tank. As long as the temperature in the top of the cold tank (S5/S6) was below 25 °C, then the flow from the solar collector loop was directed through the cold storage tank. Otherwise, it was bypassed. The maximum temperature in the cold tank was due to the maximum allowed inlet temperature in the cold side of the heat pump of 30 °C. When the temperature in the top of the DHW tank (S-HP) dropped below 42 °C, then the heat pump started and charged the top of the DHW tank to 50 °C via the top spiral.

Test periods

The system ran continuously in four individual periods between August 2016 and January 2017. The system was not in operation in some periods due to development of the system and maintenance of the measurement equipment. In the beginning of the test period, the PV generation was not active due to incomplete installation of the inverter for the PV part of the system.

Sensor S2 was located on the outer surface on the bottom of the cold storage tank during the initial testing and was moved to a sensor pocket inside the lower part of the tank for the testing from December and onwards.

Flow distribution

To have the best performance of the solar collector array the flow of heat transfer fluid should be similar in each collector. In this case, the collectors were parallel connected and the layout of the connecting pipes may have affected the flow distribution in each collector due to different hydraulic paths, which may have different pressure drops. The flow distribution in the collector array was evaluated by thermal imaging during operation in sunny conditions. Similar temperatures in the three collectors would indicate similar temperature increase across the collectors and therefore similar flow. A FLIR T-Series Thermal Imaging Camera was used for the evaluation.

Collector efficiency

The solar collector loop ran when the solar irradiance raised the temperature in the collector above the tank temperature. In these cases, the PVT panels worked as solar thermal collectors.

The temperature of PVT panels was close to the ambient temperature when there is no solar irradiance. The solar collector loop also started when the temperature of the cold storage tank dropped below the collector temperature, also in the cases when there was no solar irradiance available. This happened typically after the heat pumps had been running and discharged the cold tank. In this case, the PVT panels extracted heat from the ambient and they worked as energy absorbers. In the analysis there is distinguished between when the PVT collectors worked as thermal collectors of solar irradiance and as energy absorbers where it extracted heat from the ambient when there was no solar irradiance available. When the total irradiance on the PVT panel was lower than 50 W/m^2 and the collector loop was running, it was defined as the PVT panels working as energy absorbers.

The thermal and electrical efficiency of the PVT collector was evaluated from the measurement of the system in operation. The dynamic of the system during operation did not allow for completely steady state conditions, which was needed for accurate evaluation of collector performance.

Therefore, periods of 10-30 minutes where the collector inlet temperature and the solar irradiance were more or less stable were selected for the collector efficiency evaluation. In the stable periods, the solar irradiance level was higher than 500 W/

m2, varied less than 50 W/m^2 and the inlet temperature varied less than 1 K throughout the period. In "SEMI" stable periods, solar irradiance varied less than 100 W/m^2 and the inlet temperature varied less than 3 K throughout the period.

The collector thermal efficiency was calculated as:

$$\eta_{th} = ((T_{out} - T_{in})\cdot V\cdot\rho\cdot c_p) / (G_{total}\cdot A)$$

Where T_{out} is the collector outlet temperature, T_{in} is the collector inlet temperature, V is the volume flow rate, ρ is the density of the heat transfer fluid, c_p is the specific heat capacity of the heat transfer fluid, G_{total} is the total irradiance and A is the gross collector area.

The collector thermal efficiency was displayed as a function of the factor:

$$((T_m - T_a)) / G_{total}$$

Where T_m is the collector mean temperature defined at the average of T_{out} and T_{in} and T_a is the ambient temperature. The wind speed at the collector surface affected the thermal efficiency of the PVT panels as it affected the convection heat losses. Each evaluated period were denoted as the average wind speed for the selected periods to show the effect of the wind speed on the efficiency.

The efficiency of the solar cells after the inverter was calculated as:

$$\eta_{PV} = PVout / (G_{total}\cdot A(PV))$$

Where *PVout* is the measured electricity fed into the grid after the inverter and *A(PV)* is the net areas of the solar cells in the PVT panel.

Results

Energy

The energy balance of the system was set up and the energy amounts for the points of interests were summarized. For the 4 individual test period the system was running continuously and the following values were accumulated and listed in Table 1:

- Solar radiation on the total collector area
- Total solar collector thermal output
- Energy absorber output (<50 W/m^2)
- Electrical output of the PV after the inverter
- Tapped energy for domestic hot water
- Energy discharged from the cold tank by the heat pump
- Energy charged to the domestic hot water tank by the heat pump

	Energy [kWh]			
	19 Aug. – 4 Sept. 2016 (17 days)	**23 Sept. – 20 Oct. 2016 (27 days)**	**21 Oct. – 21 Nov. 2016 (32 days)**	**21 Dec. 2016 – 22 Jan. 2017 (33 days)**
Solar radiation in PVT collectors	732	550	469	267
Total collector thermal output	106	117	138	102
Energy absorber output (<50 W/m^2)	0*	11.5*	20*	46
PV output	NA	NA	NA	28
Tapped hot water	77	122	142	149
Energy discharged from cold tank	47	128	178	179
Energy charged to DHW tank by heat pump	43	131	180	192

Table 1. Accumulated energy quantities for the periods.* non optimal placement of control sensors.

Thermal efficiently of collectors

Figure 4 displays the measured thermal efficiency of the PVT collectors without the PV cells in operation. The efficiency showed to be relatively low because the collectors were uninsulated and the wind caused significant heat losses. Guiding lines representing potential efficiency curves for different wind speeds assuming an optical efficiency of 0.75 are inserted in the figure.

In Figure 4, solid markers represents data from the more stable conditions and the thin markers represents data from measurement in the “SEMI” stable periods. Grey plots represents data for measurements with little or no wind, red plots a wind speed at the collector surface of 0.5 – 0.7 m/s and the black plots represents high wind speeds between 0.8 – 1.5 m/s.

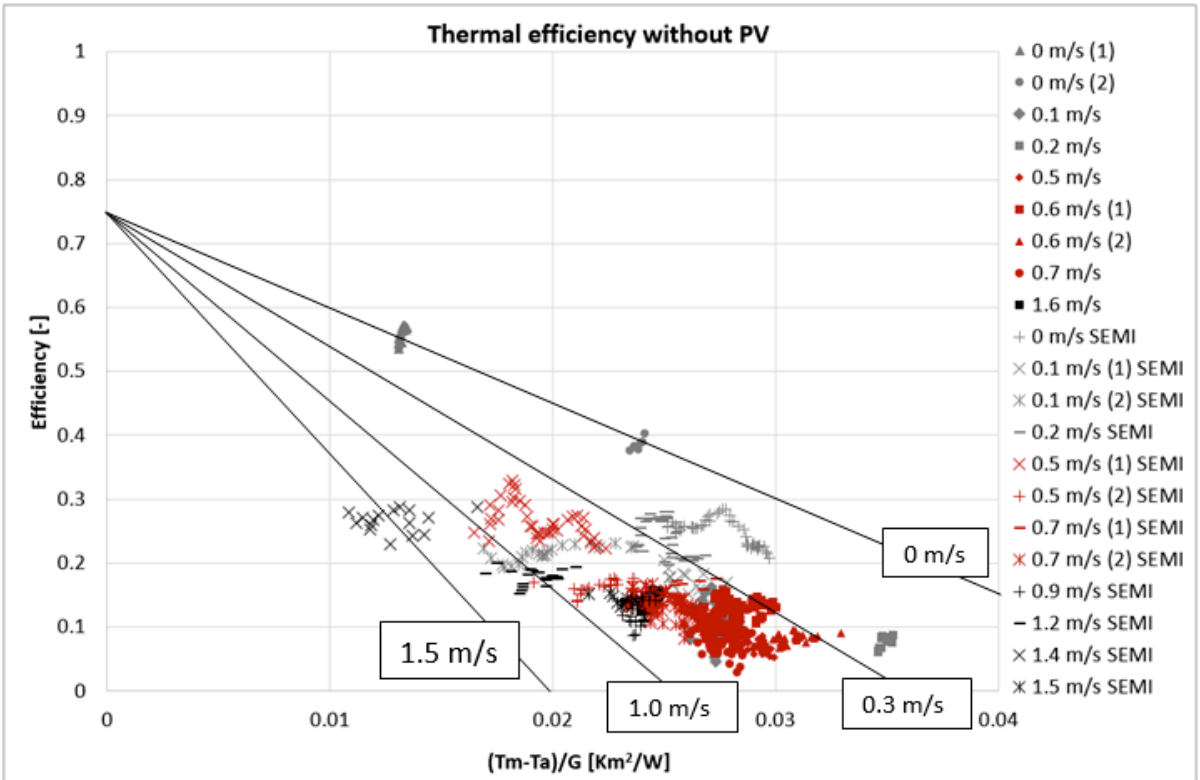

Figure 4: Measured thermal efficiency of PVT collectors in operation without electricity production.

The tendency of the plots in Figure 4 is that the measurement from periods with little or no wind show a higher efficiency compared the measurements from the periods with high wind. This is as expected for the thermal part of the uninsulated collector.
A similar evaluation of a PVT panel was previously made by Perers et al. (Perers, Furbo, & Johansen, 2014). The PVT panel they investigated was insulated on the back, while the PVT panels in this investigation was not insulated and air could pass below them. When comparing the two evaluations it is clear that the uninsulated PVT panels are more sensitive to wind than the insulated PVT panel. This can be seen, by the measurement points being more to the left in the diagram and the guiding lines for each wind velocity are significantly steeper compared to what Perers at al. found.
The average efficiency of the PV part of the PVT panels was measured to be 0.148 for irradiance levels above 400 W/m^2.

Flow distribution in collectors

Figure 5 shows that the temperature in the left PVT collector was lower than the other two. This was because the flow rate was slightly higher through the left collector due to the pipe layout. In each collector, the temperature was highest in the central upper area of the collectors due to the flow direction, the manifold and distribution pipe design.

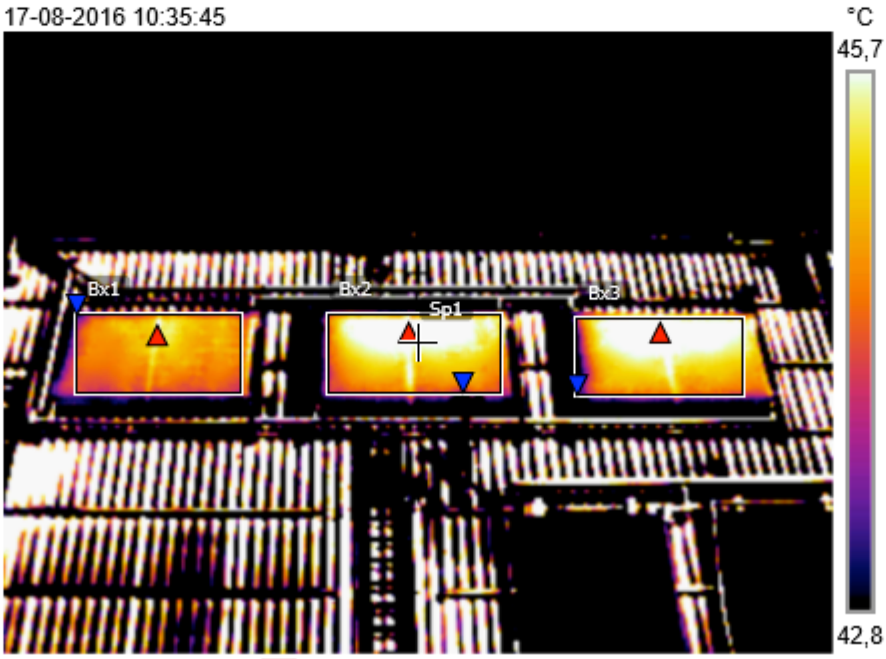

Figure 5: Thermal vision image of PVT collectors during operation in sunny condition.

Conclusion

The investigations showed that the concept with two storage tanks worked well in connection with the uninsulated PVT collectors. On sunny days in the summer, the collectors almost covered the heat demand for domestic hot water preparation. The thermal efficiency of the collectors was relative low as expected and highly affected by the wind speed. The PVT panels were able to extract heat from the ambient when there was no solar irradiance available when the cold storage tank was cooled below the ambient temperature by the heat pump.

Acknowledgement

RACELL Saphire Technologies ApS has developed the PVT panels and the solar heating system concept was developed in collaboration with COWI A/S. The research was funded by the Danish Energy Agency through the EUDP programme grant no: 64014-0561.

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Waste Management Cost Impacts on Project Finance: A Case Study of Solar Photovoltaic Rooftops in Thailand

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Abstract
The royal government of Thailand announced promotional policies for solar photovoltaic (PV) roof mount. The feed-in tariff policy of three project scales (small <10kW, medium 10-250kW and large 250-1000kW) has been granted to the applicants for the duration of 25 years at 6.96, 6.55 and 6.16 Baht (0.18, 0.17 and 0.16 Euro), respectively. However, there is no regulation on waste generated from solar PV project that will lead to environmental effect especially at the decommissioning phase. The effect of waste handling cost on the project finance has been analyzed using Thailand's circumstance data in 2015. Cash flows of 54 cases have been calculated along with other financial parameters. The results indicated that the most profitable case for small scale is disposal to existing land filled (IRR 13.01%, NPV 260,718.32 Baht, and BCR 1.19). In same trend, the highest return case for medium scale is disposal to existing landfill (IRR 14.34%, NPV 11,789,246.01 Baht, and BCR 1.37). For large scale, waste handling method generating the highest yield is waste incineration (IRR 14.27%, NPV 43,458,050.35 Baht, and BCR 1.36). Sensitivity analysis indicated that the project return of small, medium, and large scales would be below the benchmark value, 12.63% calculated from the ROE of the power producing companies in the national open market, at 5%, 10% and 10% income reduction, respectively. The financial results are used in predicting the designated solar PV waste, which requires proper policies in order to enforce and encourage responsibility of relevant parties.

Keywords: Solar Rooftop, Financial Analysis, Waste Management, Photovoltaic

Introduction

The electricity requirements of Thailand were rising up continuously reflecting from historical record of gross energy generation requirement. It was reported average energy requirement of Thailand during 2002-2012 was increasing 5% (Energy Policy and Planning Office, Ministry of Energy, Thailand, 2013). Regarding expansion of energy requirement, Thailand's electricity productions still relied on natural gas that was used at 71.1% of the generation in 2011 (Energy Policy and Planning Office, Ministry of Energy, Thailand, 2013). In case of nature gas shortage, the main production would be switched to other sources of energy which had an effect on electricity prices or environmental problems. For example in 2011, to compensate amount of electricity generated by using natural gas, around 21,790 million liters of fuel oil will be burned to generate same amount of heat which will be continuously converted to be electricity (Intergovernmental Panel on Climate Change, 2006). This example clearly indicated that Thailand would be facing with energy insecurity if main proportion still depends on natural gas (Cabalu and Alfonso, 2013).

Renewable energy would be a solution to increase domestic energy production that would improve energy self-dependence. Ministry of Energy of Thailand has announced 10 years of energy plan, the Alternative Energy Development Plan (AEDP) 2012-2021, to expand proportion of renewable energy up to 25% of net energy consumption or 25,000 ktoe in 2021. The plan has been updated in 2015 named AEDP2015 focus on promoting energy production by domestic renewable energy resources. To achieve the target, Government of Thailand announced various supportive policies for renewable energy such as giving premium electricity tariff to electricity produced from renewable energy that feeds to Thailand national grid. Particularly when focusing on one of proven technology like Solar Photovoltaic (PV), 3,000 megawatt (MW) of solar PV will be implemented. According to the national plan, the current status of Energy Regulatory Commission's database is presenting an overall installed capacity of commissioning solar PV projects in Thailand which is around 1,298 MW and more than 1,345 MW currently is in developing phase (Department of Alternative Energy Development and Efficiency, 2016). Another 600 MW of solar communities based policy will be implemented in upcoming future (GIZ Thailand, 2014).

At the end of project cycle, the massive amount of at least 3,000 MW of solar PV that is equally to 600,000 ton of electronic waste will unavoidably be generated. The environmental preferred waste handling methods require investment and improvement on technology, infrastructure and resources that are unattractive on economic aspect. The options for the e-waste management are still opened which some guideline suggested by Energy Regulatory Commission (ERC) at the application process. Generally, the assessment of financial feasibility of solar PV project is uncounted waste management cost as the project's expenditure. In case of absorption of waste management cost by project operator, the environmental cost of solar PV project especially waste disposal cost is usually ignored by investors. Moreover, the appropriated waste management methods are not applicable for Thailand due to national circumstances such as lack of infrastructure to recycle, insufficient sanitary landfill and less concerns on waste management policy. Furthermore, almost of solar panels in Thailand are imported from overseas which is absent of responsible agency willing to absorb the trans-boundary cost of waste generated from solar project. In the same way, the solar panel manufacturers in Thailand do not have taken-back policy due to limitation on their technology and cost.

At decommissioning phase which is potentially absent of supplier's warrantee, decadent panels may be neglected by operator due to financial reasons. The assessment on effects of each waste handling method should be conducted to plan the appropriated waste management. Therefore, this present study was aimed to propose the most suitable case and appropriate mitigation measures of solar PV rooftop scenarios with financial analysis. The finding will be useful information for decision makers about feasible economic and waste management of solar PV

Methodology

Conceptual framework

The overall income and expenses of electricity production from solar PV rooftop focusing on a main commercialize technology as crystalline was assessed which base on 2015 circumstance. To determine viability of the solar PV project, income and expenses of Thailand scenarios which comprise feed-in tariff, project debt and interest loan rate, investment cost, operation and maintenance cost and environmental cost was used in a financial analysis of each scenario. The costs occurred by waste management methods specifying as landfill, incineration, and sending back to producer were assessed and used in determination effects on the project return. The financial assessment of each waste handling option varying with size of project was performed. Schematic of conceptual framework is shown in Fig. 1.

Sources of input data

The information of 3 scales of solar PV rooftop (0-10kW residential base, >10-250kW small-medium enterprises base, and >250kW – 1 MW industrial base) in Thailand were reviewed and updated including national policy on electricity produced by renewable sources purchasing (as a main income of the project), investment cost, operation & maintenance cost, and waste management cost. The financial assessments were performed by using specific technology of solar panel mainly used in Thailand. Any expenditures of project were surveyed by using cost of solar PV from pubic information such as brochure of related companies in Thailand and international sources. Costs of the project comprised project debt and interest loan rate, investment costs, operation and maintenance costs, and environmental costs Main project revenue set as feed-in tariff rate announced in 2015. In case of no supportive policy, energy saving can be used as revenue of the project that electricity price included float time (Ft) rate from Metropolitan Electricity Authority (MEA) or Provincial Electricity Authority (PEA) was used. Another input data affected on project performance like plant load factor, solar radiation, sun hour, and etc. would be fixed as default value based on Thailand scenario.

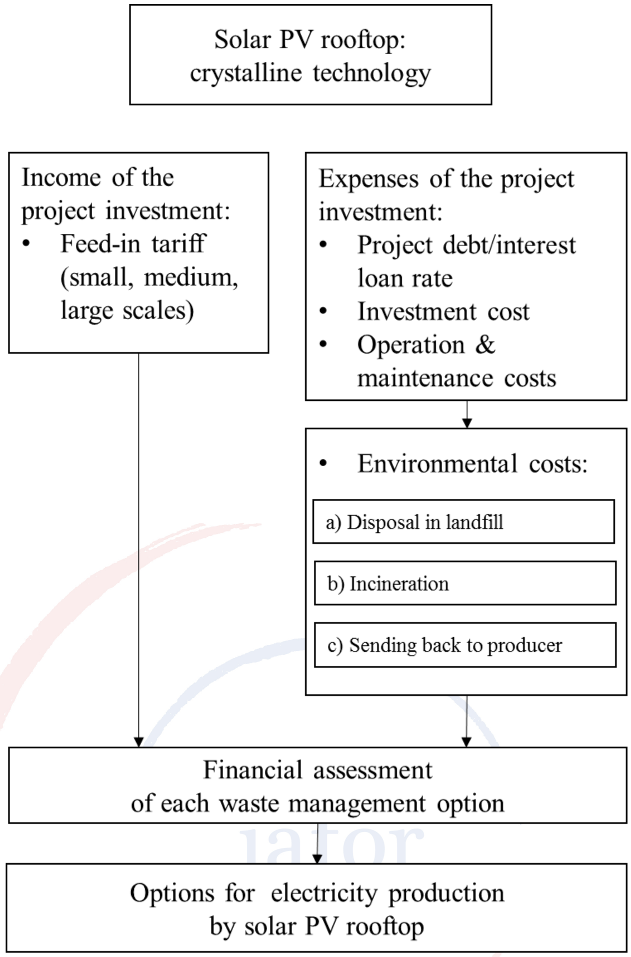

Figure 1 Schematic framework for investigating most suitable option for electricity production by solar PV rooftop with financial analysis

Financial Assessment

The first analysis in this study focused on estimating cost of waste management and its effect on project's return. Project's equity internal rate of return (equity IRR) (Blasberg, et al., 1991; Delmon, 2009) and net present value (NPV) (Welch, 2009) of each scenario were calculated. Then, the average return on equity (ROE) of all electrical companies that listed in stock exchange of Thailand was used as financial benchmarking (Delmon, 2009). The results of IRR and ROE were used to calculate break through event test of main parameters (FiT rate, base tariff rate and investment cost) which aim to identify effect of main parameters on equity IRR and NPV. The sensitivity analysis of FiT, one of tools using for trying out different assumptions to see how sensitive the IRR and NPV is, was used to indicate effect of its change to viability of the project (Welch, 2009). In this study, the main project's income as FiT rate and project's cost will be varied at different level as 5, 10, 15 and 20 percent.

Some parameters affecting on project cash flow were fixed including debt equity ratio, tax rate and loan interest rate and installment period. Debt equity ratio was fixed at 50:50

(UNFCCC, 2011). Tax rate followed the current of the Board of Investment of Thailand which giving tax promotion scheme for renewable project at 0% for 0-8 years, 15% for 9-13 years and 30% for 14-25 years over the project life time. The average of Minimum Loan Rate (MLR) of commercial banks registered in Thailand was used as loan interest of industrial base project with amortization type. The average of Minimum Retail Rate (MRR) of commercial banks registered in Thailand was used for loan interest of home and SME base project. The project scenarios were varied for 3 main parameters as scales, waste handling methods, and income of the project. All of 54 combination scenarios are summarized as Table 1.

Table 1 Fifty-four combinations of scales, three of waste handling methods, and income and cost of the PV rooftop project

	Solar PV technology: Crystalline																	
	0-10 kW (residential base)																	
Waste handling methods	Disposal to existing landfill						Send back to producer						Incineration					
Income & Cost	Sensitivity level (%)					Energy saving	Sensitivity level (%)					Energy saving	Sensitivity level (%)					Energy saving
	0	5	10	15	20		0	5	10	15	20		0	5	10	15	20	
Combinations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Scales	**10-250 kW (SME base)**																	
Waste handling methods	Disposal to existing landfill						Send back to producer						Incineration					
Income & Cost	Sensitivity level (%)					Energy saving	Sensitivity level (%)					Energy saving	Sensitivity level (%)					Energy saving
	0	5	10	15	20		0	5	10	15	20		0	5	10	15	20	
Combinations	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Scales	**250 kW - 1 MW (industrial base)**																	
Waste handling methods	Disposal to existing landfill						Send back to producer						Incineration					
Income & Cost	Sensitivity level (%)					Energy saving	Sensitivity level (%)					Energy saving	Sensitivity level (%)					Energy saving
	0	5	10	15	20		0	5	10	15	20		0	5	10	15	20	
Combinations	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54

Gaps identification is a comparison between ROE and IRR results of each combination in topic of IRR, was used to indicate gap of financial performance and benchmark. The results of gaps identification presented the requirements support of appropriated waste management of each scenario. Break through event test, an analysis for identification the effect of cash flow changing on the IRR, was performed and aimed to identify changing level of main parameters that can adjust IRR to reach the benchmark.

Research Finding

Project revenue

For energy saving cases (off-grid mode), the electricity-selling rate and floated time (Ft) rate for Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) have been used as the project revenue in term of saving expense because generated electricity can be used internally. The base electricity tariff with concerned peak and off-peak rate are included in the calculation. For the other cases, the promotion scheme has been applied. The current purchasing rate announced by Energy Policy and Planning Office, Ministry of Energy, Royal Thai Government (EPPO) has been used in financial analysis as feed-in tariff rate (FiT). The FiT rates of small, medium and large scale are 6.96, 6.55 and 6.16 Thai Baht per kilowatt hour (THB/kWh), respectively. The information has been used in calculation of gross project income which is pre-tax and not reduced by other project expenses (Table 2).

Table 2 Key parameters of input data for project income calculation

Parameters	Value (THB/kWh)
Feed-in tariff (small)	6.96
Feed-in tariff (medium)	6.55
Feed-in tariff (large)	6.16
Peak rate (small)	3.6246
Off-Peak rate (small)	1.1914
Peak rate (medium)	2.695
Off-Peak rate (medium)	1.1914
Peak rate (large)	2.695
Partial rate (large)	1.1914
Electricity rate for large scale	132.93
Average Ft rate of year 2015	0.5282

Remark: Small (<10kW), medium (>10-250kW), and large (>250-1000kW)

Investment cost

Twenty-four service providers in Thailand have been identified comprising of two individual and twenty-two corporate service providers. Most of technologies have been fixed by services providers as crystalline module and electrical inverters that registered with the electricity authority. All of the published solar rooftop system was prices based on lump sum per Watt basis. An option for adjustment of each project component was rarely available. Only nine services providers has disclosure their prices per Watt consisting of 4 small scale, 2 large scale and 3 of unspecific. The average values were used 60.0, 56.7 and 53.4 THB/Watt for small, medium, and large scale respectively.

Regarding collected information, the investment cost was ranging and depending on the project' details. The factors should affect project cost were 1) size of the project; if the project is too small or retail, the prices per Watt will be higher compared with the bigger project scale 2) type of services provider; there are some gap between the individual and large firm services provider which there are not all cases that individual services provider is more expensive and vice versa, and 3) the grade of the project components; the main cost of the project is the solar module but others are still effect on the cost.

Not only the different on the price, after sale services were also different between the type of service providers. The project owner may choose the cheaper option that may not include the after sale services. In addition, the project life time is long with minimum at 25 years, the small service provider may exist to facilitate project owner when the decommissioning period has come. There is no manufacturer in Thailand advertised about taking back policy or responsible on the waste during the time of survey. There is a possibility that if the waste handling program has implemented, the cost of the project would be higher.

Financial cost (Lending rates)

The financial cost is mainly occurred by lending rates. Regarding the financial assumption of 50/50 as debt/equity, it has been fixed as interest rates. The interest rate is the rate of return or amount of money that borrowers agree to pay back the creditors, as per agreement. The lending rate is comprised of 3 main rates as follows; Minimum Lending Rate (MLR) (or Minimum Loan Rate) refers to the interest rate at which the lending commercial bank charges its most creditworthy major borrowers on loans with pre-specified repayment; Minimum Overdraft Rate (MOR) refers to the interest rate at which the lending commercial bank charges its most creditworthy major borrowers on overdrafts, and Minimum Retail Rate (MRR) refers to the interest rate at which the lending commercial bank charges its most creditworthy retail borrowers on loans. This rate, when used in conjunction with the MLR, reflects the difference in risk premium between major and retail borrowers. (Bank of Thailand, 2016)

Regarding the project scheme, MLR is applicable for large-scale project and MRR is applied for medium and small-scale project. The lending rates of 19 commercial banks registered in Thailand have been published by Bank of Thailand and exhibited average at 7.09% and 8.39% for MLR and MRR, respectively (Bank of Thailand, 2016). Recently, the local banks are more familiar and confident to provide commercial loans for the solar PV rooftop. The average lending rate of 2014 from 123 countries worldwide is 11.52% (World Bank, 2016). Thailand interest rate is lower than the world average value. Hence, the local project may unattractive by the overseas banks which the lending rate of Thailand have been applied for this study which aims to reflect the status of Thailand.

Environmental cost

The cost that related with waste management after end of project life has been considered as environmental cost. Regarding the assumption of 3 methods of waste handling, the waste management cost of each method is calculated as follows

• **Tipping fee** the tipping fee of each case has been calculated by assumption of maximum collecting rate at 4 kg/day and monthly lump sum price at 220 Baht referring to the draft rate for collection fee at 65 Baht and sanitary landfill fee at 165 Baht (Information Division Office of the Permanent Secretary for Interior, 2015). The amount of generated waste per watt is fixed at 0.06 Watt/kg. The amount of waste of small, medium and large scale has been calculated as 594 kg, 14,940 kg and 59,400 kg which will be required the time for collection those waste. The period has been determined at 5, 125, and 495 months, respectively.

• **Incineration fee** the rate of incinerating waste has been surveyed from the service provider that has facility of industrial waste incinerator. The rate has been fixed at 30,000 baht/ton (transportation included).

• **Shipping fee** the rate of shipping waste has been collected from the full cycle shipping agency. The rate has been fixed at 168 baht/kg without concerning about dimension of the waste.

The information used in this topic has focusing on the related cost occurred during the decommission phase of the project. The miscellanies cost during the operating project are not considered. The selected waste management options would affect the environment i.e. air pollution by incineration the solar PV waste, heavy metal leakage or over-capacity by disposal to the landfill. The related cost with the environmental restoration and remediation that might be occurred by the eliminating the waste are not included in this study. These topics should be researched in the future to scope of environmental damages and responsibility of polluters.

System efficiency and other assumptions

The Photovoltaic module degenerates by ageing of its. The yearly degradation rate of first ten years is 0.70% and next decade rate is 0.46% and more than twenty years is at 0.43%. Another project component efficiencies are directly affected the electricity yield. The international data has been used in the assessment of system efficiency. The weather conditions of Thailand might affect overall system efficiency and plant availability i.e. hot and humid climate are cause the cracking of wiring system. Furthermore, as per imported technologies from other countries, the efficiency of components from various sources are affected the overall system performance. These issues have been concerned by conducting conservative sensitivity analysis. The results of sensitivity analysis indicated that if the system efficiency affects production by 5-10% reduction the project may unattractive comparing with the benchmark value.

Other parameters are also affected the return of the project. For examples, install capacity of three different scales are set at 9.9, 249.0 and 999.0 kW. The numbers are close to cap of supportive policy at 10, 250 and 1,000 kW. Number of operation days can be varied depend on the hypothesis of the study, in this study it is fixed with entire years. Others are be categorized into 4 main groups as operating conditions, period of construction and permitting, Maintenance and finance. These parameters are affected the electricity yield and project cash flow and it was also concerned.

Financial Assessment

• **Internal rate of return,** the calculation of 54 cases have been conducted which the maximum Internal Rate of Return (IRR) value is at 21.10% (the most profitable case) as case no.23.1 (scale; medium, waste management method; disposal to existing landfill in Thailand, supporting scheme; Feed-in tariff SME rate and sensitivity analysis; 20% cost reduction) and the minimum IRR value is at -7.37% (the most loss case) as case no. 30 (scale; medium, waste management method; send back to manufacturer, supporting scheme; non and sensitivity analysis; non).

• **Net present value**, the calculation of 54 cases have been conducted which the maximum Net Present Value (NPV) is at 68,086,401.59 Baht (the most value case) as case no.53.1 (scale; large, waste management method; incineration, supporting scheme; Feed-in tariff factory rate and sensitivity analysis; 20% cost reduction) and the minimum NPV value is at -51,669,604.99 Baht as (the most negative value case) the most case no. 48 (scale; large, waste management method; send back to manufacturer, supporting scheme; non and sensitivity analysis; non).

• **Benchmark calculation**, the average ROE of energy and utilities and power producing companies are 11.61% and 12.63% respectively. The value of 12.63% has been set as benchmark due to conservative assessment. As the benchmarking can be used as a financial justification, if the return of the project is below the benchmark value, the investor may decide to invest in open market instead the benchmarked project.

Internal Rate of Return (IRR) values of the solar PV projects are trend to be higher because the fact that the prices of the project components have been reduced, the efficiency of the system has been improved and the effect of production scale. These situations are the reasons that the project costs are continuously reduced. IRR of the solar PV projects in India vary 31.81-10.59% by the effects of interest rates at 0-13%. These values have calculated for the without storage system cases. (Prasanna, Sameer, and Hemavathi, 2014). A residential PV system in Oahu, Hawaii with conditions of 30% federal tax credit and 25 years of system lifetime is calculated at IRR 4% and Net Present Value (NPV) 2,031 USD (Richter, 2009). However, the feasible levels of the project have been impacted by the cost of waste management indicated by this study that the different methods of waste handlings are caused the lower financial indicators. The original cases that absorb the waste management costs are still achieve the benchmark which the policy maker may enforce the project to choose any less environmental effect conditions. On the other hand, confirmation that all scale would be survived with the upcoming regulation on the waste, the tolerant options that still achieve the benchmark when sensitivity analysis has been performed i.e. case no. 20, 26, 32, for medium scale; case no. 38, 44 and 50 for large scale. For small scale (residential base), the projects would not be financial attractive, in case of absorb the waste management costs with the sensitivity cases. Hence, the policy marker may consider adjusting the other supportive scheme to enhance financial viability of the project scale, if the enforcement of the waste would be applied.

The financial results of without feed-in tariff cases are lost because project income (in term of energy saving and calculating from the base electricity tariff of Thailand) is lower than other countries. If the selling electricity rates of Thailand increase, the return of the cases would be better. For examples, small scale project (incineration case), IRR will be positive when the electricity price increases 27 percent and will over the benchmark value when the electricity price increases 2.1 times. For medium scale (incineration case), IRR will be positive when the electricity price increases 27.5 percent and will achieve the benchmark value when electricity price increases 2.29 times. For large scale (incineration case), IRR will be positive when the electricity price increases 17.7 percent and will achieve the benchmark value when electricity price increases 2.18 times. Regarding the calculations, It can prediction the solar rooftop use for energy saving will be financial attractive if the electricity cost are increase more than 2 times.

• **Gap identification,** to maximize benefit of the investment, comparison the return of the cases with the return of investment in open market by using IRR compared with ROE respectively can be used in justification of the investment. The gap between project performance and the market have to indicate which aims to analyze the financial performance of each case. The bigger gap will lead to higher of unattractive in the investment. Financial return compare with benchmarking value which were reflecting gap are shown in Fig. 2.

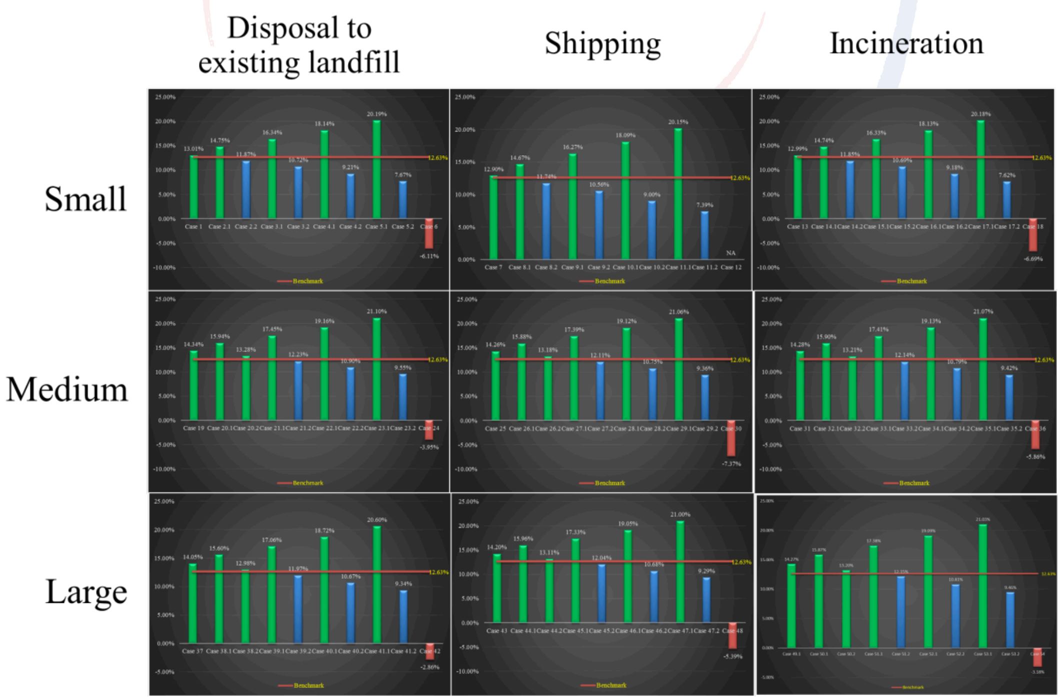

Figure 2 Benchmarking of small, medium, and large scale and comparison between three waste management methods

Conclusion

Regarding the results of calculated financial indicators, the evaluation of each project scales have been conducted to classify the justifiable of the cases. The comparison has been organized within the same project scale as per the fact that a large project could easily have higher values than a small project. The evaluation criterions used to consider worth of cases, are as follows 1) the net present value must be positive (NPV > 0), 2) the discounted present value of the benefits is greater than the discounted present value of the costs (IRR > 0) and the value have to over the benchmark of the open market (IRR > Benchmark), and 3) the ratio between the present value of the benefits and the costs must be more than one.

The results of the evaluations of each scale are presenting as follows.

- **Small scale** the different waste management costs has affected the financial indicators. The most profitable case is disposal to existing landfill consisting of IRR (13.01%), NPV (260,718.32 THB), and BCR (1.19). The other profitable waste handling methods are incineration and sending back to producer, respectively. The IRR of all cases have below the benchmarking at 12.63% when the conducted sensitivity analysis by 5% income reduction but these cases are still be commercial. All cases of the small-scale project would be lost, if the income reduces by 20% or the Feed-in tariff cannot be applied.

- **Medium scale** the different waste management costs has affected the financial indicators. The most profitable case is disposal to existing landfill consisting of IRR (14.34%), NPV (11,789,246.01 THB), and BCR (1.37). The other profitable waste handling methods are incineration and sending back to producer, respectively. The IRR of all cases have below the benchmarking at 12.63% when the conducted sensitivity analysis by 10% income reduction but these cases are still be commercial. All cases of the medium-scale project would be loss, if only the Feed-in tariff cannot be applied.

- **Large scale** the different waste management costs has affected the financial indicators. The most profitable case is incineration consisting of IRR (14.27%), NPV (43,458,050.35 THB), and BCR (1.36). The other profitable waste handling methods are sending back to producer and disposal to existing landfill, respectively. The IRR of all cases have below the benchmarking at 12.63% when the conducted sensitivity analysis by 10% income reduction but these cases are still be commercial. All cases of the large-scale project would be loss, if only the Feed-in tariff cannot be applied.

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Using Asset Management to Unlock Sustainability Potential

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Abstract

The US Department of Energy's (DOE) National Nuclear Security Administration (NNSA) ensures the nation's nuclear security. Comprised of eight science and manufacturing campuses covering 36 million square feet of facilities, NNSA is the heart of the United States nuclear deterrence and non-proliferation missions.

NNSA must invest in its workforce and specialized functions, while repairing and replacing old facilities--54% of facilities are over 40 years old. The expanded Asset Management Program (AMP) uses a systems-engineering approach to invest in infrastructure to include roofs and cooling and heating equipment. The Roof Asset Management Program (RAMP) and the Cooling and Heating Asset Management Program (CHAMP) actively integrate sustainability into its core processes.

This paper determines how asset management and sustainability frameworks can be used together when applied to infrastructure investment programs. Asset management can provide definitions and process, and sustainability can provide a decision-making framework. This combination of frameworks addresses the challenge of translating sustainability concepts into action, as well as establishes a decision-making paradigm for infrastructure asset management processes.

Background

What is NNSA?

The US Department of Energy's (DOE) National Nuclear Security Administration (NNSA) ensures the nation's nuclear security. Comprised of eight science and manufacturing campuses covering 36 million square feet of facilities, NNSA is the heart of the United States nuclear deterrence and non-proliferation missions. Its unique capabilities, from supercomputing to laser science, and workforce of upwards of 40,000, together consume 9.1 trillion BTU's per year. A snapshot of NNSA is provided in Figure 1.

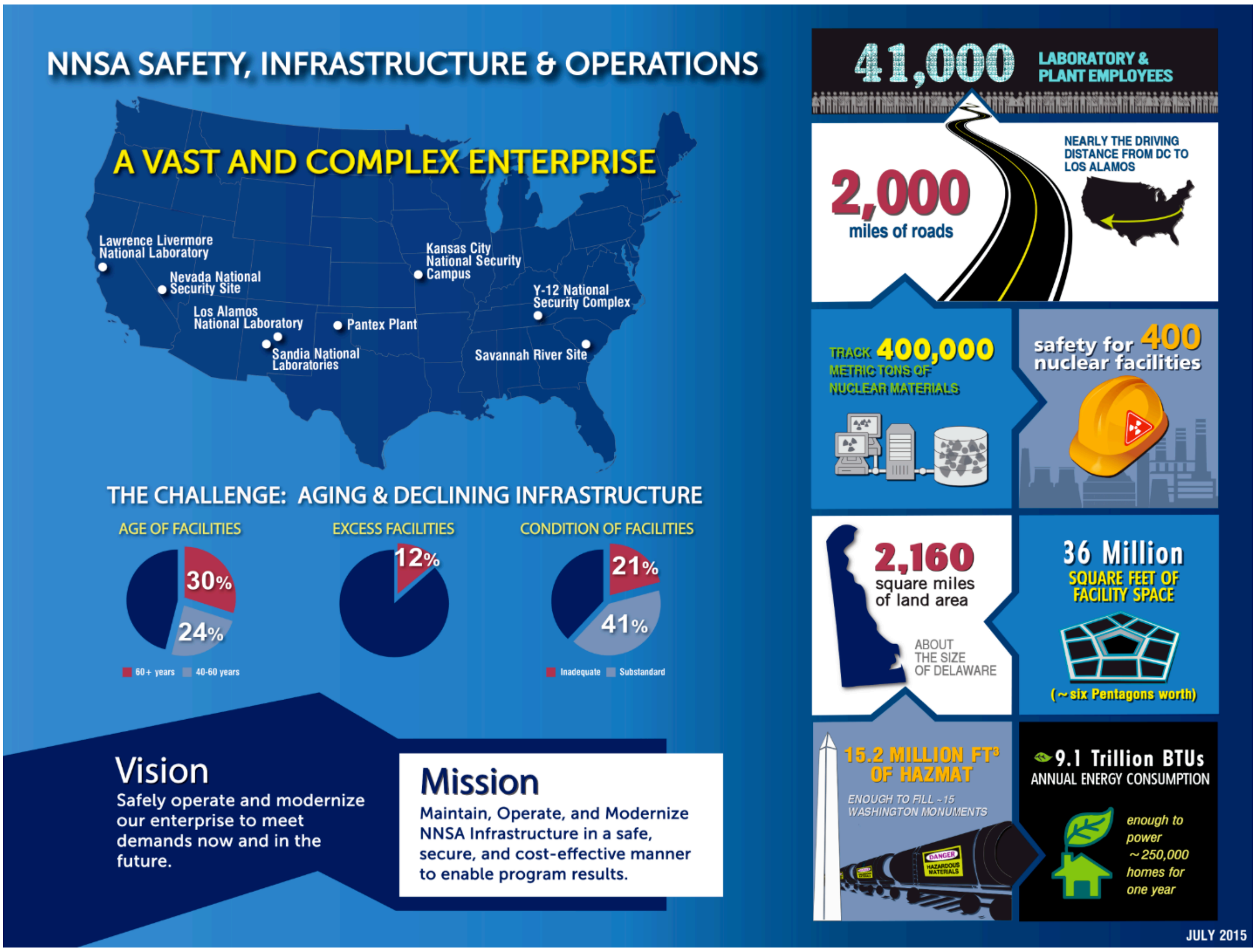

Figure 1. Snapshot of NNSA Infrastructure

What is the NNSA Asset Management Program?

Given the complex, nuclear work of NNSA, the organization aligns with similar industries who manage processes down to a low level of detail. One industry, off-shore oil drilling, for example, could benefit from the comprehensive, holistic approach of asset management (Markeset, 2012). Some have suggested that failure in effective asset management had catastrophic consequences for this industry as demonstrated by the British Petroleum 2010 oil spill in the Gulf of Mexico (Ratnayake, 2013, p. 198).

The Roof Asset Management Program (RAMP) was started in 2003 and established the Asset Management Program (AMP) concept used by NNSA today. RAMP's goal set aside funding for failed and leaking roofs affecting personnel and equipment. The program employed a national company that specialized in roof design and construction.

Starting in January 2015, NNSA started to expand AMP in hopes of applying the program methodology to other infrastructure systems. NNSA decided to focus on heating, ventilation, and cooling systems (HVAC) ranging from building-level thermostats to large cooling towers because of the broad impact HVAC. HVAC affects mission operations, workplace comfort, safety, and sustainability. NNSA HVAC relies on components that no longer have replacement parts, are non-functioning, and are not configured to support the current building uses. The Cooling and Heating AMP (CHAMP) is expecting contract award in early 2017.

NNSA's sites are operated by Management and Operating (M&O) contractors. The work of RAMP and CHAMP both made possible by contracts held by Management and Operating (M&O) contractors. The RAMP contract is held by the National Security Campus, Honeywell's contractor for NNSA's Kansas City Operations, and the CHAMP contract will be held by the Lawrence Livermore National Security, LLC, the operator of Lawrence Livermore National Laboratory.

Both programs operate with the M&O hiring a contractor who is an expert in assessing, designing, and leading the construction for the infrastructure system. Annual work packages at a site are $1M to $5M. Working with an industry sub-contractor expert gives NNSA and sites access to cutting-edge, industry-tested technologies and implementation strategies.

What is the Challenge?

NNSA must invest in its workforce and specialized functions, while repairing and replacing old facilities--54% of facilities are over 40 years old. The expanded Asset Management Program (AMP), which on average is funded at $20-30M per year, uses a systems-engineering approach to invest in infrastructure to include roofs and cooling and heating equipment.

By using asset management, an organization can flexibly define and target performance goals, including sustainability. RAMP, in place for more than a decade, has implemented a white roof, high insulation roof standard pre-dating mandatory codes. CHAMP integrates sustainability primarily in the design phase.

Purpose

The purpose of this paper is to determine how asset management and sustainability frameworks can be used together when applied to infrastructure investment programs. It also provides some tools and approaches, "for tailoring the rehabilitation technique selected for a given asset and context," (Marlow, Beale, & Burn, 2010, p. 1254). While some are challenged with how to make sustainability "practically feasible" to their business operations (Jamali, 2006, p. 813), the analysis contained herein supports the claim that performance of physical assets in the terms of sustainability can provide benefits to the asset owners (Markeset, 2012, p. 145). Asset management provides definitions and process, and sustainability provides a decision-making framework, allowing for prioritization. Combining these frameworks addresses the challenge of translating sustainability concepts into action, as well as establishes a decision-making paradigm for infrastructure asset management.

Procedure

To combine these two management systems, this paper employs analysis of two existing infrastructure investment programs, the roof asset management program (RAMP) and cooling and heating asset management program (CHAMP). Different analyses are created to, 1) define asset management and sustainability approaches for these programs, and 2) analyze program preferences, trends, and outcomes to determine how the two frameworks can be combined.

Defining asset management. Asset management programs for NNSA have the following key features:

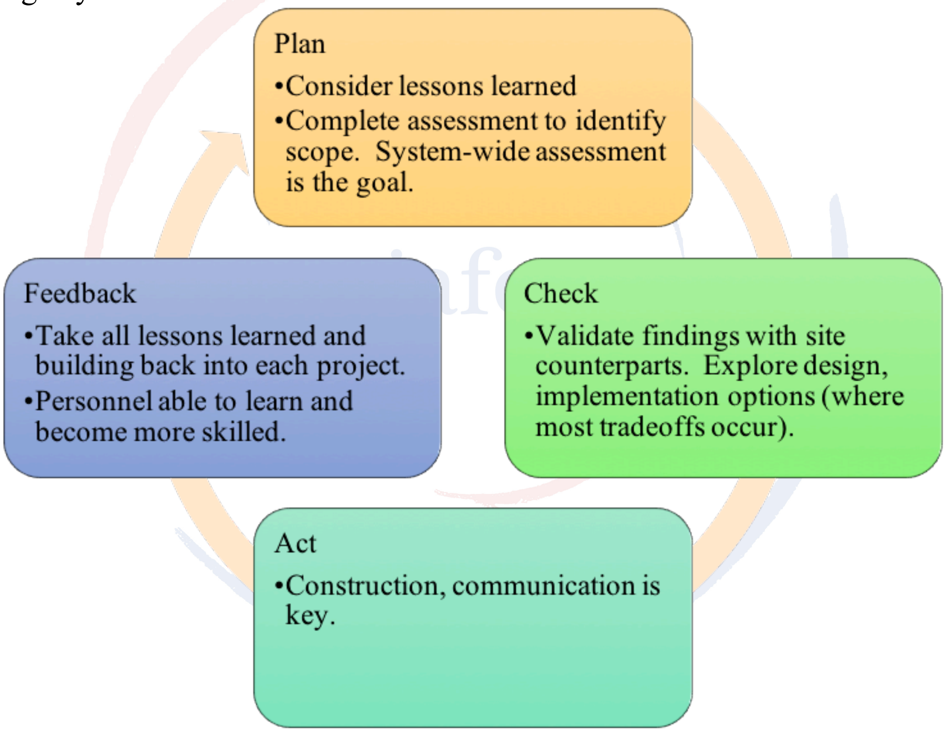

Figure 2. NNSA Asset Management Framework

Figure 2 shows an adaptation of the typical plan-do-check-act cycle that underlies asset management (The Economist, 2009). For the adapted model, the steps before “act” are expanded. The “act” step corresponds with construction, so little can be changed during this change without severe impacts to project performance. More focus must be placed on steps prior to “act” to reduce cost and safety risk.

Table 1 presents the desired outcome for each step in the asset management cycle and how each program can meet that goal. Roof and heating and cooling systems will meet asset management outcomes in different ways. For example, under the “plan” step, an identified goal is to “complete a system-wide assessment.” For roofs, portfolio-wide assessment is achievable, as it is non-intrusive, inexpensively executed via aerial photography, and returns consistent results. Conversely, cooling and heating system assessment is more costly. It is more intrusive, as it involves going into buildings with design engineers to determine options for repair, replacement, and reconfiguration.

Table 1. *Comparison of Asset System Type to Asset Management Goals*

Asset Management Goal	Why this matters	Ability to Attain Goal	
Plan		**Roof**	**Cooling and Heating**
Complete system-wide assessment, cost-effectively	Enables fact-based condition assessment and prioritization. Assessment cost should be low compared to construction.	High – Roof conditions can be determined through aerial photography and spot inspection. Low assessment to construction cost ratio.	Low – Cooling and heating systems vary greatly by configuration and system components. High assessment to construction cost ratio.
Various technologies available	Provide more tailored solutions to specific issues.	Low – Few roof designs and options.	High – Many configurations and equipment types can be used.
Technical lessons learned can be used	Reduce assessment and design effort, increasing construction value.	High – Fewer options for roof-system types allow for more system-wide applicability.	Medium – Share and implement technology lessons learned, but variances limit applicability.
Plan		**Roof**	**Cooling and Heating**
Operational lessons learned can be used	Reduces cost and time to implement. Creates consistency which improves performance.	High –Although locations are spread across the country, requirements between locations are comparable.	High –Although locations are spread across the country, requirements between locations are comparable.
Check			
Validate findings with site and explore options.	Enables better design and constructability solutions for the project and repair life-cycle.	High - RAMP algorithm generates a roof construction priorities, which is validated with site and walk-thru. Cool roof standard implemented. Non-compliance is rare.	High – Conceptual designs developed. Alternatives address technology, cost, and installation. Strong sustainability preference ensures robust options. Employ triple-bottom-line analysis here.
Act			
Establish strong communication before construction start.	Stronger communication results in fewer construction issues.	High – Strong site oversight model results in check and balance during construction.	High – Strong site oversight model results in check and balance during construction.

Feedback		**Roof**	**Cooling and Heating**
Effective collection and use of lessons learned.	Strong lessons learned process ensures that failures are not made twice and successes are built upon.	High – As a mature program, lessons learned are easily implemented. Variances are obvious. Lessons learned focuses on construction.	Medium – New program, so few lessons learned. With more complexity, it can be more difficult to determine how to replicate results.
Personnel able to learn and become more skilled.	People's expertise enables them to quickly recognize potential failures and opportunities to maximize system effectiveness.	High – Program employs specialized contractor, using latest industry standards and trends. Expertise enables effective oversight of the construction process.	High – Program employs specialized contractor, using latest industry standards and trends. Expertise enables effective oversight of the construction process.

Defining Sustainability

Although a fairly recent concept, the triple-bottom-line is the cornerstone of sustainability decision-making. "The Economist" (2009) explains the history and definition of the TBL:

> The phrase "the triple bottom line" was first coined in 1994 by John Elkington, the founder of a British consultancy called SustainAbility. His argument was that companies should be preparing three different (and quite separate) bottom lines. One is the traditional measure of corporate profit—the "bottom line" of the profit and loss account. The second is the bottom line of a company's "people account"—a measure in some shape or form of how socially responsible an organisation has been throughout its operations. The third is the bottom line of the company's "planet" account—a measure of how environmentally responsible it has been. The triple bottom line (TBL) thus consists of three Ps: profit, people and planet. It aims to measure the financial, social and environmental performance of the corporation over a period of time. Only a company that produces a TBL is taking account of the full cost involved in doing business.

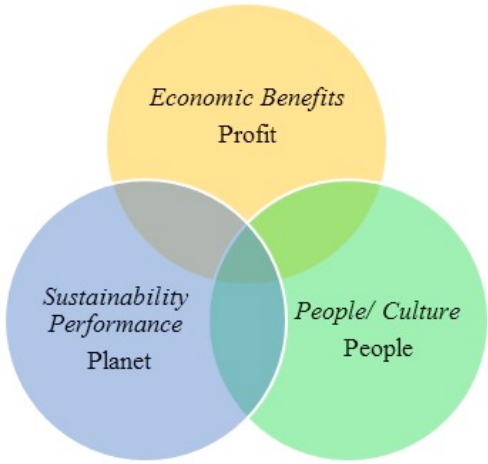

Figure 3. Triple Bottom Line (TBL) Model. In italics is the NNSA's AMP adaptation of the TBL. Overlapping sections represent decisions or projects that are beneficial for multiple reasons.

Despite the wide acceptance of the TBL, many argue that turning the concept into reality can be a challenge. As stated by Jamali, "the problem still facing organizations is the absence of a comprehensive management framework that would address, balance and integrate triple bottom line (TBL) considerations," (2006, p. 809). Therefore, it was important to map the model to concepts that fit better with a government program.

As a government program "profit" would seem to be a difficult idea to apply. However, by re-thinking profit as financial benefit, the concept is applicable.
The "planet" aspect of TBL is well-integrated into the culture of NNSA. As a government organization that handles nuclear materials, responsibility for ensuring the planet is reinforced by several federal, state, local, and NNSA requirements.

The "people" element of the TBL asks users to consider how a product was produced—how is the workforce and local community affected by the work needed to create this product or service. Jamali expands on this concept, and defines this aspect of the TBL as including, "issues of public health, community issues, public controversies, skills and education, social justice, workplace safety, working conditions, human rights, equal opportunity, and labor rights," (2006, p. 812). For NNSA, the elements that asset management programs affect directly is workplace safety, working conditions, equal opportunity, and labor rights, and goes one step further. As an organization responsible for scientific, industrial, and nuclear operations, the workforce must be engaged and highly skilled to discover and correct safety issues.

Defining the triple bottom line for NNSA AMP's. To extend the concept of the triple bottom line (TBL) to NNSA's asset management programs, one must identify what is considered a desirable and undesirable result for each TBL. Desirable results for the optimal air-handler unit is: installing an air-handling unit that meets the most recent green building standard is good for sustainability performance, equipment and installation cost that is cheaper than an conventional unit is good for economic benefit, and equipment installation times are shorter and easier to maintain is good for people, tenants of a building and for maintenance personnel. Table 2 summarizes potential desired and undesired TBL aspects.

Table 2. *Desirable and Undesirable Results for TBL Aspects*

Criteria	Desirable	Undesirable
Sustainability performance	• Technology that meets latest energy or green building codes • Metering and diagnostics • Redesign to maximize efficiency for components	• Like-for-like with old, inefficient equipment • Higher waste/less efficient equipment and operations • Less sustainable solutions to achieve other performance goals
Economic costs	• Cheaper capital/first costs • Cheaper operating costs • Fewer repair costs	• Long return on investment for technologies and installations that are life-cycle cost effective
People/culture	• Lower exposure to hazards • Simplified, easy to understand operations • Clear roles and responsibilities	• Too complex, requires attention, excessive maintenance • Complicated data interfaces • Creates confusion on who is doing what

The following sections analyze how the RAMP and CHAMP programs meet TBL criteria of sustainability performance, economic costs, and people/culture.

Sustainability Performance

RAMP. The roof program implements a white roof, high-insulation standard. Replacing or repairing a roof inherently benefits the energy efficiency of a building because holes and cracks in the roofing cause inefficiency in heating and cooling. RAMP has also adopted sustainable features to include: 1) thicker roof layers ("build up") to achieve target insulation thickness, currently R-30 for all roofs, and 2) a high reflectance requirement.

Occasionally, the additional roof thickness can create issues because it can change the elevation of the roof surface, requiring movement of other equipment on the roof. Roof repair work requires the temporary removal of equipment regardless, so this build up is usually easy to implement. High reflectance on the roof reduces the heat gained by the building, which minimizes heat island effects, as well as reduces how hard the HVAC system work.

CHAMP. CHAMP has several options when achieving sustainable performance. The availability of affordable, sustainable HVAC equipment and designs is ubiquitous. As a result, replacing any equipment in an older facility increases energy efficiency and sustainability performance simply by using common equipment.

However, with several options available for configuration and equipment, it is also easy to miss opportunities. Therefore, the assessment team must go into any project asking "how can we make the project as sustainable as possible?" as a like-for-like replacement is usually inappropriate, but avoids design costs.

One of the sustainability requirements of the program is sub-metering. When installing of large equipment, such as chillers and cooling towers, submetering better monitors equipment health, and therefore, helps target maintenance and energy efficiency improvements.

Economic Costs

RAMP. The sustainability improvements such as roof insulation and reflectance do not have significant cost compared to other standard practices. The cost for RAMP is optimized through the bidding process. Best practices include:

- More work at a site means lower cost per unit (economies of scale)
- Pre-bid processes in early/mid Fall notifies the market of our interest and identifies any fatal flaws for the program early enough for changes to be made
- Expand qualified subcontractor base in order to create competition and reduce prices.
- Perform work in the dry and warm/hot season. Roof material behaves better in these conditions. Extend construction season by phasing work across the country.

While these practices benefit RAMP economically, sustainability practices do not improve the economic outcomes. Therefore, there is not much overlap between economic benefit and sustainability benefit.

CHAMP. Most HVAC work must go far beyond simple design attributes to balance sustainability performance with cost. The potential variability of HVAC systems means economic trade-off analysis must be complete, but for small projects, trade-off analysis must also be inexpensive.

Sustainability was identified as a key requirement at the beginning of the project. During the pilot phase, the program stressed that projects must use modern energy codes and prioritize sustainability. However, the program did not specify the use of green building codes, such as ASHRAE 189.1, to see how HVAC designers would meet the challenge.

When the design team conducted their pre-conceptual design inspection, potential sustainability design elements were identified without considering cost. At the next stage, 75% design, major decisions were made, and trade-offs occurred. Design alternatives were refined and compared to meet all performance goals. Because of the small size of each project, decisions must be quick and inexpensive. Generally, there is bias towards the status quo because it has the most data available, and several of the pro's and con's are qualitative and cannot be costed. This echoes analysis on incorporating sustainability into asset management, stating that, "At present, there is a tendency to adopt like-for-like replacement for many assets, rather than consider if there is an opportunity to defer investment in a given asset and subsequently replace a group of assets with a different configuration or approach to service provision," (Marlow, Beale, & Burn, 2010, p. 1254).

The use of the TBL allowed the program to quickly determine best value. By using a TBL approach, the designer was able to select smaller, less costly equipment rather than assuming like-for-like replacement without extensive analysis. A life-cycle-cost analysis was also used for selection of major HVAC equipment, but as some of indicated, the significant costs associated with life-cycle-cost assessment made it infeasible to complete analysis for the entire project (Niekamp, Bharadwaj, Sadhukhan, & Chryssanthopoulos, 2015, p. 24). Furthermore, qualitative aspects of the project, like usability, expected maintenance behaviors, and tenant comfort remained difficult to incorporate, although obviously critical to decisions for the project team.

People/Culture

RAMP. Given the nuclear nature of its work, safety is a key concern of NNSA. For RAMP, safety risk is greatest during construction, and includes the risk of falling, exposure to chemicals and other hot industrial materials, limited ability to hear on a roof, and exposure to the weather, especially heat and lightning.

A key element to the safety of the program is the oversight by both a third-party and site representatives. By having a work being completed by a third-party with a vetted and competitively selected construction team, NNSA can select the best value team for its work. The program also works with the different sites that review and oversee safety and security documentation, as well as construction. Each site representative gains valuable hands-on experience and gains expertise in roof safety, materials and installation methods. As a result, NNSA has reinforced and increased roof expertise by requiring knowledge at each site be exercised continuously. This builds a basis for informed feedback to improve implementation each year.

CHAMP. CHAMP's close engagement with site representatives occurs early in the project. HVAC system improvement is typically more intrusive, so the program and site benefit from more interaction prior to and during the assessment process.

CHAMP's assessment process aims to collect as much pre-visit design and performance data available for a project. The program then conducts a walk-through to explore options for technologies, configuration and operation. When a site has a preference for what exactly needs to be done to complete a repair, the site ownership can be so strong, better solutions can be dismissed. However, if no solution is envisioned, it is difficult to complete a comprehensive and inexpensive assessment. Therefore, it is critical to understand how much work has already been done, so the program can know how to approach a project.

Because of the importance of the pre-design and design phases, this is where people are considered the most, and must be built in. In addition, the process itself includes the relationship building between the program, the sites, and the specialty design contractor. This relationship is long-term, so investing in communication and a healthy relationship is critical to both ensuring project result and program longevity.

Method for Combining Asset Management and TBL

The analysis presented in this paper demonstrates that asset management and sustainability concepts can be translated into distinct decisions and actions in an infrastructure project and program. The following figures expand on the analysis and show how mapping questions that correspond with TBL onto the asset management process can provide a decision-making tool. The project used to develop these questions was the replacement of an HVAC system for a 25,000 square foot mixed use office building that also has a cafeteria.

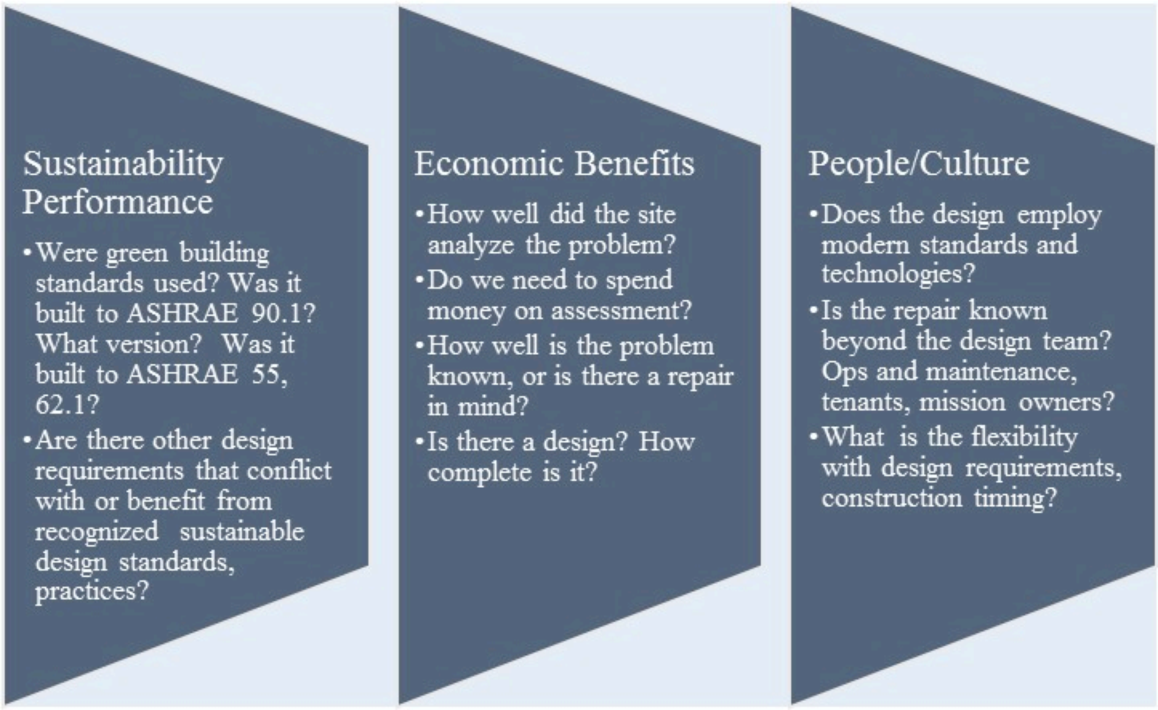

Figure 4. Plan

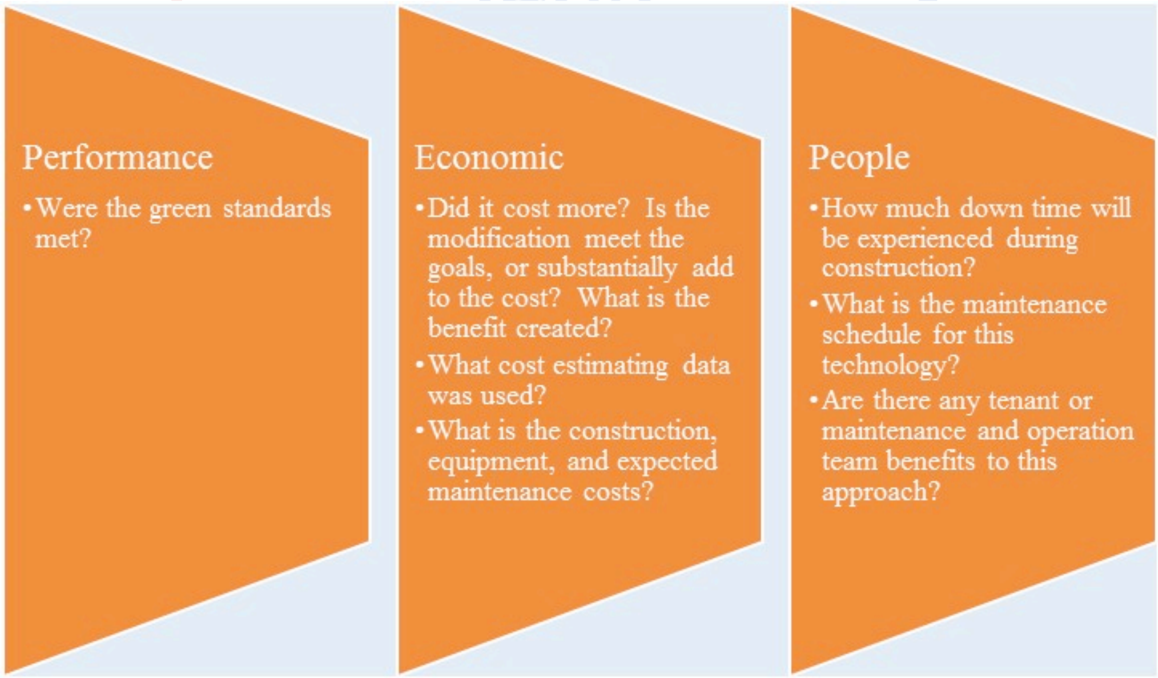

Figure 5. Check

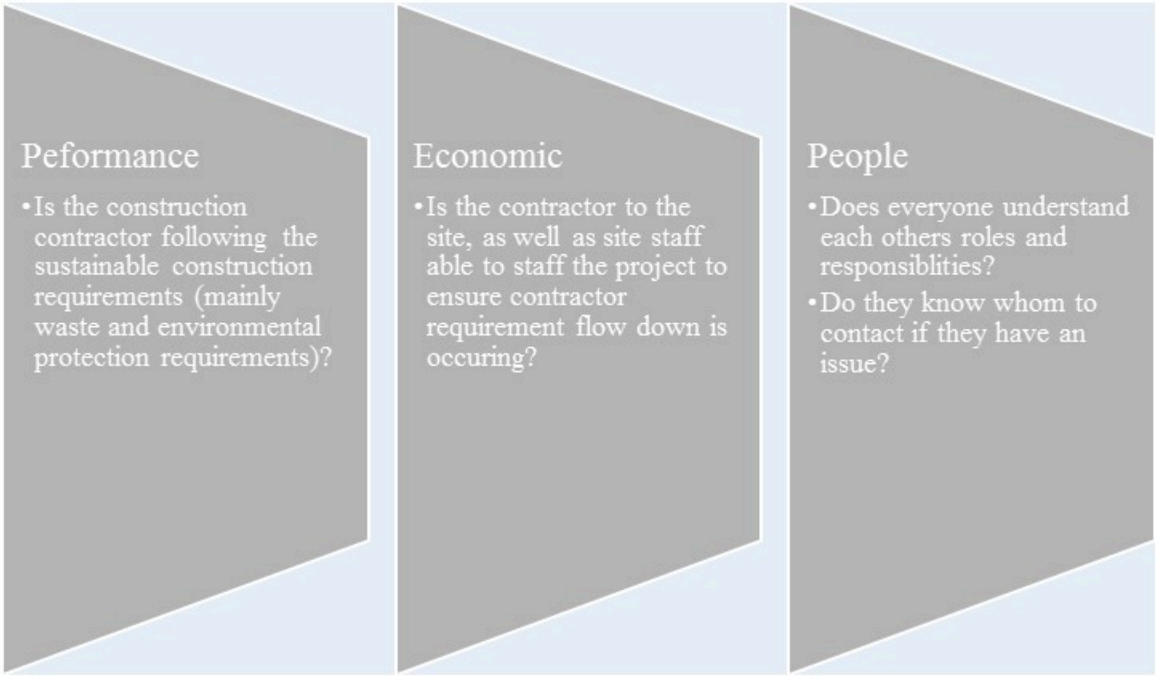

Figure 6. Act

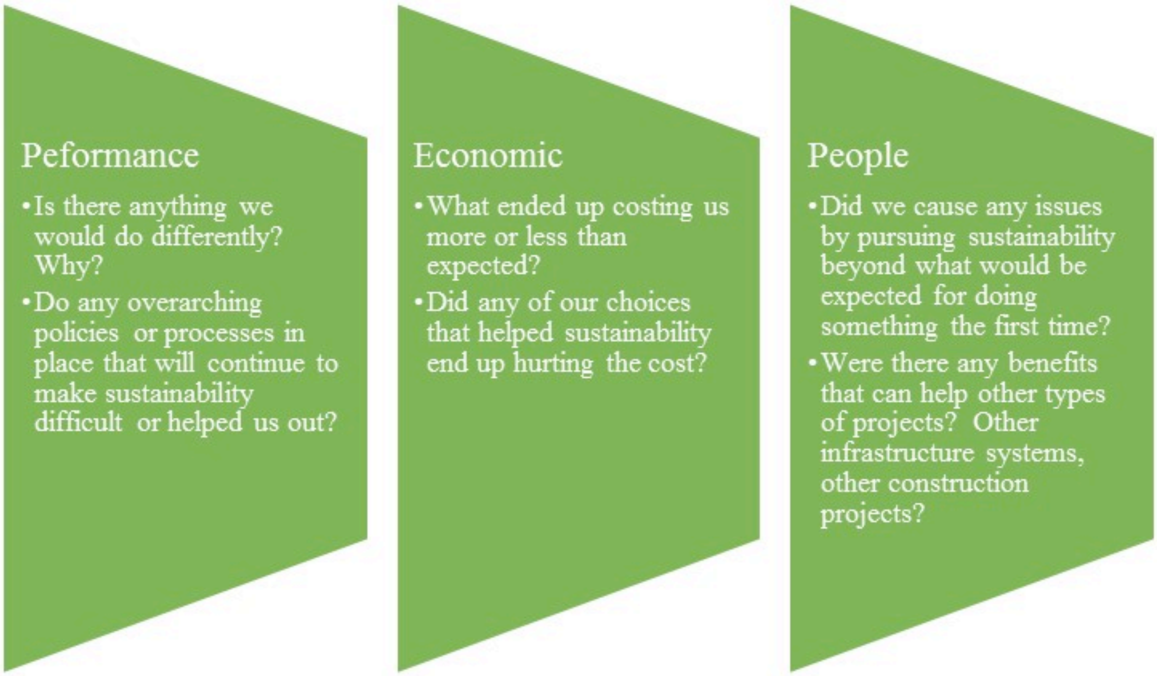

Figure 7. Feedback

Conclusions

Before a project begins, analyzing how asset management and sustainability applies to that infrastructure system is also important because infrastructure systems can differ in significant ways. This analysis shows that roof and HVAC systems can differ, changing what would be a good or a bad outcome. This paper shows that the two systems can be combined in a simple, repeatable way, as shown through the combined sustainability and asset management model presented.

An infrastructure asset management program can help focus attention on specific infrastructure issues. Following an asset management process also opens up the possibility of integrating other frameworks, such as sustainability and the triple-bottom-line in particular, in a systematic way. Sustainability also offers a decision-making framework that is simple and fast, which is a benefit for small projects.

Future Plans

While this paper shows that it is possible to combine these two frameworks for specific infrastructure investments, the next questions are, what is allowing these systems to be compatible, and what are the highest-value activities for both management systems. For example, human factors which would include feedback and the people/culture elements of asset management and sustainability respectively may be a critical factor. Ratanyke explains that "human performance is central to any kind of the asset intensive organization," (2013, p. 205). The implications for infrastructure programs to determine its most influential aspect would then allow a program to invest in its most critical elements, obtaining the best value for its work.

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Quantitative Assessment of River Environment by Focusing on Benthic Biota

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Abstract

River ecosystem is a fragile environment because it can be a primal receptor of wastewater from human society. However, there are few studies evaluating the factors which lead to the loss of biodiversity of river benthos from multiple dimensions. In this study, we try to clarify the interrelation among biodiversity, structure of river ecosystem, and water quality. Field research on benthic species (mainly aquatic insects) was carried out at 17 different sites in the Gunma prefecture in Japan. Sample collection was carried out twice at each station during March 2015 to May 2016 by a Beck-Tsuda β method. In total, we identified 5,141 benthos of 145 species. Biodiversity was calculated by Simpson's diversity index. Structure of river ecosystem was checked at each stations and principal component analysis was carried out for score matrix on structure of river ecosystem. Database of water quality was obtained from website of Gunma prefectural government and principal component analysis was carried out for data matrix on water quality. After that, structural equation modeling (SEM) was carried out. Values of Simpson's diversity index were defined as the objective variable, and scores of respective principal components were defined as explanation variables. As a result, increase in water pollution level causes negative effect to the biodiversity of benthos. On the other hand, increases in submerged plants and litter pack provide positive effects to the biodiversity. Therefore, the improvement of water quality and conservation of habitat will be the important aspects to establish the preferable management program of river environment.

Keywords: Biodiversity, River ecosystem, Structural equation modeling (SEM)

Introduction

Our life is supported by various kinds of ecological services from biodiversity such as resource supply, stabilization of the living environment, and a chance of recreation. Costanza et al. (1997) reported that the world's ecological services account for 33 trillion US dollars. Therefore, the conservation of biodiversity which provides ecological services is one of the important issues in recent environmental interests. However, recent extinction rate of species is estimated to be accelerated in 1,000 to 10,000 times of the natural situation in today's fast-changing environment. Island region originally has high biodiversity but most of them face a crisis of damage. Japan is one of the hot spots of biodiversity as with the other island countries (Myers 1988).

Several types of ecosystem such as forest, river, agricultural land, and ocean play prominent roles in preserving biodiversity. Among them, river ecosystem is fragile environment because it is a primal receptor of wastewater from human society. However, there are few studies evaluating the factors which lead to the loss of biodiversity of river benthos from multiple dimensions.

Katoh et al. (1995) evaluated the changes in benthic biota in the river by using multivariate analysis. This study shows that flow velocity and sediment characteristics are the important factors effecting species composition of aquatic invertebrates. They concluded that the diversity in channel morphology should be considered to conserve ecological community. Nakajima et al. (2007) showed that the physica1 structure of river environment had a positive influence on macroinvertebrate communities via the mode1 with multip1e indicators. In particular, the number of loose stones, depth, flow velocity, and distance from river bank has referred to the significant positive effects to the diversity of benthos. These studies provide important aspects for the conservation of river ecosystem. However, effects by diversity of vegetation and water contaminants were not discussed in detail.

In this study, we try to evaluate the factors which lead to the loss of biodiversity in river ecosystem. We focus on two factors. One is the structure of river ecosystem which dominates the habitat of benthos. The other one is water quality, because benthos have specific pollution tolerance by species (Noguchi et al. 1997). In order to conserve the biodiversity, it is essential to clarify the interrelation among these factors. This study is intended to establish the preferable management program of river environment by focusing on the interrelation among the biodiversity, structure of river ecosystem, and water quality.

Method

A. Monitoring stations

We set up seventeen monitoring stations of ten rivers in Gunma prefecture (see Fig. 1, Table 1). Gunma prefecture located in the northwest area of 100 km away from the central Tokyo. These rivers have important role as the reservoir suppling water resource to the Tokyo Metropolitan Area. Blue solid lines in Fig. 1 indicate the river flow, and red markers indicate the monitoring stations set upped. In case the river has long flow channel, we set up the stations in the upper and lower reaches. The Tone River (Station ID: TN (U), TU (L)) is the main river in this area. It runs from north area to southeast area. The Katashina River (KT (U), KT (L)) flows north area in

Gunma. There are five rivers flow west area in Gunma. From the north, the Agatsuma River (AG (U), AG (L)), the Karasu River (KR (U), KR (L)), the Usui River (US (U), US (L)), the Kabura River (KB (U), KB (L)), and the Kanna River (KN (U), KN (L)). In the east area, we focus on three rivers, The Ishida River (IS), the Watarase River (WT), and the Yada River (YD).

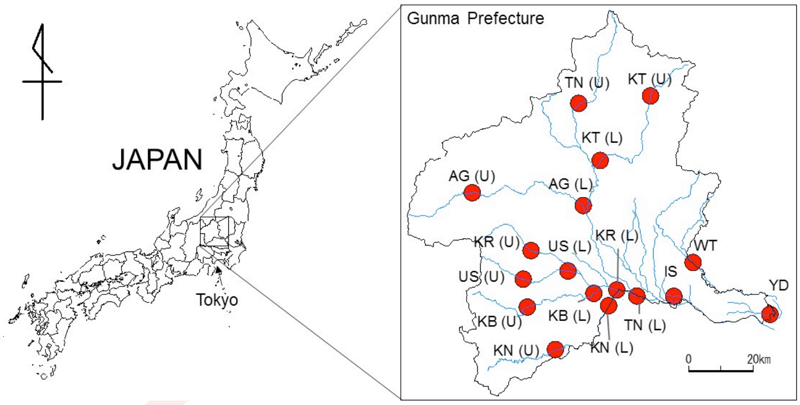


Fig. 1: Location of monitoring stations

Table 1 List of monitoring stations

River	Area	Station ID
Tone River	Upper	TN (U)
	Lower	TN (L)
Katashina River	Upper	KT (U)
	Lower	KT (L)
Agatsuma River	Upper	AG (U)
	Lower	AG (L)
Karasu River	Upper	KR (U)
	Lower	KR (L)
Usui River	Upper	US (U)
	Lower	US (L)
Kabura River	Upper	KB (U)
	Lower	KB (L)
Kanna River	Upper	KN (U)
	Lower	KN (L)
Ishida River	-	IS
Watarase River	-	WT
Yada River	-	YD

(U): Upper, (L): Lower

B. Collection of benthos

Sample collection of benthos was carried out twice at each station during March 2015 to May 2016 by a Beck-Tsuda β method. A Beck-Tsuda β method is a sampling method which enables to collect benthos from various points in the river ecosystem. Kick swipe and stirring are the main ways. In this study, sample collection was carried out in one hour by one parson. Collected benthos were fixed with 75% alcohol and identified species by using a microscope. We refer "Aquatic Insects of Japan: Manual with Keys and Illustrations (Kawai et al. 2005)" for identifying species. *Ephemeroptera*, *Plecoptera*, *Trichoptera*, and *Odonate* are the major species in Japan.

C. Evaluation of biodiversity

Diversity index enables quantitative evaluation on biodiversity, and is often used for environmental assessment (Peet 1974, Nakamura 2000). In this study, we used Simpson's diversity index which is defined as the function indicates below (Simpson 1949). Here, S indicates the number of species. *Pi* indicates *ni /N,* where *ni* indicates the number of the i th species and N indicates total number of collected benthos. D measures the probability that randomly selected two individuals will belong to the same (function (1)). Therefore, diversity index can be defined as the reciprocal of D (function (2)).If many species are well balanced, the index tends to increase. On the contrary, if poor species are out of balance, the index tends to decrease.

$$D = \sum_{i=1}^{S} (P_i)^2 \quad \cdot \cdot \cdot (1)$$

$$\frac{1}{D} \quad \cdot \cdot \cdot (2)$$

D. Evaluation for structure of river ecosystem

We prepare the check list consists of "Flow", "Structure", and "Bottom sediment". From the view point of "Flow", the items of rapid, slow, and stagnate were specified. Rapid indicates the flow with waves. Stagnate indicates stopped or almost stopped flow. Slow indicates intermediate of rapid and stagnate. From the view point of "Structure", the items of riffle, lateral pool, and deep pool were specified. Riffle indicates shallow area. Lateral pool indicates side area like a pond which was separated from the main flow. Deep pool indicates deep area. From the view point of "Bottom sediment", the items of embedded stones, loose stones, gravels, mud, litter pack, moss mat, and submerges plants were specified. Two types of stones can be found. Embedded stones hold tight each other. Loose stones are generally on the other stones, and easy to move. Twenty sites were randomly selected in respective monitoring stations. We filled the check list by presence or absence. The score appeared from zero to 20 by each item.

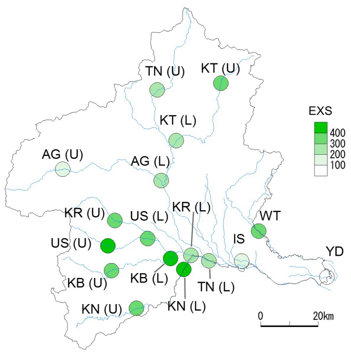
E. Evaluation of water quality

Database of water quality was obtained from website of Gunma prefectural government. In Japan, the water quality of the river is researched by Local government regularly, and disclosed as Database of Water Quality Survey of Public Water. We focus on dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), Total coliform, T-P, T-Zn, T-N, NO_3-N, NO_2-N, NH_3-N, and electrical conductivity (EC). These items are the indicators of the water pollution.

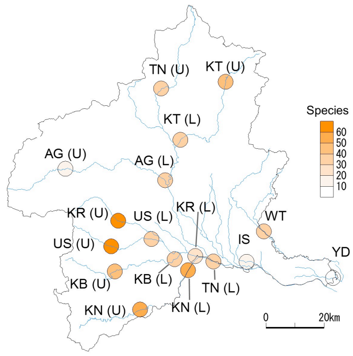
Result and discussion

A. Benthic biota

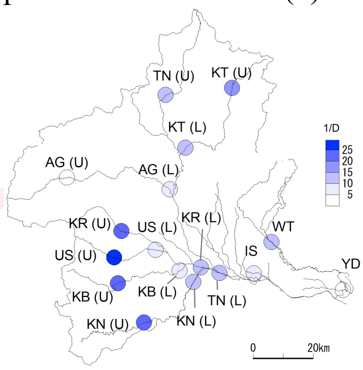
In total, we identified 5,141 benthos of 145 species. Except for AG (U), IS, and YD stations, large variety of benthos was generally observed in each station (see Fig.2 (a)). The result in number of benthos also showed similar distribution. Remarkably small number of benthos was observed at AG (U), IS, and YD stations (see Fig.2 (b)). From the viewpoint of Simpson's diversity index, relatively high values were shown in the upper reaches of southwest basin (KR (U), US (U), KB (U), and KN (U)). On the other hand, notably low values were obtained at AG (U), IS, and YD stations (see Fig.2 (c)). Interrelation among the biodiversity, structure of river ecosystem, and water quality will be discussed below in detail.



(a) Number of species



(b) Number of benthos



(c) Simpson's diversity index

Fig. 2 Distribution of biological indices

B. Structure of river ecosystem

The score matrix characterized the difference in structure of river ecosystem among respective stations (see Table 2). Stations located in the upper reaches (e.g. TN (U) and KR (U)) can be characterized as rapid flow with loose stones on bottom. Stagnated sites were frequently observed at the stations located in the lower reaches (e.g. KN (L) and YD). Moss mat were typically shown on the bottom of slow flow at the stations located in the lower reaches (e.g. TN (L) and KR (L)).

Table 2 Score matrix on structure of river ecosystem

River	Area	Station ID	Flow			Structure			Bottom sediment						
			Rapid	Slow	Stagnate	Riffle	Lateral pool	Deep pool	Embedded stones	Loose stones	Gravels	Mud	Litter pack	Moss mat	Submerged plants
Tone River	Upper	TN (U)	10	8	2	18	2	0	7	15	0	0	2	0	0
	Lower	TN (L)	0	11	9	11	9	0	17	0	0	3	0	17	0
Katashina River	Upper	KT (U)	7	7	6	14	6	0	10	11	0	0	1	0	2
	Lower	KT (L)	7	8	5	15	5	0	7	13	1	0	0	6	4
Agatsuma River	Upper	AG (U)	2	6	12	8	5	7	11	6	0	5	0	0	0
	Lower	AG (L)	6	9	5	15	5	0	7	13	0	2	0	0	2
Karasu River	Upper	KR (U)	8	6	6	14	6	0	7	11	0	1	2	0	2
	Lower	KR (L)	0	16	4	16	4	0	17	10	0	0	0	20	0
Usui River	Upper	US (U)	5	12	3	17	0	3	11	7	0	2	0	2	5
	Lower	US (L)	4	8	8	12	8	0	7	10	1	2	0	15	2
Kabura River	Upper	KB (U)	5	13	2	18	2	0	15	5	2	1	1	17	3
	Lower	KB (L)	7	10	3	17	3	0	8	9	1	0	0	8	4
Kanna River	Upper	KN (U)	6	7	7	13	3	4	6	10	2	0	4	0	0
	Lower	KN (L)	0	0	20	0	5	15	10	3	4	0	3	0	3
Ishida River	-	IS	4	11	5	15	0	5	7	5	3	4	0	0	4
Watarase River	-	WT	6	7	7	13	7	0	6	11	0	2	0	11	4
Yada River	-	YD	0	0	20	0	0	20	14	5	2	6	0	14	0

In order to elucidate the major factors of river ecosystem, a principal component analysis was carried out to the score matrix obtained. As a result, structure of river ecosystem was aggregated into four components (see Table 3). Respective components were interpreted as follows.

● 1st component: Water stagnation (Stagnate (+), Deep pool (+), Rapid (-), Riffle (-)) .
● 2nd component: Embedded stones with moss mat (Embedded stones (+), Moss mat (+), Rapid (-). Litter pack (-)).
● 3rd component: Submerged plants (Submerged plants (+), Gravels (+), Lateral pool (-)).
● 4th component: Litter pack (Litter pack (+), Mud (-)).

Table 3 Principal component profile of river ecosystem

	Component			
	1	2	3	4
Rapid	-0.80	-0.49	0.01	-0.13
Slow	-0.64	0.64	0.25	0.23
Stagnate	0.94	-0.20	-0.20	-0.10
Riffle	-0.94	0.20	0.20	0.10
Lateral pool	-0.10	0.17	-0.77	-0.07
Deep pool	0.92	-0.26	0.18	-0.05
Embeded stones	0.40	0.78	-0.01	0.32
Loose stones	-0.71	-0.38	-0.26	-0.20
Gravels	0.56	-0.38	0.47	0.41
Mud	0.59	0.28	0.17	-0.62
Litter pack	0.07	-0.68	-0.23	0.64
Moss mat	0.14	0.80	-0.07	0.18
Submerged plants	-0.30	-0.17	0.65	-0.17

C. Water quality

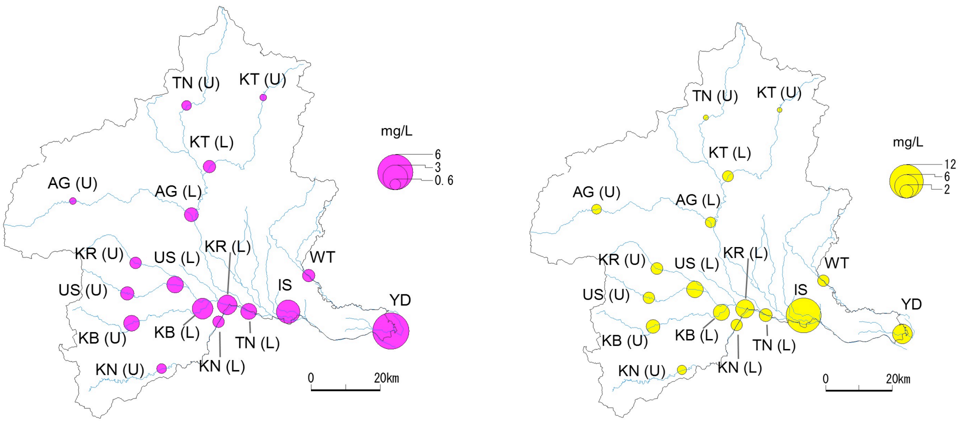
The data matrix characterized the difference in water quality among respective stations (see Table 4). Stations with low diversity index (AG (U), IS, and YD) had unique characteristics in water quality. AG (U) station was situated in relatively low pH condition. It might be due to the contamination of runoff from volcanic hot springs. High concentration of BOD (surrogate of organic pollution) was observed at the lowest YD station (see Fig. 3 (a)) due to a large population who has insufficient sewage treatment system. Remarkably high concentration of T-N (causing an eutrophication) was observed at IS station (see Fig. 3 (b)) located in the extensive farming zone.

Table 4 Data matrix on water quality

River	Area	Station ID	Temperature (ºC)	Water temperature (ºC)	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	SS (mg/L)
Tone River	Upper	TN (U)	15.7	9.8	7.09	11.0	0.5	2.1	3.0
	Lower	TN (L)	17.8	12.8	7.40	12.0	1.3	3.0	9.5
Katashina River	Upper	KT (U)	14.8	8.5	7.40	11.0	0.3	1.6	1.0
	Lower	KT (L)	16.5	11.1	7.62	12.0	0.8	2.0	4.0
Agatsuma River	Upper	AG (U)	14.8	10.8	5.18	12.0	0.3	2.2	21.0
	Lower	AG (L)	17.3	14.6	7.41	11.0	1.0	2.5	13.0
Karasu River	Upper	KR (U)	16.2	13.1	7.69	11.0	0.7	1.6	3.3
	Lower	KR (L)	16.8	15.3	7.61	10.3	1.9	4.2	9.0
Usui River	Upper	US (U)	18.4	13.1	7.97	12.0	0.9	2.6	3.0
	Lower	US (L)	17.5	15.1	8.14	12.0	1.4	3.6	4.0
Kabura River	Upper	KB (U)	17.9	14.1	8.24	13.0	1.3	2.9	2.0
	Lower	KB (L)	20.0	16.2	8.33	13.0	2.1	4.7	9.0
Kanna River	Upper	KN (U)	18.2	12.6	8.14	12.0	0.5	1.6	2.0
	Lower	KN (L)	13.9	13.5	7.89	11.0	0.7	2.1	3.0
Ishida River	-	IS	20.2	18.5	7.66	10.0	2.7	5.4	14.3
Watarase River	-	WT	18.9	14.9	7.63	12.0	0.8	2.5	3.0
Yada River	-	YD	19.3	17.4	7.66	9.3	6.4	11.0	22.0

Table 4 Data matrix on water quality (continue)

River	Area	Station ID	Total coriform (MPN/100ml)	T-P (mg/L)	T-Zn (mg/L)	T-N (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	NH3-N (mg/L)	Electric conductivity (μS/cm)
Tone River	Upper	TN (U)	540	0.01	0.00	0.33	0.23	0.01	0.01	42.8
	Lower	TN (L)	7225	0.09	0.01	1.90	1.50	0.03	0.08	177.5
Katashina River	Upper	KT (U)	138	0.01	0.00	0.30	0.26	0.01	0.01	58.8
	Lower	KT (L)	1625	0.03	0.00	1.38	1.25	0.01	0.02	110.0
Agatsuma River	Upper	AG (U)	33	0.05	0.01	1.10	1.00	0.01	0.05	230.0
	Lower	AG (L)	3300	0.06	0.01	1.28	1.30	0.01	0.04	240.0
Karasu River	Upper	KR (U)	4900	0.02	0.00	1.60	1.50	0.01	0.04	120.0
	Lower	KR (L)	22000	0.16	0.02	3.70	3.10	0.12	0.28	280.0
Usui River	Upper	US (U)	4275	0.03	0.00	1.50	1.40	0.01	0.02	180.0
	Lower	US (L)	33000	0.08	0.09	3.00	2.60	0.05	0.11	402.5
Kabura River	Upper	KB (U)	8250	0.03	0.00	2.10	2.20	0.01	0.06	365.0
	Lower	KB (L)	3300	0.10	0.00	2.90	2.70	0.05	0.08	360.0
Kanna River	Upper	KN (U)	455	0.01	0.00	1.00	1.00	0.01	0.01	180.0
	Lower	KN (L)	5425	0.03	0.00	1.50	1.48	0.01	0.01	220.0
Ishida River	-	IS	132500	0.28	0.02	13.00	10.25	0.18	0.27	552.5
Watarase River	-	WT	2550	0.08	0.01	1.50	1.30	0.01	0.02	120.0
Yada River	-	YD	45500	0.48	0.02	4.18	2.95	0.16	0.94	730.0



(a) BOD (b) T-N

Fig. 3 Concentration distribution of water contaminants.

In order to elucidate the major factors of water contamination, a principal component analysis was carried out to the data matrix of water quality. As a result, water quality was aggregated into two components (see Table 5). Respective components were interpreted as follows.

- 1st component: Water pollution level (BOD (+), T-P (+), T-N (+), EC (+), DO (-)).
- 2nd component: Type of contaminants (T-N (+), BOD (-)).

Table 5 Principal component profile of water quality

	Component 1	Component 2
DO	-0.65	0.12
BOD	0.90	-0.36
COD	0.91	-0.36
SS	0.69	-0.29
Total coliform	0.82	0.55
T-P	0.96	-0.22
T-Zn	0.35	0.19
T-N	0.79	0.59
NO_3-N	0.76	0.63
NO_2-N	0.96	0.13
NH_3-N	0.88	-0.44
Electric conductivity	0.91	-0.06

D. Interrelation among the biodiversity, structure of river ecosystem, and water quality

To identify the interrelation among the biodiversity, structure of river ecosystem, and water quality, structural equation modeling (SEM) was carried out. Values of Simpson's diversity index were defined as the objective variable, and scores of respective principal components were defined as explanation variables (see Table 6). It is known that well fitted model has RMSEA with 0.08 or less and the lower in AIC.

Table 6 Variables for structural equation modeling (SEM)

			Biodiversity	Structure of river ecosystem				Water quality	
River	Area	Station ID	Simpson's diversity index	Water stagnation	Embedded stones with moss mat	Submerged plants	Litter pack	Water pollution level	Type of contaminants (Nitrogen or Organics)
Tone River	Upper	TN (U)	14.02	-1.12	-0.97	-0.59	0.28	-0.71	-0.23
	Lower	TN (L)	13.76	0.66	2.04	-1.2	0.44	-0.2	-0.18
Katashina River	Upper	KT (U)	15.91	-0.57	-0.41	-0.8	-0.05	-0.78	-0.11
	Lower	KT (L)	11.97	-0.76	-0.39	0.18	-0.43	-0.6	0.04
Agatsuma River	Upper	AG (U)	2.25	0.89	0.27	-0.68	-1.4	-0.33	-0.49
	Lower	AG (L)	9.39	-0.66	-0.23	-0.34	-1.08	-0.24	-0.4
Karasu River	Upper	KR (U)	23.51	-0.58	-0.86	-0.89	-0.19	-0.53	0.1
	Lower	KR (L)	10.6	-0.31	1.96	-0.46	1.34	0.65	-0.05
Usui River	Upper	US (U)	27.74	-0.52	0.33	1.75	-0.45	-0.51	0.02
	Lower	US (L)	6.92	-0.11	0.35	-0.8	-0.54	0.28	0.82
Kabura River	Upper	KB (U)	20.67	-0.33	1.01	1.23	1.58	-0.37	0.22
	Lower	KB (L)	9.91	-0.78	-0.01	0.85	0.03	0.09	-0.17
Kanna River	Upper	KN (U)	23.56	-0.08	-1.45	-0.53	1.64	-0.69	0.07
	Lower	KN (L)	11.59	2.03	-1.56	0	1.49	-0.45	0.06
Ishida River	-	IS	5.14	0.16	-0.21	2.35	-0.43	2.24	2.85
Watarase River	-	WT	11.02	-0.46	-0.02	-0.39	-1.2	-0.51	0
Yada River	-	YD	4.22	2.53	0.15	0.33	-1.04	2.67	-2.57

As a result of SEM (see Fig. 4), the biodiversity is dominated by structure of river ecosystem and water quality. According to the standard partial regression coefficients indicated on the path, increase in water pollution level causes negative effect ($p<0.05$) to the biodiversity of benthos. On the other hand, increases in submerged plants and litter pack provide positive effects ($p<0.10$ and $p<0.05$, respectively) to the biodiversity. Watanabe et al. (2006) suggested that removal of the natural reed riverbed has negative effect to the biological indices. Therefore, the improvement of water quality and conservation of habitat will be the important aspects to establish the preferable management program of river environment.

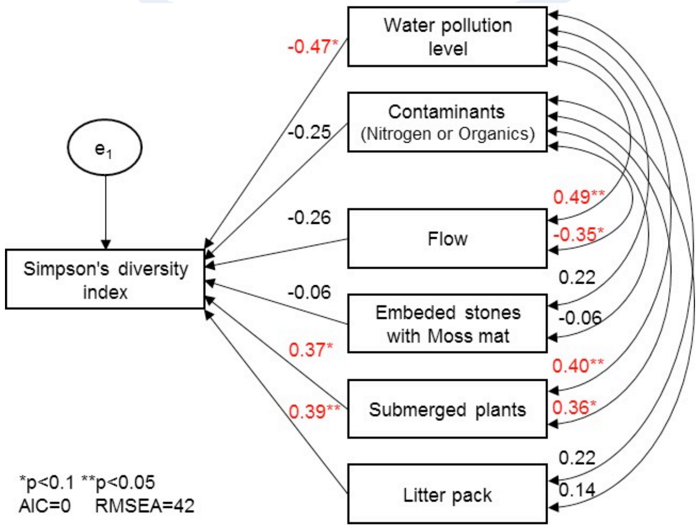


Fig. 4 Interrelation among the biodiversity, structure of river ecosystem, and water quality

Conclusion

Biodiversity of river benthos is dominated by various elements of the ecosystem. To establish the preferable management program of river environment, we need to understand the interrelation among the biodiversity, structure of river ecosystem, and water quality. In terms of the conservation of biodiversity in the river ecosystem, following two efforts will be needed. One is the improvement of the water quality particularly in the lower reaches of the research area. The other one is the conservation of habitat containing submerged plants and litter pack in abundance. To achieve a symbiosis with nature, we hope for evidence-based policy and decision making.

Acknowledgements

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Sustainable Development of Catchment Land-use for Multifunctional Agro-ecological Landscapes under a Changing Climate

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Abstract

Incorporating the likely impacts of climate change into regional and rural planning is vital to accommodate their profound effects on anthropogenic systems such as agriculture that interact with, or are directly dependent on, natural environments. In Australia, adaptation is already occurring at local and regional levels through regulatory shifts, new resource management strategies, and land-use change, both voluntary and forced by regional policies and strategic priorities. Agricultural land-use has been undergoing a transformation. The continuous optimization and direction of adaptation activities provides regional authorities with the opportunity to ensure that economic and environmental benefits are maximized.

This paper outlines research assessing potential land use changes over a long planning horizon (to 2070), by looking at impacts of climate change on agricultural sector of Regional Victoria. The modelling indicates that a transition to intensive horticulture would be biophysically possible and economically feasible. Phasing out livestock farming and replacing it with optimally diversified horticulture would enable largescale protection of existing carbon stocks and guide further carbon sequestration efforts. Well managed land-use would also increase overall resilience, while ensuring its contribution to a less carbon-intensive future of the industry.

This research will develop new framework assessing land suitability of rural areas under rapid change by analyzing both biophysical and socio-economic factors. The proposed strategic foresight scenarios will take into account risks and opportunities presented by projected land-use shifts in the context of local economy.

Keywords: Climate change impacts, adaptation, land-use optimization, strategic foresight, spatial modelling

I. Introduction

Climate change is a serious threat to the world economy, environment and communities, with profound impacts on many systems, particularly agriculture (Meadows et al. 2006; IPCC 2014). The world faces a great challenge to continue producing enough food for a rapidly growing population during an era where natural resources (arable land, water) are scarcer and where the biophysical environment is becoming increasingly unfamiliar to farmers. The key to addressing this challenge is a focus on building adaptive capacity to ensure currently productive regions remain so, and to increase the resilience of farming systems to ensure they remain viable despite the inevitable climate-shocks associated with extreme weather. These can be anything from technological advances, to development of new methodologies that incorporate existing frameworks to ensure successful adaptation of rural regions to climate change and resilience building. Significant economic, social and environmental opportunities can be capitalized on by communities with well-established strategic foresight and planning for the projected climate changes in their regions.

This paper outlines a framework that focuses on bio-physical as well as socio-economic components necessary for a successful regional development planning, with agriculture at the forefront of the development efforts. This framework is applied in the state of Victoria, Australia. The economy of the State of Victoria makes up a significant part of Australian economy. Agriculture formed 21% of national production total gross value in 2014-2015 (ABS 2016). With 60% of the state's land area used for agriculture, its rapid transformation caused by environmental and socio-economic stressors show the great importance of robust planning and decision making (Sposito et al. 2010). Many Victorian regions are known as the 'food-bowl' of Australia and capitalize on their favorable soil and climate conditions as well as close proximity to major ports connecting the state to emerging markets in Asia. Driven by growing middle class, especially in China and India, the Asian-Pacific markets generate demand for a large portion of crop and livestock production, making up a fifth of the national export value (Van Dijk et al. 2013; Faggian et al. 2012; Hatfield-Dodds et al. 2015; Sposito et al. 2010; Beyond Zero Emissions 2014).

All the outlined changes in environmental conditions as well as economic opportunities for regional branches of Victorian agricultural sector indicate a strong need for a better planning across farm, community and regional scales. Planning is generally concerned with reducing the likelihood of failure (for example, by systematically addressing risks, and can therefore be linked to climate change adaptation). This paper will introduce a number of governmental schemes designed to help the Victorian agricultural sector, regional economies, and also the climate change mitigation/adaptation efforts. A number of which have failed due to the lack of foresight in the early planning stages. When compared with planning, foresight techniques are more concerned with proactively shaping events over a long time horizon by developing knowledge about possible futures (and can therefore be linked to building climate resilience). Pro-active along with pre-active approaches advanced by foresight help linking the anticipation of a planning scheme or a regional strategy to the action (Godet 1994) of particular farmers and communities by implementing proposed land-use changes.

The scenario-based crop-yield models generated at this stage of the project will be presented to local farmers and regional government and other planning organizations. Some of which will use the generated information to inform their own conceptual models of their system of interest (be it a farm, a food-production system or a region), which in turn will inform how they think about, and implement, actions that contribute to climate adaptation and resilience. For instance, a farmer may look at the aforementioned models and decide to diversify their production system by introducing a new variety or species. This action, along with the farmers subsequently increased knowledge of the biophysical environment and the plant interactions with it, will contribute to their resilience. The same modelling will have different (complimentary or perhaps competing) implications at higher levels of abstraction (regional-level, food-system level, etc.), which will shape the next stages of the project.

The framework presented throughout this article helps to determine challenges along with opportunities necessary to be included in planning schemes, strategies and policies. Firstly, a *Land Suitability Analysis (LSA)* methodology working with bio-physical variables in a GIS environment will be introduced. The analytic approach will then be followed by a set of climate projections for Victoria, which have to be taken into account when developing all future scenarios and recommendations for the state's regions. Subsequent discussion on the development potential of Regional Victoria analyzes a number of historical shocks and past government programs, looking at their primary incentives as well as outcomes, with the aim of informing future planning decisions. The last section introduces *Strategic Foresight* as a decision making support tool with the aim to increase transparency of regional decision making process and bridge the gap between strategy formulation and implementation.

II. Methods

Land Suitability Analysis (LSA) evaluates a biophysical quality of an area by determining the potential of an optimal land use or cover. This depends on the environmental requirements of targeted commodities to reach an optimal yield without compromising vital attributes such as fertility and biodiversity (Ferretti & Pomarico 2013; Malczewski 2004; Romeijn et al. 2016). Even though this approach is predominantly analytical, it also incorporates expert opinion of specialists and farmers to reflect their knowledge in the evaluation stages of the commodity models and output maps. The early participation of regional stakeholders contributes to an overall transparency, making projects truly regional and tailored to the needs of local communities. The expert involvement increases robustness of the environmental models, ensuring an appropriate representation from specialists in fields integrated in the land-use and managed ecosystems science. To further enhance the relevance of our research findings and their translation into plans, strategies and policies, this framework proposes a further use of both experts from local institutions, commercial bodies and individual farmers to account for the uneven distribution of information (Farmer & Foley 2009) and diverse perspectives of the involved parties. Their evaluation and the resulting consensus between scientific expert and local knowledge is critical to form pertinent decisions about future land use and the role of agriculture in local economies.

Land Suitability Analysis

Multiple Criteria Analysis (MCA, or Evaluation MCE) is a commonly utilized methodology used to develop the aforementioned mathematical suitability models. It uses suitability as a proxy for crop yields that determine values of all underlying environmental attributes (Sposito et al. 2013; Romeijn et al. 2016). It considers 3 main variables: *Climate, Soil* and *Landscape*, with assigned weights depending on their influence on commodity growth and subsequently yield. Those variables are subdivided into several other attributes, whose value ranges are set to meet the optimal yield, with indexes ranging from 0.0 to 1.0 depending on the agricultural potential of 0% to 100% suitability. The attributes with their criteria are analyzed using an *Analytical Hierarchy Process (AHP)* developed by Saaty (1987) an example of which can be found in Figure 1.

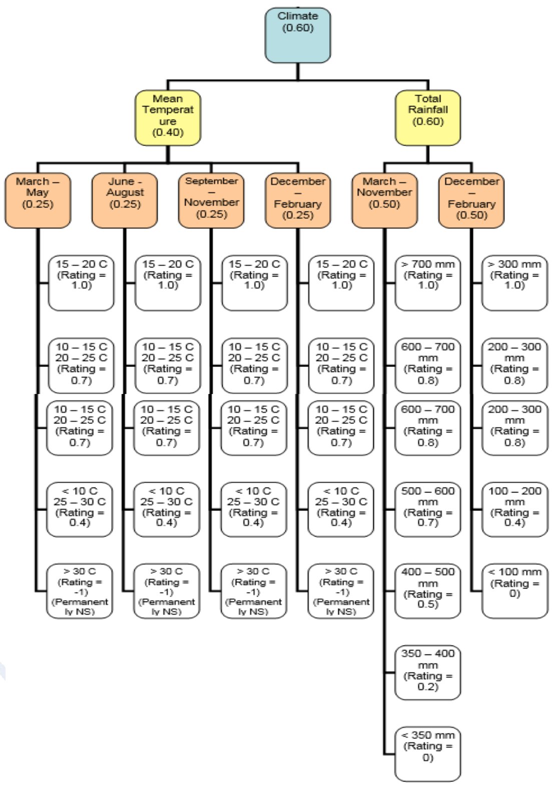

Figure 1 – Land Suitability Model: Climate Hierarchy

Both MCA and AHP are widely used in LSA studies and are embedded in a GIS environment, producing a spatial representation of outputs by using a weighted overlay of all the attributes and their extremities (Ferretti & Pomarico 2013; Malczewski 2004; Dujmovic et al. 2009; Bathrellos et al. 2013). The models are developed for multiple timeframes, the first one being a climate normal, or a baseline, and future projections. The baseline represents a current climate by averaging values of measured historical data from a period of 1960-1990. The projections are modelled for years 2030, 2050 and 2070.

Climate Projections

The baseline climate data has been derived from an averaged overlay of SILO and WorldClim datasets. SILO data has a resolution of 5 km^2 and provides historical climate data (precipitation; maximum, minimum and mean temperature) from Australian Bureau of Meteorology (Department of Science, Information Technology and Innovation 2016). WorldClim data has a resolution of 1 km^2 and was created by interpolating average monthly values by combining data from a number of global as well as local Australian databases (Hijmans et al. 2005). The output baseline layers have a 1 km^2 resolution, to be comparable with the projection datasets. Values for 2030, 2050 and 2070 have been derived using a 1 km^2 ACCESS 1.0 global climate model developed for Australia by CSIRO-BOM (Ramirez & Jarvis 2008). The projection models represent the most recent Representative Concentration Pathways (RCP) scenarios (IPCC 2014).

Foresight Framework

The study will use *Framework Foresight* developed by Peter Bishop and Andy Hines, presenting a standardized method that promotes supplementation from other techniques at various steps (Hines & Bishop 2013). It assesses their strengths and weaknesses, making it easier for foresight practitioners to determine which methods suite their objectives the best within different phases of the foresight analysis. The use of this particular well-established framework increases the potential for the land-use framework to be adopted as a tool for a strategic regional land-use planning by involved parties without the need for a scientific intermediary. Following three scenario techniques have been selected to be best suited to complement the Framework Foresight and promote community-based decision making.

Incasting works with scenarios created ahead of time. Those scenarios are often global in nature (such as those created by Shell and IPCC, or as in the case of this project more localized such as CSIRO Natural Resource Management scenarios used in the context of Victoria (CSIRO and Bureau of Meteorology 2015; Grose et al. 2015)). The Incasting method can be used with groups of stakeholders that are presented with a number of alternative future pathways as determined by the general scenario (Schultz 2003). The participants are then encouraged to determine the impacts each of the scenarios would have on different domains within their region (often from the STEEP categories of Social, Technology, Environment, Economics and Political). It is based on judgement and is logistically quite simple, since the scenario kernels are already provided (Hines & Bishop 2013; Hines & Bishop 2015). Incasting promotes stakeholder participation and engagement which can increase acceptance of the resulting strategies formulated on the basis of the scenario analysis (Mrazova et al. 2016).

Backcasting starts with multiple visions of the future and works backwards, creating a new set of scenarios based on the stakeholder input (Bishop et al. 2007; Kröger & Schäfer 2016; Börjeson et al. 2006). This approach aims to break away from the historical trends and encourage creative thinking, balancing between the realms of plausible and possible (Börjeson et al. 2006). Backcasting has a number of different techniques, all of which are better suited for medium to long term time horizons. Similarly to the incasting techniques, all of them are based on judgement and can be participatory (Bishop et al. 2007).

La Prospective as developed by Godet and his team created a number of tools focused at strategy formulation and scenario analyses in regional context. It seeks large participation, encouraging information exchange and strategic dialogue between community leaders, representative and the public. As in the case of incasting, it explains global trends in a local context. Godet and Durance (2011) state that 'the external influences such a globalization, technological change, climate change, external constraints are not to be seen as obstacles to be overcome but rather opportunities to be seized,' promoting change as an opportunity, which could lead to a positive change of attitude. As a methodology, the prospective approach is rather complex and resource intensive, but the computer programs developed by Godet and his team can be complementary to the Framework Foresight, providing well established tools for phases such as stakeholder analysis carried out by the Micmac software.

III. Climate Change

Australian climate is characteristic by its high natural variability. If coupled with the projected impacts of climate change, primary industries such as agriculture and forestry are likely to face more severe changes with an earlier onset than the rest of the world (Beyond Zero Emissions 2014; CSIRO 2015; Grundy et al. 2016). The climate models that are visualized in Figure 3 and Figure 4, are accompanied with large uncertainty due to the aforementioned natural volatility of Australian weather. Accounting for the uncertainties, the possible environmental shifts are alarming, as they are *'likely to affect all aspects of Australian food production'* (Beyond Zero Emissions 2014). The following sections cover environmental as well as socio-economic impacts of projected climate change on agricultural sector of Victoria. The contribution of the primary industries to greenhouse gas emissions, pointing out the potential for climate change mitigation along with sequestration possibilities will be covered in the discussion.

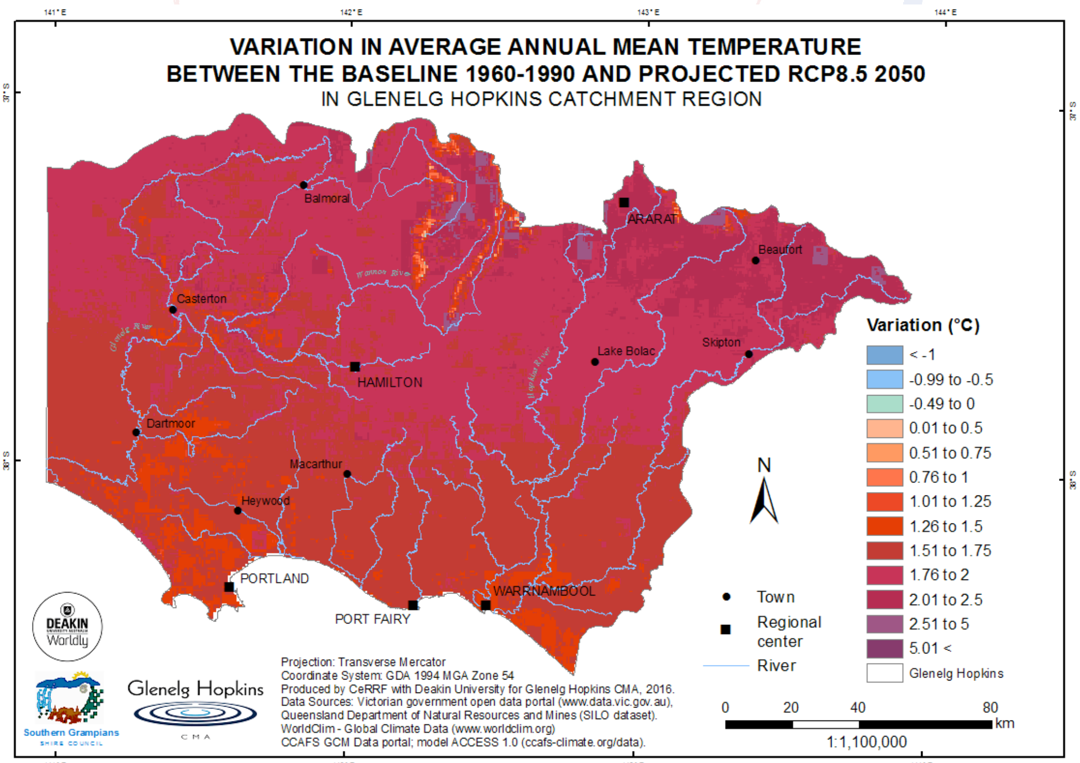

Figure 2 – Projected change of annual mean temperature averages between baseline 1960-1990 and RCP 8.5 values for 2050

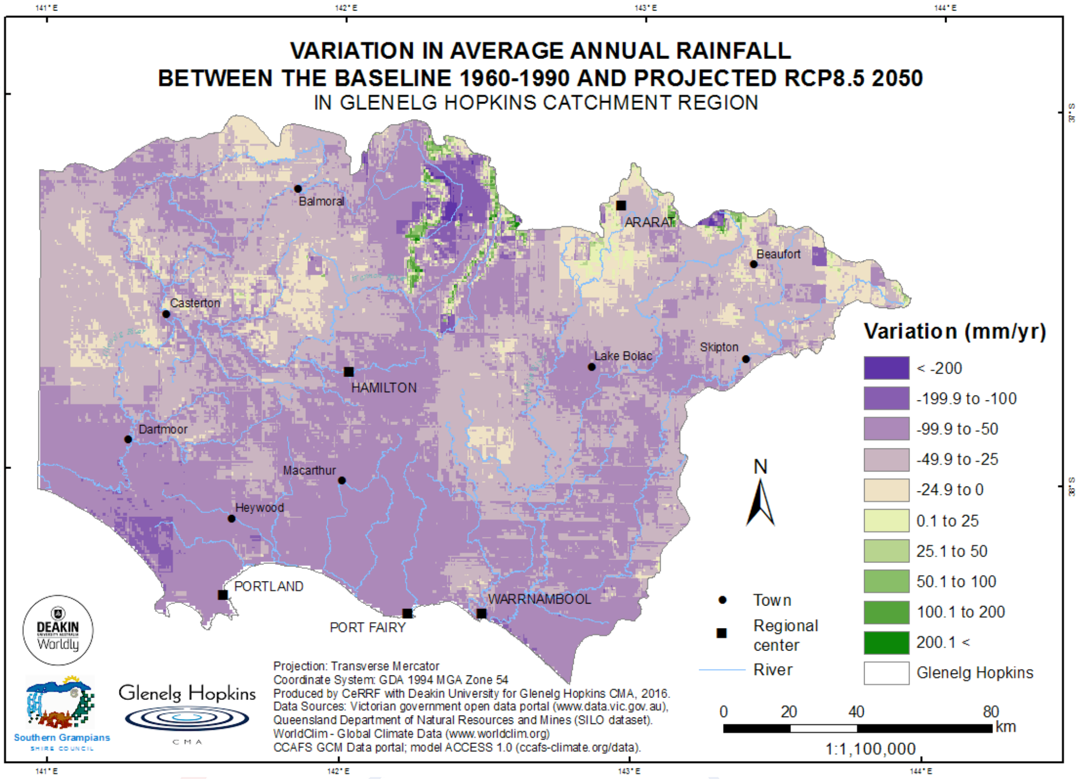

Figure 3 – Projected change of annual precipitation between baseline 1960-1990 and RCP 8.5 values for 2050

Environmental impacts of projected climate change

As apparent from Figure 1 showing an example of an AHP model, climate is a variable with the highest influence on agricultural commodities. The projected increase in average mean temperature accompanied by less accumulated frost days has the potential to severily hinder growth of some commodities (such as desidious fruit trees) that require a certain number of accumulated chilling units (consecutive days of negative temepratures) to ensure a long enough dormant stage vital for a healthy development of their buds (Sposito et al. 2013; State Government Victoria 2013). A long enough period of colder temperatures are beneficial for temperate crops in general to minimise spread of certain diseases and pests that thrive under warmer conditions (Altieri et al. 2015).

More heat days of temperatures above 35°C coupled with a reduced average rainfall and consequently stream flows also negatively impact on many commodities suffering from the lack of available soil moisture and increasing erosion. Less frequent but heavier rainfall during winter months that is already being recorded around Victoria (most recently in September 2016) results in floods, causing depleted soils to waterlog and damage winter crops before harvest. Water shortages as well as the lack of infrastructure engineered to accumulate flood water for use in dry summer months cause droughts, that together with bushfires threaten summer crops. (State Government Victoria 2013; The State of Victoria Department of Environment and Primary Industries 2013)

South East Australia has faced three major droughts in the recorded climate history, *Federation* (1895–1902), *WorldWar II* (1937–1945) and the most recent *Millennial*

Drought (1997–2010) that is the most severe drought since European settlement at the end of 18th century (Verdon-kidd & Kiem 2009; Cai et al. 2014; Kiem 2013; Heberger 2012). The study by Verdon-kidd & Kiem (2009) determined that *'the three droughts differ in terms of severity, spatial footprint, seasonality and seasonal rainfall make-up. This diversity arises due to the fact that the droughts are driven by different climatic teleconnections with the Pacific, Indian and Southern Oceans'*. High variability of Australian weather and climate forcings coupled with uncertain impacts of climate change potentially exacerbating the already existing volatility, therefore makes forecasting of droughts rather difficult, but vital for the survival of dry-land agriculture typical in Victorian regions. Van Dijk et al. (2013) calculated that the Millennium Drought caused an amplification of wheat crop yield decline by a factor of 1.5-1.7. Offset of some of the long-term negative impacts of the drought caused by increased water use efficiency, although significant, was overshadowed by several non-linear responses and accumulating impacts on the hydrological system. Consequential lower yields and higher costs put the Victorian farmers and environment under stress for over a decade, emphasizing the importance of timely and comprehensive adaptation efforts (Van Dijk et al. 2013; Heberger 2012; Kiem 2013).

The above mentioned environmental impacts of a warming climate create challenges as well as opportunities for Victorian regions. Given that the soil erosion is kept to the minimum by employing low or no-till sowing, crop rotation, improved irrigation and soil fertility management practises, heat or drought-resistant crops present lucrative alternatives. (Sá et al. 2016; Bryan et al. 2014; Glenelg Hopkins CMA 2015; Beyond Zero Emissions 2014; Heberger 2012; Cassman & Wood 2005) The high resistance plants as well as commodities suited for warmer climates are ideal for diversification, increasing resilience of the region's agriculture, with a potential to create jobs supporting regional communities and their growth.

Socio-economic impacts of projected climate change

As mentioned above, agriculture constitutes a large portion of many regional economies across Victoria. Due to the significant portion of produce being exported to Asian-Pacific region, it also plays an important role in global food security. The projected growth of Asian population and middle-class along with modelled climate change impacts, Victoria's and even Australia's position on the global food market can be weakened and consequently threaten its contribution to food security (Qureshi et al. 2013; Fischer et al. 2014; Smith et al. 2016; Vermeulen et al. 2012; Challinor et al. 2014; Altieri et al. 2015; Kpadonou et al. 2017).

Qureshi et al. (2013) calculated a total mean expected agricultural production for a *climate normal* based on historical average and alternative scenarios based on the amount of available rainfall. For the dry climate projection of 2030 consistent with findings of the above presented models of Victorian rainfall, the research estimates an average decline in total production of 29%. The rest of researched commodities and their estimated values are in Figure 5, showing the largest decline for staple crops and smallest for horticulture and viticulture. Diversification of existing agriculture by introducing intensive horticulture and viticulture to suitable land has the potential for a higher economic feasibility than continued use of land for cereals and pasture that can be seen across the state.

Commodity	Climate normal expected mean production (1000 tonnes)	Climate dry production (% change)
Cereals	594	-25
Rice	625	-71
Pasture related activities	8470	-31
Horticulture	1488	-15
Viticulture	1403	-18
Total	12,579	-29

Figure 4 – Total mean expected production (tonnes) in climate normal and percentage change in alternative dry scenario (Adapted from: Qureshi et al. 2013)

Close cooperation with Victorian Regional Councils, Catchment Management Authorities and farmers as well as the outcomes of an inaugural conference on *Rural and Regional Futures organized by Planning Institute Australia* in November 2016 suggest that demographic pressures such as aging and overall population decline together with a shortage of skilled workforce present other challenges faced by Regional Victoria and Australian regions in general. Lack of facilities further impedes any demographic incentives by regional governments to attract younger generations (Spataru et al. 2016).

IV. Discussion

It is essential for Australian regional communities as well as the agricultural sector to build resilience to be able to face shocks caused by environmental and socio-economic pressures highlighted in the previous sections. The recent history in rural Victoria has seen a number of significant disturbances such as the failure of chickpea crop in recent years due to the extended drought (Siddique & Sykes 1997) and the collapse of the wool and hardwood industries. The Australian Government has had a number of incentives to support agriculture as a vital part of regional economies and more recently as a possible carbon sequestration tool in climate change mitigation. Success of such government programs can often be undermined by frequent changes in leading political parties with different agendas and priorities combined with insufficient long-term project planning.

For example, the economy of southwest Victoria was underpinned by wool production for 150 years. The industry boomed in the 1980's due to a highly favorable climatic period and high commodity prices. However, in the late 1980's, the collapse of the *Australian Wool Reserve Price Scheme* (due to falling international demand) saw the local wool industry collapse (Bardsley 1994). Farmers proudly identify themselves as a type of producer (for example, a 'wool producer'). It seems, for some, that diversifying production is too high a cost as it dilutes their claim to 'wool producer' status and therefore diminishes their identity in the farming community, even if the alternative is financial hardship. Similar trends can be observed with cattle and dairy farmers alike.

The *Managed Investment Schemes (MIS) was* another governmental incentive addressing the deficit in Australian trade in wood products in the 1990s that has also proven to be insufficiently planned and executed. Allowing income tax deductions for investors in timber plantations caused agricultural land prices in southwest Victoria to artificially grow due to increased demand. Hardwood plantations of Bluegum trees required a large upfront investment that first time investors often did not have, with an average growth period of 10 to 15 years (NewForests Asset Management Pty Limited

2015). The economic downturn precipitated by the 2008 financial crisis caused many individuals and businesses to default on their hardwood plantation loans. The affected plantations were subsequently sold off to larger companies or reverted back to agricultural use. The decline in land prices that followed has resulted in land-use transition back to agriculture in many places, but at a price of up to AUD 2,000 per hectare to remove tree stumps and rehabilitate pastures (Beyond Zero Emissions 2014; NewForests Asset Management Pty Limited 2015; Schlesinger 2014). Also, low prices for hardwood and high labor costs mean it is often too expensive to harvest the timber in plantations. As a result, many plantations established under Managed Investment Schemes have effectively been abandoned – not only have they locked up potentially productive agricultural land, but they also pose a significant fire hazard in the landscape. Of course, global economic crises or shocks (such as the 2008 Financial Crisis or the Great Depression) are very difficult to predict. Including foresight analyses in the process of articulating governmental incentives resulting in large scale land-use change are vital in order to increase resilience of the branches of primary industries already under stress from bio-physical drivers of change

The most recent governmental schemes for the agricultural sector are the *Carbon Farming Initiative* and the *Emissions Reductions Fund* launched in support of farmers wishing to introduce carbon offsetting as a part of their farming system, in exchange for tradeable carbon credits. Bryan et al. (2015) modelled the potential of carbon and environmental plantations (such as the aforementioned Bluegums) for emissions abatement, and adoption rates of new land-use practices. Their results indicate an average lag of new land-use implementation of 16 years, determined by a range of hurdle-rates using profitability as the driver of land-use change rather than bio-physical factors. The study calculated that *'plantings-based land sector abatement has the potential to supply between one third and one half of Australia's total abatement potential from 2031–2050, assuming substantial abatement of direct emissions from other sectors',* and proposed Bluegums as the fastest growing type of carbon plantations, offering the highest sequestration rates (Bryan et al. 2015, p.31). The slow adoption rates, and more importantly, the aforementioned problems with forestry in South West Victoria suggest that there is sometimes a significant gap between research (that informs policy) and reality.

Robust decision making with strategies based on historical trends as well as sound future scenarios built on challenges and opportunities are important to achieve desired, yet well-planned change in regional communities (Sposito et al. 2010). There is a number of decision support tools for local governments or farmers (Kerselaers et al. 2015; McCown 2012) that seek to influence seasonal planning, whereas the framework proposed by this research focuses on long term decision making, influencing the overarching direction of the agricultural sector and consequently the regional economy structure. The framework structure is shown in Figure 5. Reactive planning common in the current practice proves to be insufficient when attempting to tackle complex issues such as climate change and regional development. Pro-active and pre-active approach is proven to be better, allowing for a foresight component ensuring longevity of vital projects. Small scale foresight projects designed for specific communities and their circumstances are essential, with a notable example of the regional scenario development of irrigation futures for the Goulburn Broken Catchment in Victoria that showed large participation and positive outcomes in terms of transparency and project commitment (Wang et al. 2007).

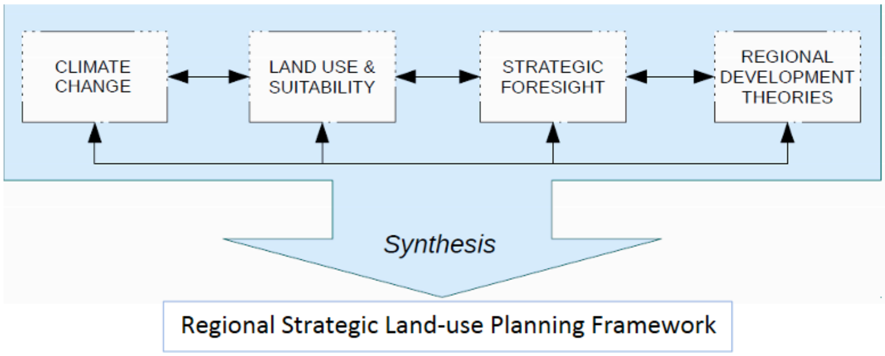

Figure 5 – Regional Strategic Land-use Planning Framework

Foresight is a useful decision support tool for interdisciplinary projects involving stakeholders from various backgrounds. Kröger & Schäfer (2016) have used scenario techniques to facilitate cooperation and communication between an interdisciplinary research team focusing on sustainable land-use. The apparent lack of foresight expertise and project design (shown by insufficiently chosen objectives as well as foresight methods, and lack of transparency of the underlying foresight decision about main drivers, storylines and used techniques observed by the participants) apparent from the publication shows the difficulty of interdisciplinary work involving scientists alone. Successful engagement of stakeholders of varying backgrounds and positions is equally or perhaps more challenging, and can be further hindered by the aim of the presented research to create a transformative change of agriculture, known to be among the most traditional and conservative sectors of primary industries, but also the most threatened by the projected bio-physical and socio-economic changes.

Future research will therefore focus on developing a holistic regional development framework that uses modelling of bio-physical attributes as a bases for land-use optimization and a specifically tailored strategic foresight methods to guide regional councils along with their communities to a sustainable future of agricultural sector as a significant contributor to local employment and income.

V. Conclusion

Climate change is a phenomenon containing significant uncertainties and requires a long-term view, while farming as well as political planning horizons are rather short (e.g. the next cropping season or election period). Long-term decision making, essential when tackling climate change, therefore tends to be overshadowed by operational, short-term planning. Australian agriculture has been faced with, and adapted to, more sudden shocks, such as deregulation of the economy, the collapse of the Australian Wool Reserve Price Scheme and subsequent local wool industry downfall, the rise and fall of the MIS scheme or the millennial drought. Long-term transformational decisions concerning land-use optimization are needed, but unfortunately hindered by ill-planned government incentives on one hand and deeply imbedded preconceptions against innovative agricultural techniques, reinforced by community pressures to conform to traditional agricultural practices on the other.

The aforementioned observations demonstrate how vital, yet difficult engagement of all stakeholders is in successful strategy formulation and execution. A successful introduction of foresight scenarios into planning has the potential to bridge the gap between stakeholders, and between strategy formulation and implementation. It is also likely to improve the resilience of impacted systems and overcome the challenges presented by uncertainty. The resulting maps of land suitability for particular crops and an overall versatility (coupled from all the target commodities) are transparent and easily comprehensible outputs for the community, planners and decision-makers alike. Assessment of an impact of climate change on overall versatility is vital, but the comparison between current and future suitability for individual crops allows for long-term yet specific path to be taken toward a shared regional vision. A desired future built on resilience and sustainability, which does not compromise the region's natural resources and stays profitable by capitalizing on intensification as well as diversification of its agricultural sector.

Using expert opinion and evaluation as an input throughout the various stages of the study, embodied in the design of the future output framework is vital in order to ensure transparency and decrease the inequality of access to information across the community. It aims to provide the decision makers with adequate tools and unbiased data relevant in the regional context to form long-term vision and ensure its successful implementation.

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Influence of Indole 3- Butyric Acid on Hardwood Propagation of Lantana camara L.

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Abstract
To determine effect of indole 3-butyric acid (IBA) on rooting of *Lantana camara* L. cuttings were treated with 1, 10, 100 and 1000mg/liter of IBA. Tap water was used as control. Except at 1mg/liter, IBA improved rooting of *Lantana camara* L.cuttings in all concentrations used, however, IBA at 100mg/liter gave the greatest root production rate as indicated by highest rooting percentage, highest primary root number and longest roots.

Keywords: *Lantana camara* L., Hardwood propagation, Indole 3-butyric acid, Rooting

Introduction

Lantana camara L., a vigorous small shrub (Ruter,1996) , has ornamental interest because of its dense attractive foliage and the multi- colored flowers (Pizzetti and Cocker, 1975). Due to these features, lantana and especially *Lantana camara* L. subsp. camara is used widely in several countries as landscape plant.

Vegetative propagation is important in horticulture, particularly for mass producing improved materials within a short time and perpetuating the characteristics of the parent plant. The oldest and safest method of propagating grapevines for trueness of variety is through rooting grapevine cuttings. Propagation through cuttings is cheaper and easier than other vegetative propagation techniques such as grafting and in vitro techniques. Use of auxins such s indole-3 butyric acid (IBA) has been shown to improve rooting in both difficult-to-root and easy-to-root woody plants species. Auxins are reported to involve the division and elongation of meristematic cells and differentiation of the root primordial, as well as the mobilization of reserve food materials to the site of rooting. *Lantana camara* L. is a popular ornamental plants and the response of IBA on rooting of L. camara cutting sis yet to be known. The purpose of this study was to investigate the effects of different concentration of IBA on rooting of softwood cuttings of Lantana.

Materials and Methods

Single node hardwood cuttings (～15 cm length) of L. camara L. were collected in February 2004 from the University Farm of Tokyo University of Agriculture, Tapan. The collected cuttings were treated with four concentrations IBA (1, 10, 100 and 1,000 mg/liter). IBA powder was dissolved in small amount of 100% ethanol firstly, and then the solution was diluted to 1, 10 and 100 mg/liter with deionized water respectively, but 1,000 mg/liter IBA was dissolved in 50% ethanol. Cuttings soaked in tap water were used as controls. The basal ends (～2-3 cm) of the cuttings were dipped in IBA concentrations of 1, 10, 100 mg/liter ethanol for 30 seconds. The treated cuttings were allowed to stand for fifteen minutes at room temperature to remove the ethanol from the cut surface. Cuttings thus prepared were planted in a tray (35 cm×25 cm×10 cm) containing vermiculite soil. The transplanted cuttings were kept in a plastic house. Irrigation was applied frequently to maintain optimum moisture conditions. Data on rooting percentage, root length, and root numbers were recorded two months after transplantation.

We used 10 cuttings per treatment and each treatment had 3 replicatons.

Results and Discussion

The addition of IBA enhanced rooting in all concentrations tested except 1 mg/liter (Fig. 1). Indole 3-butyric acid at 100 mg/liter was found to be most effective for the rooting of L. camara since it gave the highest percentage of rooting (83%) and the longest (71.0 mm) and highest numbers of primary roots (5.84). No rooting was observed with the 50% ethanol treatment. Rooting percentage, root length and primary root numbers increased as the concentration of IBA increased until 100 mg/liter; however, rooting percentage and root length decreased slightly at 1,000 mg/liter of IBA treatment. Indole 3-butyric acid not only induced rooting percentage, but also improved root quality (Fig. 2 to Fig. 3).

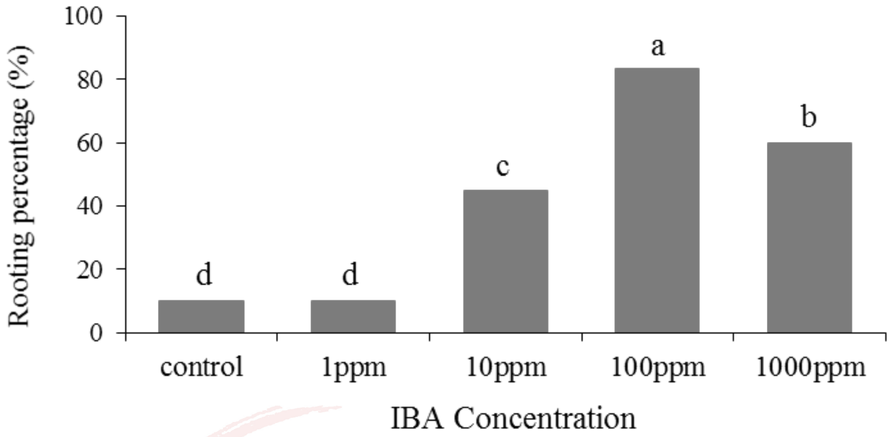

Figure 1: Rooting percentage of *Lantana camara* L. Mean values labeled with different lowercase letters were significantly different according to Fisher's protected least significant difference test as $P<0.05$.

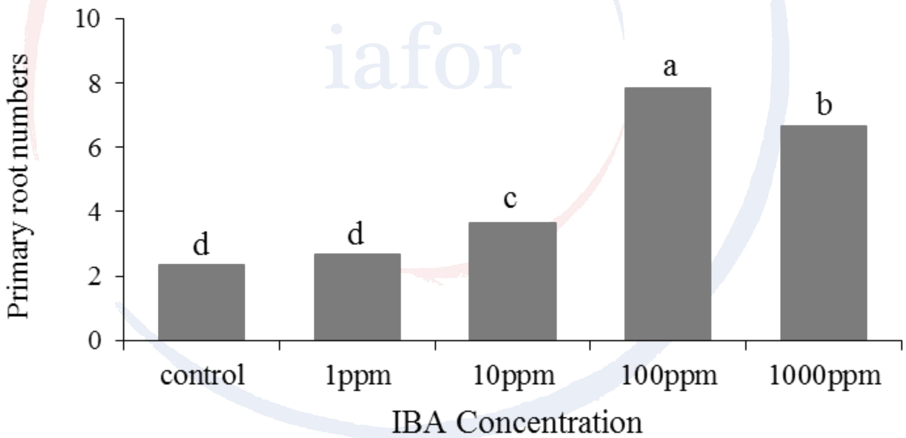

Figure 2: Primary root numbers of *Lantana camara* L. Mean values labeled with different lowercase letters were significantly different according to Fisher's protected least significant difference test as $P<0.05$.

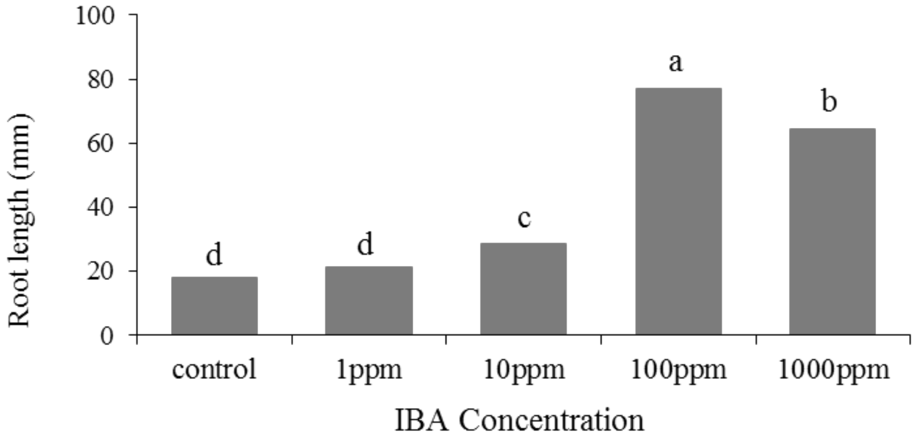

Figure 3: Length of the longest of *Lantana camara* L. Mean values labeled with different lowercase letters were significantly different according to Fisher's protected least significant difference test as $P<0.05$.

The effectiveness of IBA on the hardwood propagation of grapevines as noted in the present study was reported previously by several authors in many grape genotypes; however,in grapes reported that IBA did not improve rooting of St. George rootstocks, suggesting interactions between genotype and exogenous IBA application. Other reported that rooting percentage increased as the exogenously applied auxin concentration increased in Norton (V. aestibalis) hardwood cuttings. Indole 3-butyric acid reduces the time required for cuttings to callus and roots to appear . The mechanisms of exogenous IBA application on rooting involve the conversion of IBA into indoleacetic acid (IAA), the most active auxin, in plant tissue . Liu et al. (reported that the auxin-induced root formation was accompanied by increasing levels of putrescine (polyamines) in soybean hypocotyls explants and suggested that the exogenously applied auxins (IBA and NAA) may act on polyamine synthase and IAA oxidase activity.

Liquid preparations are easier to formulate and are more readily available in a wider range of concentrations(Berry,1984). Liquid IBA may also induce better rooting than talc IBA(Bonamino and Blazich,1984) and, at high concentrations (≧1%IBA),may stimulate rooting of many difficult to root species(Chong and Daigenault, 1986).

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Influencing Factors and Processes Involved in the Commercialization of the Industry-University-Government Alliance Outcomes

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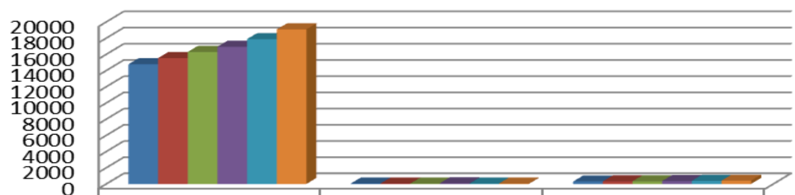
Abstract
According to data from the Japan Science and Technology Agency (2009 to 2014), total numbers of Industry-University-Government Alliances (IUGA, hereafter) more than doubled. However, from the industry side, there are few analyses about influencing factors and processes involved in the commercialization of IUGA outcomes. Thus, an understanding of factors and organizational cooperation processes (internal & external) which stimulate commercialized outcomes from IUGA is needed.
From this background, the current study identifies the factors influencing the coordination of technology systems among companies aiming for mass production then, identifying organizational processes among companies which commercialized. For identifying factors and processes, case study the data was compiled for the Toshiba Corporation in Japan, which participated in IUGA for reducing greenhouse gases in Yokohama city (April 2010 to March 2015).
From the analysis, this research found that the project leader who has both technological knowledge and an understanding of the overall process is able to manage the outcomes of the project. Furthermore, adopting the standard interface (Open ADR2.0b) for CEMS and BEMS can enable companies to establish mass production with improved coordination. Additionally, local government leadership was identified as being significant in encouraging commercialization.

Keywords: Industry-University-Government Alliances, leadership of local government, management factors, technological factors.

1. Introduction

In recent years, the number of companies participating in the total numbers of Industry-University-Government Alliances (IUGA) has substantially increased (figure1). Previous research looked only at the factors and reasons involved in the IUGA process which was separated into 3 stages prior to commercialization: the initial structure establishment period, the technology and system establishment period and the commercialization period. It should be noted that the technology and system establishment was further divided into research about economic efficiency, safety, and the combination of technology on the one hand and research about the safety and stability system for mass production on the others.

Figure 1. Alliance partners with university between other entities



	Companies	Government	Local government
2009	14779	57	307
2010	15544	54	319
2011	16302	38	329
2012	16925	89	360
2013	17881	46	382
2014	19070	62	400

(source)
https://sangakukan.jp/top/databook_contents/2015/cover/2015-2016_databook_ALL.pdf

The research within the first 2 stages of the IUGA process looked at management factors and also the technological factors affecting coordination among entities. However, this level of research was not applied to the safety and stability systems for mass production within the second technological and system establishment stage. Nor, was it applied to the final stage of commercialization.

From this background this paper identifies factors influencing the coordination of among companies within the safety and stability systems for mass production within the second technological and system establishment stage and the final stage of commercialization.

2. Previous Literature

2.1 Initial structure establishment period: Management side factors influencing coordination of entities

In the beginning of IUGA, participation entities had to consider the governance structure in each period for IUGA. It summed up the IUGA needs several stages and coordinative considerations of the R&D, assessment and investment system to commercialization (Fujikawa, 2011; Koh, 2015). In addition to this they decided to formation of promotion councils for the management of entities. In this process local governments helped the participation entities with the subsidies (Koh, 2015).

2.2 Initial structure establishment period: Technological side factors influencing system coordination

With the promotion council in place, the coordination of participation entities from the technology system commenced (Koh, 2015). The formation of this coordination varied due to differences in the technology. At the beginning of this period, local government entities met with companies to better understand these differences though this process was marked by trial and error (Koh, 2015).

2.3 Technology and system establishment period: Management side factors influencing coordination entities

During this period, a practical awareness of error-free economic efficiency, that made use of technology realized (Ring & Van de Ven, 1992; Doz & Hamel, 1998; Morandi, 2013). The nature and purpose of entity participation in IUGA had an effect on the form system development and coordination among companies.

2.4 Technology and system establishment period: Technological side factors influencing system coordination

Coordination among companies was shaped by the level of technological relatedness. The more they were related, the greater was the hierarchical coordination both vertically and horizontally, between participating entities. Achieving efficiency development and mass production, a modular system was adopted by the participating entities. (Koh, 2015).

The first 2 stages of the IUGA process looked at management factors and also the technological factors affecting coordination among entities. However, these levels of researches were not applied to the safety and stability systems for mass production within the second technological and system establishment stage and the final stage of commercialization.

From this background this paper identifies factors influencing the coordination of among companies within the safety and stability systems for mass production and system establishment stage and the final stage of commercialization.

3. Case Analysis

3.1 Research Method

For identifying factors influencing the coordination of among companies within second stages, this paper used the case analysis with semi-structured interviews to Toshiba Corporation (hereafter, Toshiba) and Yokohama city in Japan. The former had participated in IUGA as the project manager to develop smart grid system as an example and the later as a local government for supporting companies to progress IUGA.

In Yokohama city, named as the Next-Generation Energy and Social system project started in 2010 with the participators those who are the ministry of economy, trade and industry in Japan, universities, local government and companies. This is for the smart grid system development that is next generation type of power transmission and distribution network to reach stable supply of power, using IT technology.

Generally, the energy supplier provides electricity from the power plant through the Electric Grid and Telegraph Poles. However smart grid system is two way systems. The solar panels attached to homes and buildings accumulate electricity and store any excess in batteries. The connection between Central Energy Management System (hereafter, CEMS) and Home Energy Management System (hereafter, HEMS), Building Energy Management System (hereafter, BEMS) allows the energy supplier to draw electricity from these batteries during peak demand. Additionally, the end user is compensated financially for their electricity. The development of the smart grid system in Yokohama city had promoted from April 2010 to March 2015 and the two thirds of its budget covered by government subsidy and last of it covered by participating companies.

3.2 Case Analysis about factors influencing the coordination of among companies within the safety and stability systems period preparing for mass production

The IUGA (named Next-Generation Energy and Social system project) in Yokohama city separated with 4 working groups those are CEMS, HEMS, BEMS, EV (electric vehicle).Toshiba participated 3 projects excepting EV and have been the project manager. Figure 2 shows how many companies participated within each working group and the necessity of the coordination among companies.

Figure 2. The Steering committee and members of working groups within IUGA in Yokohama city

Steering Committee :General manager in Yokohama representatives of working groups and related firms				
Board of Governors				
Project Manager : Toshiba Corporation	CEMS Working Group Leader: Toshiba	HEMS Working Group Leader: Toshiba	BEMS Working Group Leader: Meidensha	EV Working Group Leader: Nissan
	• Accenture • Kasai Electric Power CO.INC. • Sharp Corporation • Sony Energy Device • Tokyo Electric Power CO.INC • Hitachi Ltd. • Meidensha Corporation • NEC Corporation	• Daikyo Astage Inc. • Tokyo Gas • Toshiba Corporation • Panasonic Corporation • Mitsui Fudosan Real estate company • JX Nippon Oil and Energy • NTT Docomo • NTT Facilities	• Shimizu Corporation Engineering Company • Sumitomo Electric Industries Companies • Taisei Corporation • Toshiba Corporation • JGC Corporation • Meidensha Corporation • NEC Corporation	• Orix Corporation • Orix Auto Corporation • Hitachi Ltd. • NEC Corporation

(source: From the interviews to Yokohama city and Toshiba)

Toshiba participated two projects within the each working groups(CEMS, HEMS, BEMS). For this reason Toshiba could share information within the company about customers and projects. Additionally, persons in charge of CEMS, involved in the same business unit in Toshiba, though they can understands how the other projects progressed during the safety and stability systems stage. However, the commercialization to use outcomes of the IUGA not just made with coordination of the knowledge inside companies. In addition to the coordination between the projects within company, considering about coordination among companies to utilize outcomes of the IUGA would be necessary. It means coordination ways among companies are necessary.

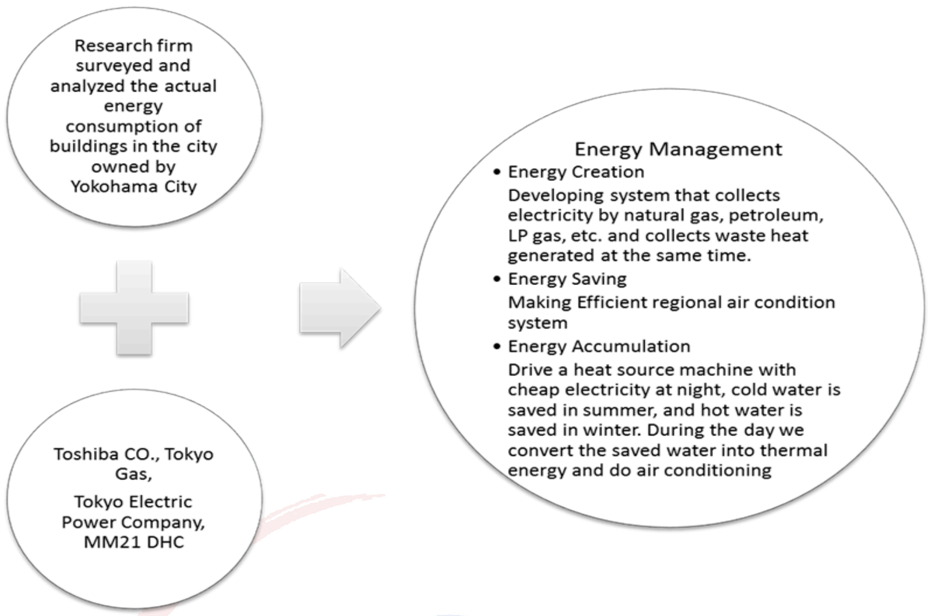
Participating companies developed system separately and combine them. For constructing smart grid system, there should be the way to coordinate them from the management and technology sides. Yokohama city and Toshiba as a project manager make the system to implement the regular meeting among working groups companies and within the working groups. As a local government, Yokohama city not only participated in constructing of the steering committee and its operation but also explain the intention of IUGA to citizen and handled complains from participating companies and citizen. The supporting of the local governments is one of factors that successfully shared information among companies. In addition to management side, technological factors also influenced coordination among companies.

The meeting within and among working groups make sense as the place that can sharing information but the purpose of participating to IUGA, the policy of each company to projects and the knowledge related system development are different. Though the technologically companies needed the way to coordinate them. For coordinate variety companies the interface standard called as Open ADR 2.0 is adopted as they developing a system. It is adopted in United States first as for the networks connecting standards. By adopting Open ADR 2.0, each company just focus on recognizing the connection part when combining with another system that developed other systems, and develop other part based on its own knowledge.

3.3 Case Analysis about factors influencing the coordination of among companies for the commercialization

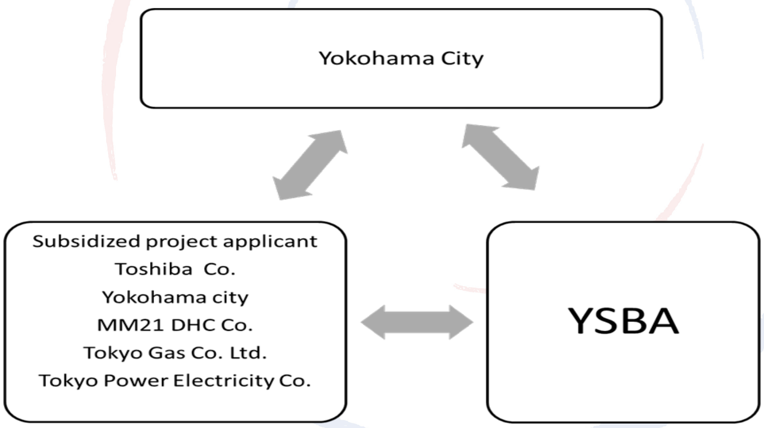
Yokohama city, Toshiba and other 14 companies organized Yokohama Smart Business Association (hereafter, YSBA) after IUGA finished on March, 2015 for commercialization of outcomes of the IUGA. YSBA started on April, 2015 under the formation of figure3 and the information flow of figure4. Figure3 explained formation and role of the executive committee for commercialization. Additionally, figure4 shows the information flows among Yokohama city, YSBA and other participating entities. Except Yokohama city, the motivation to participated in YSBA is the aggressive supporting attitude of the Yokohama city to commercialized the outcomes of the IUGA.

Figure 3. Formation and role of the executive committee for commercialization



(sources: http://www.city.yokohama.lg.jp/ondan/ysba/sanka.html)

Figure 4. The information flows among participators within YSBA



(source: http://www.city.yokohama.lg.jp/ondan/ysba/sanka.html)

As figure3 and 4 shows the leadership of the Yokohama city as the local government would be the one of factors to make participation to the other companies.

4. Conclusion and Contribution

The purpose of this paper is identifying factors influencing the coordination of among companies within the safety and stability systems for mass production within the second technological and system establishment stage and the final stage of commercialization. From the analysis, the local governments support from management side and standard interface from the technological side have the possibility to influence the coordination of among companies within the safety and stability systems for mass production. Furthermore, the aggressive attitude and leadership of the local government to utilize the outcomes of IUGA has the possibility to be the influencing factor of coordination among companies during commercialization stage.

Previous research analyzed the role of local government in the period of initial structure establishment and technology (Fujikawa, 20011; Koh, 2015) and system establishment for consideration of economic efficiency and combination of the technology (Ring and Van de Ven, 1992; Doz and Hamel, 1998; Morandi, 2013). However, those are the only limited to the first two stages. From this paper it found that the role of local government has the possibility to continue to the commercialization stage to make coordination companies. Furthermore, the local government supporting for providing experimental facility first, then providing information necessary for making the smart grid system to companies on the commercialization stage would be the one of the factors to progress commercialization.

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Stochastic Model of Demand Curve Supported in Consumption Habits of Electric Energy for Residential Sector

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Abstract
This paper shows the methodological aspects to design and develop a stochastic model, which determines the demand curve from variation in energy consumption habits, using a survey that was applied to a group of 114 residential users located at Bogotá-Colombia in South America, in the same socio-economic sector, which is called four stratum. It was chosen because it does not receive any government subsidy; nevertheless, the proposed methodology can be replicated in any residential environment for its random nature. The users were chosen at different places of the city, taking into account aspects related to: knowledge of energy resource, habitual consumption behaviors and behavior regarding electrical energy management. The developed stochastic model shows consumption variations in eight groups of devices that are commonly used in a household. It should be noted that each time that another simulation is performed with same parameters; likewise, it is possible to determine how changes in the consumption habits influence energy's demand projection for a residential sector. The changing of the energy consumption habits directly impacts on demand curve, but such changes should be based on aspects related to incorporation of dynamic knowledge of energy resource and everything that surrounds it.

Keywords: Consumer habits, Demand Curve, Knowledge Resource, Stochastic Model.

Introduction

The electrical system needs correct mechanisms to maintain the balance between generation program and reality, if this does not happen, the system operator which is in charge of balancing the demand curve may have costs and penalties (Kieny, Berseneff, Hadjsaid, Besanger, & Maire, 2009). The active participation by electrical energy users is used to increase the system efficiency with its proper use and makes possible a flattening for demand curve (Cerezo Moreno, 2010). It requires users contribution to adapt their consumption habits to situations in system and complementary services that market offers (Vallés Rodríguez, Frías Marín, Reneses Guillén, & González Sotres, 2013). Flattening for demand curve could decrease needs for investment in networks offering contracts to consumers adjusted to their consumption habits, including greater choice and savings in electricity bill (Spees & Lave, 2007). In foregoing view, energy consumption habits become a fundamental element to know the consumption patterns and its behavior in different signals.

This paper proposes a stochastic model to see changes in demand curve according to consumption habits and knowledge management. In section two conceptual elements are displayed related to stochastic models about demand curve analysis linked to consumption habits and probabilistic empirical models posed by some authors, where its main features are extracted as input data, output data and processing used to obtain demand curve. Section three explains design about stochastic model proposed, taking as support the design a survey based on consumption habits with three specific aspects: knowledge of electrical energy resource, common habitual consumption and behavior for its use. Section four shows model development, starting with some data obtained by applying the survey which are basis for model development by devices group. In section 5 results of proposed model are presented, and the paper ends with conclusions.

I. Models of Demand Curve

Changes in energetic behavior by user can lead to saving energy, so regulators know that to vary the energy pattern consumption, there is a potential through a people behavior change, which is influenced by various factors such as price, security in provider, comfort, environment, commitment to change, personal actions and sometimes emotions (Zaeri, Sharda, & Zahedi, 2014).

The importance about knowing disposition in families to adopt different behaviors for energy savings, have different degrees of success (Yue, Long, & Chen, 2013). However, diversity of activities related to electrical energy can be difficult to capture, and there are many questions in relation to the users and their behavior patterns associated with energy use (Hiller, 2015).

The analysis related to energetic behavior by users are based on a theoretical framework, which covers: economic reasons, psychological ones and use of electrical appliances in a household for energy consumption decision making, which opens other factors that influence the activity in houses as well as social interaction and this way the interaction with service provider (Ek & Soderholm, 2008).

A. Stochastic models

Demand for power due to its random nature and its severe fluctuation is more complicated to predict than the demand for energy. Analysis models for electrical residential load curve have been divided into two categories: up and down (Deterministic models), and bottom-up approaches (Random statistical models, Probabilistic empirical models, etc) (Grandjean, Adnot, & Binet, 2012), see below an explanation of some about them:

- Random statistical model: applies a randomized procedure making use of statistical data to generate variations in a given scenario.

- Probabilistic empirical model: defines a probability from data collected on consumption habits, to generate a variety of results.

- Statistical engineering model: dwelling characteristics, meteorological data and input rates are included. Furthermore, statistical coefficients that adjust original results are added, which are calculated with load curves measures and socio-economic data.

- Upward hybrid models: is estimated electricity demand for few houses. These results are extrapolated to obtain unit electricity consumption for the studied area.

B. Probabilistic empirical models for demand curve based on consumption habits

Probabilistic empirical models by its nature allows to know time intervals in periods where it requires the analysis of demand curve behavior, there are some proposed models showing: input data, processing and output data:

- Yao et al Model (Yao & Steemers, 2005), proposes the demand curve generation through cluster analysis, both at macro (national) as well as micro (individual houses) level, by means of load profile for each device, with a statistical analysis using random numbers techniques for the amount of household appliances and presence in housing by occupants. With the data processing model gets: specific daily profile by appliance, load curve with presence the people in housing, load curve for single housing which is replicated at regional or national level.

- Stokes model (Stokes, 2005) calculates load factor for every appliance over time allowing to take into account the reactive power demand. The author for input data processing performs random numbers generation with Laplace-Gauss density function and employs a Boolean factor of appliances utilization, applying the likelihood that an event of demand occurs. With these elements gets: load curves adjustable to profiles of a situation both current and future, individual average profile and total households number every 30 minutes in load curve.

- The model proposed by Richardson et al (Richardson, Thomson, Infield, & Clifford, 2010), takes into account patterns of housing occupation that is limited to 5 people. When people are in house and awake, it selects electrical appliances used (week or weekend, month at the year), besides, it correlates with time amount taking into account basic appliances data (maximum 33). It uses a random process from appliances selection with random number. Similarly assigns a calibration scale that determines use percentage. Model was validated with load profiles for 22 houses in different days per week.

II. Design of Stochastic Model Proposed for Demand Curve

To design the proposed model, methodology presented in Figure. 1 was developed, which has two fundamental elements such as backgrounds found in other authors and analysis unit. From probabilistic empirical models analyzed in section two, the main characteristics for each one of them were extracted, and analysis unit is used for survey development, which was a tendency about behavior related to electrical energy consumption habits for residential users.

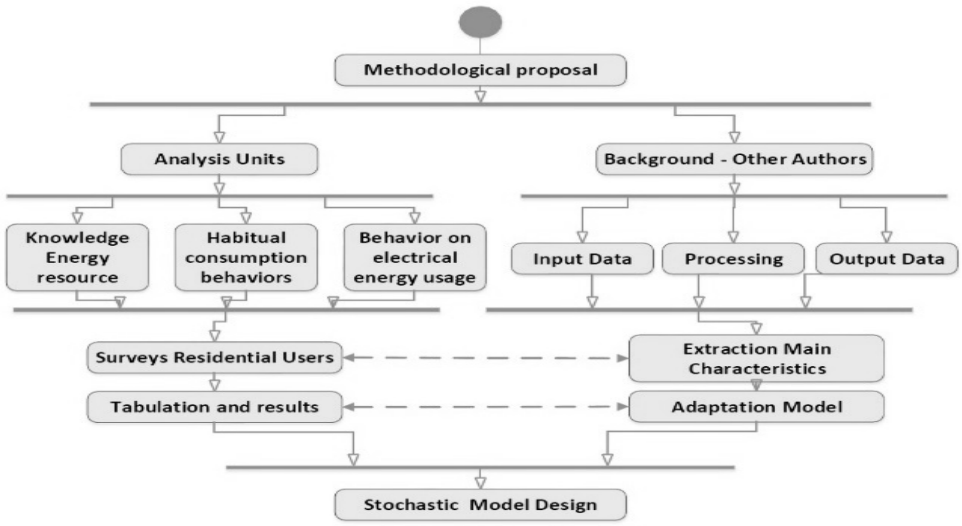

Figure 1. Development methodology for proposed model

A. Analysis Unit "Consumption Habits": With this analysis unit data related to the consumption habits and knowledge management are obtained to categorize them according to the information that is needed when establishing the demand curve. With analysis unit called "Consumption Habits and knowledge management" the way in which a user makes use electric service in his residence is seen, in such a way that was divided into three aspects: knowledge of electrical energy, behavior habits of electric energy consumption and behavior on electric energy use.

1) Knowledge of energy resource: Variables related with the understanding that target population has about basic aspects of electrical energy, according to this, the following variables are analyzed:

- Knowledge on appropriate electrical energy use,
- Energy efficiency concepts,
- Knowledge about peak time and flat time related to electric power,
- Agent "aggregator" concept,
- Smart grid concept.

2) *Habitual consumption behaviors of electric energy:* With this aspect, data related to main devices and/or residential appliances are collected to meet consumption without diminishing users comfort in a given day (Consorcio CORPOEMA - CUSA, 2012), which were established according to employment percentage of them at different times per day and devices use or intelligent technology for energy management in residences (Jiménez, 2013). The variables are: intelligent devices for energy management, one day in a week where it consumes more power, number of devices and/or appliances, hours of use, percentage use of devices and/or appliances.

3) *Behavior on electrical energy usage:* In this aspect it is discussed how user behaves in certain aspects related to use electrical energy in residence, such as: Alteration of consumption habits by dynamic pricing, Use domestic appliances (remain on or off), Own initiatives for energy saving, Community initiatives on energy savings, Renewable sources use, another motivation.

B. Elements of proposed model

The proposed stochastic model design is composed by input data, processing and output data as shown in Figure. 2. The foregoing was processed with elements obtained in survey implementation and its respective tabulation. Below each model block is detailed:

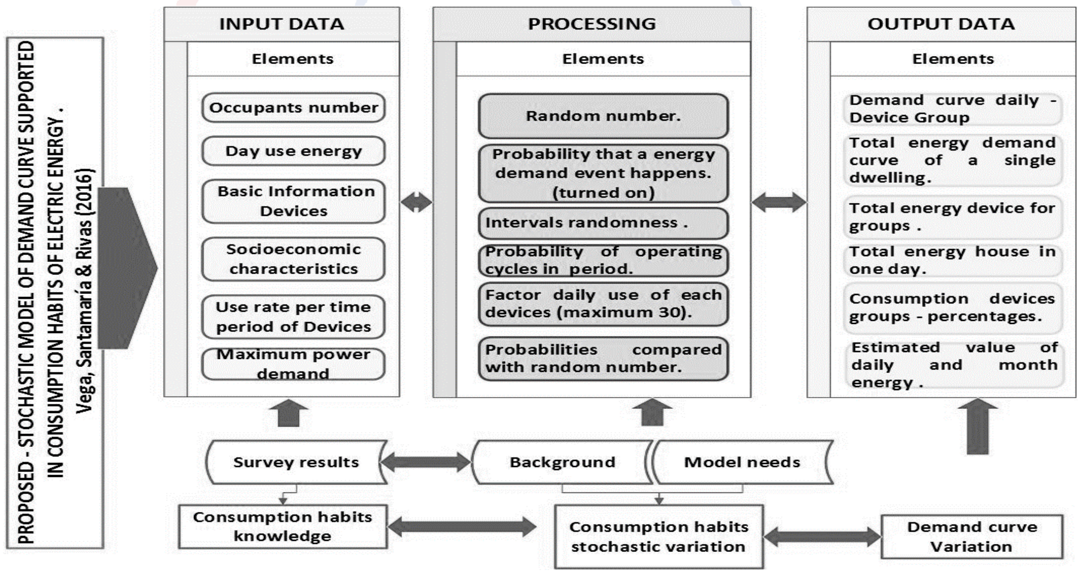

Figure 2. Stochastic model for demand curve proposed by authors

1) *Input Data:* to achieve demand curves variation according to changes in consumption habits, it was necessary to define conditions for entry to the model, which are the following: Occupant's number information dwelling (limited to 5 people), Selection of use (weekdays or weekend). Related Information with lighting, heat and/or cold appliances, entertainment, kitchen, clothing, shower among others (30 in total), Socio-economic characteristics, Use rate of each appliance by period and Maximum power demand estimate.

2) *Processing:* with input data duly established it was proceeded to identify elements that could help the proposed model to have its processing stochastic elements, which are listed below:

- Random number allocation with Monte Carlo simulation (Ramakrishnan, 2016) for the amount of turned on household appliances.
- Probability of an energy demand event is produced (power on).
- Random intervals to use electrical appliances.
- Operating probability cycles in each period.
- Factor daily use of each appliance (maximum 30).
- Power on determination by means of probability compared with random number.

3) *Output Data:* Output data processing with random components results in different types of variation in demand curve, as follows: Daily specific curve per device group, Total energy curve from a single housing, Total energy by devices groups in a day, Total housing energy in a day, and Consumption percentages by devices groups.

III. Development of Proposed Model

The development of the model, dynamic systems are used, which is a science to study multiplicity systems and their causal relationships, including social and economic systems among others, allowing to analyze behavior and perform various simulations in time (Rasouli , 2010). Similarly it allows the systems characteristics study, analyzing its entire structure, decisions and actions that influence their behavior to future (Borshchev & Filippov, 2004). Its objective is to observe what can happen along the time for different scenarios, through events definition and changes in variables (Castaño, Una aproximación a la adopción de medidores inteligentes en el mercado eléctrico colombiano y su influencia en la demanda, 2013).

The simulation software PowerSim® is used (PowerSim, s.f.), to develop model already proposed that allows to perform modeling of flows between variables, handling units, user interfaces creation, etc. in order to develop this model it was necessary to take into account the following components:

A. Input component

It was necessary to do a selection of eight groups of devices that are commonly used in a household, taking into account the model for 30 appliances in total, as it is shown in Table 1.

TABLE 1. Device Groups

Group	Devices
Lighting	Bulbs.
Fridges	Fridges.
Entertainment	Desktop PC, Laptop, TV, Audio equipment, DVD, Multifunctional Printer.
Kitchen	Coffee machine, Electric stove, Blender, Microwave, Sandwich maker, Toaster.
Heat	Oven, Dryer, Iron, Heating, Iron Hair.
Clothing	Washing machine, Dryer
Shower	Electric shower, Electric heater.
Miscellaneous	Vacuum cleaner, Treadmill machine, Shine machine, Alarm Clock, Gadgets.

Likewise, the variables that determine analysis unit of consumption patterns and whose data were obtained in survey applied were taken into account, as follows:

Knowledge of resource:

- Operation cycles probability: probability that a household appliance is power on in a given period of time. For this model the day was divided in six time periods.
- Devices amount: appliances number per group on average that a house has.
- Devices consumption: is consumption established by manufacturer in Watts. In survey the appliances age was asked.
- Price: value kWh in the month.

Habitual consumption behaviors:

- Day of greater electrical use energy in household: variable where is chosen if midweek or weekend.
- Occupant's number: amount of people living in dwelling and is limited to six.

Behavior:

- Probability of devices power on: probability that a user turns on an appliance in day.
- Daily Usage time: period by time in which the appliance takes on.

B. Stochastic processing

For the process of input data, different operation cycles were programmed and variable cycles with stochastic components, which are presented allowing: assign random numbers, probabilities application and randomness intervals, to determine operating cycles, power on devices, among others.

C. Output component

In terms of output data, after model processing, daily specific curves are obtained per device group as well as general one, a consolidated overview of energy consumed by each of appliances in group for a period by time and estimated bill value by month.

IV. Model Results

As a model result implemented it should be noted that on basis variation in consumption habits and knowledge management, it is possible to establish an approximation to daily demand curve in household, in addition the random nature of energy consumption makes clear display how behavior of users affects not only to household level but also in the entire electrical energy value chain.

As part of proposed model, a survey for a case study in a residential complex with a total of 114 people in Bogota city of Colombia, belonging to socioeconomic stratum 4, was implemented, this stratification was selected because it does not receive subsidies nor contributes as it happens in other strata according to Law 142 for 1994 of stratification and Public Services (Senado República de Colombia, 2016), and it is regarded as middle class, in addition this is only population that pays a real amount of money for public services. In the same way this model can be replicated in any residential setting.

A. Data obtained from survey

Some results obtained in analysis unit for consumption habits are shown below, which are taken to set input variables in proposed model. Figure 3 shows answers to the following question: What is your knowledge about appropriate use of electrical energy?, where it is observed that 50,88% of people consider that they have average knowledge on appropriate use electricity resource in their homes, while a 33,3% answered that their level about knowledge is high. These data are used concerning the socio-economic factor.

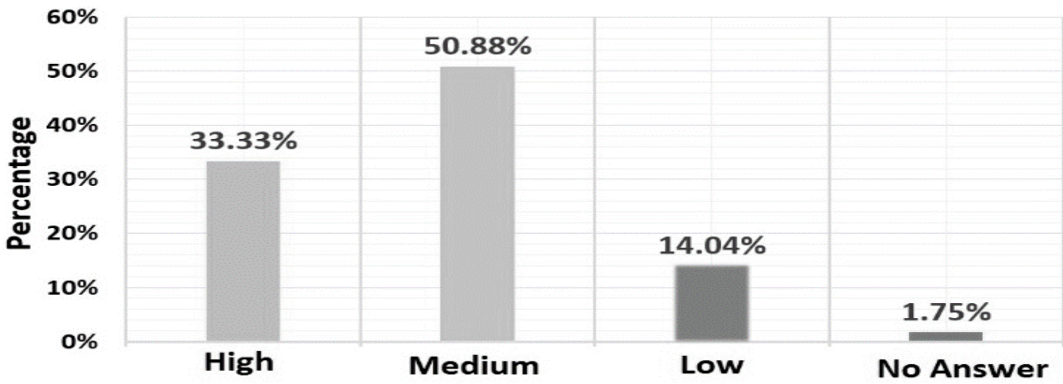

Figure 3. Knowledge about appropriate use of electrical energy

To the question: What day do you consume more electrical energy in your home?, Figure 4 shows that the highest electrical energy consumption is on weekend (Saturday and Sunday) by 77% users surveyed, which is one of inputs for more consumption period.

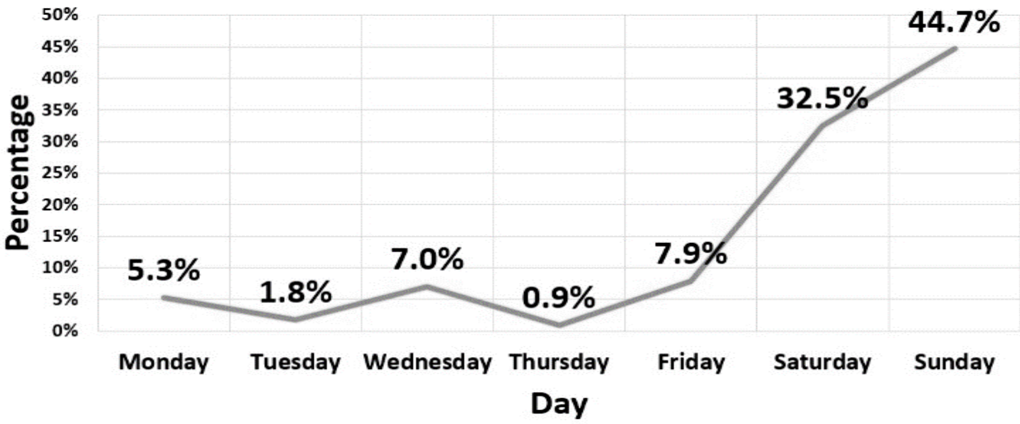

Figure. 4 Day with more electrical energy consumption

Regarding to behavior that users have compared to use lighting devices, it is observed that antiquity lightbulbs is between 2014 - 2016, that is to say that they are mainly compact fluorescent and in some cases LED type, as shown in Figure 5.

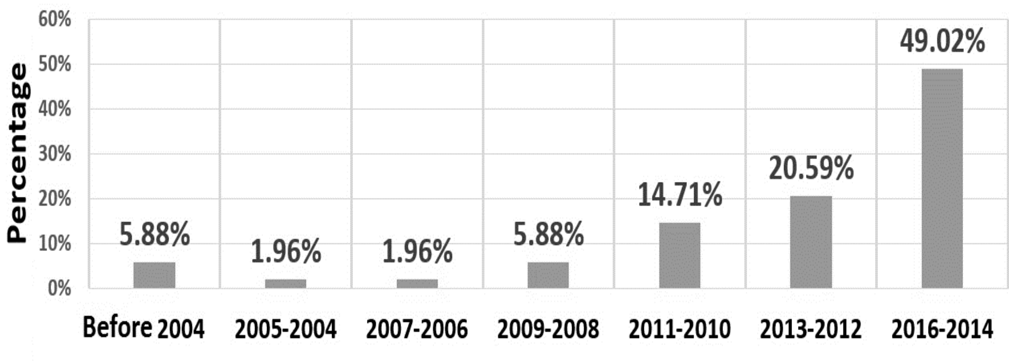

Figure. 5. Antiquity of lighting devices

B. Dynamic model proposed

Figure 6 presents a dynamic model example developed to establish the demand curve of devices group related with lighting in residences. It should be clarified that a sub-model was developed for each devices group involved in simulation.

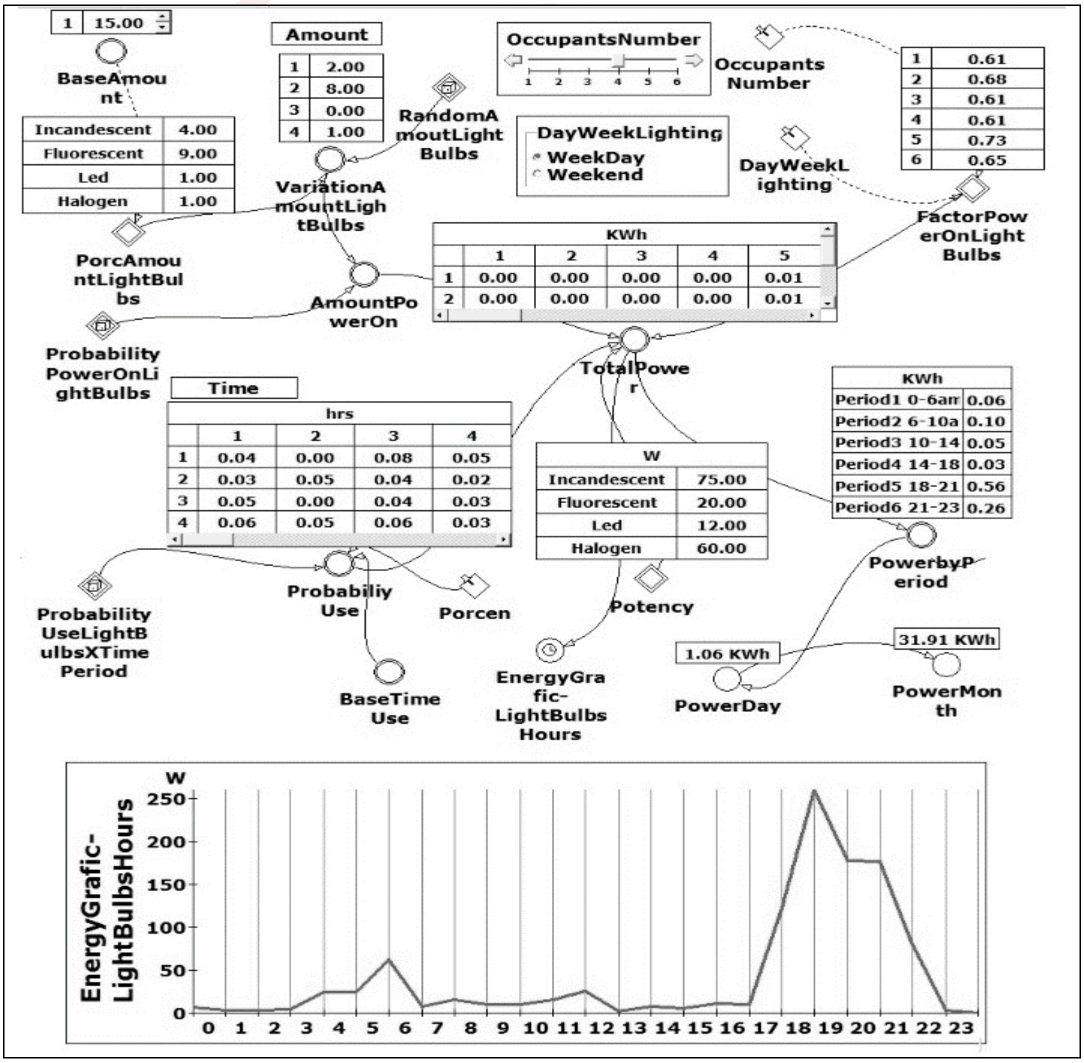

Figure 6. Sub- model for lighting devices group.

In the example of general simulation, the weekend was chosen and consumption was randomly varied in each one of the device groups analyzed. Similarly, sub-models proposed were fed by the percentages obtained from survey related to knowledge of resource, habitual behavior and behavior on users against the use electric energy, which varied 1% according to the average obtained through surveys applied. As a stochastic result processing applied to sub-models for eight devices groups the demand curve was determined for each of them through the consumer variation habits and knowledge management according to what was explained in section 4 (see Figure 7).

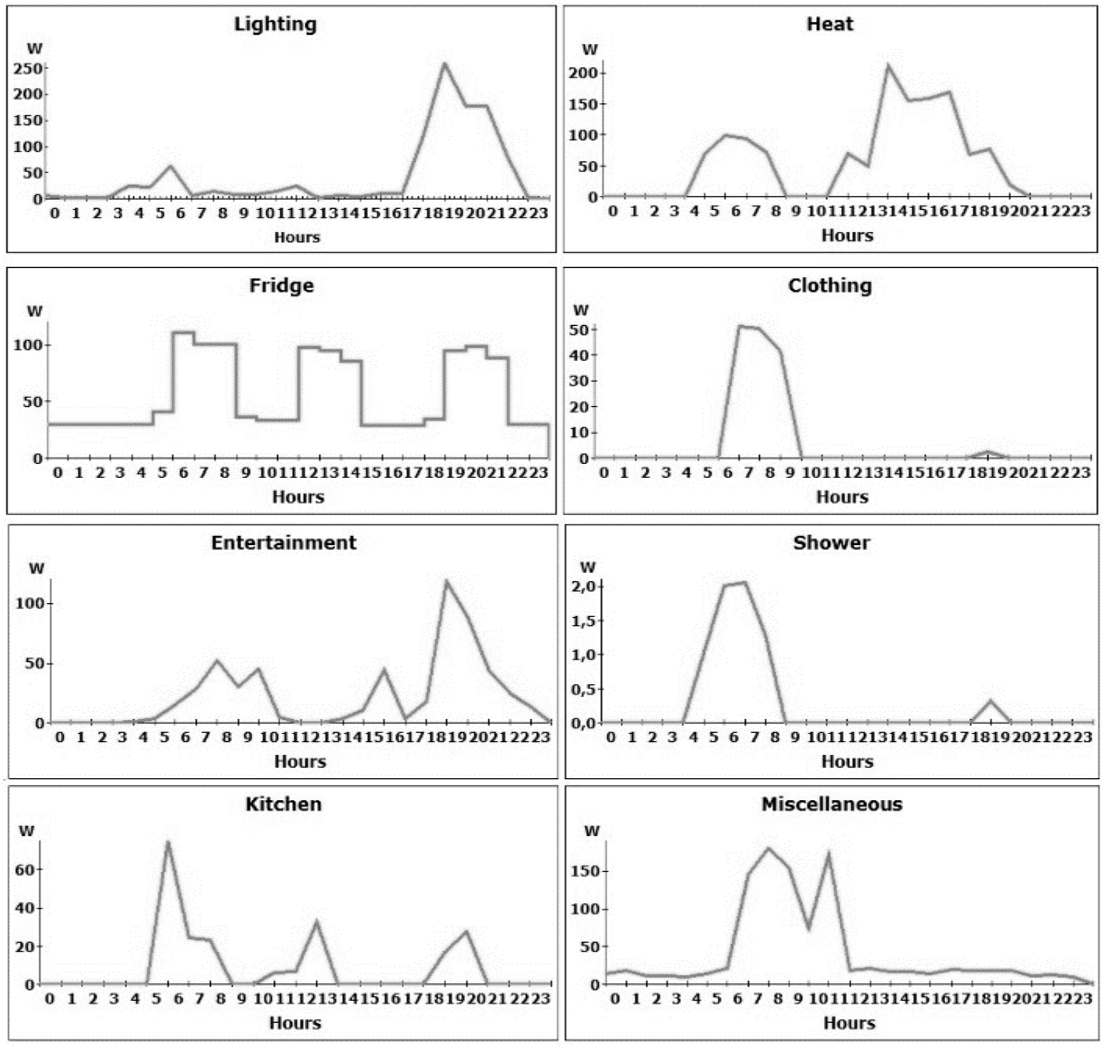

Figure 7. Simulation - Demand curve for each device groups.

In Figure 8 the consolidated consumption values are displayed by devices group, where daily and monthly consumption energy and their respective percentage is observed; as well as the total daily demand curve. In the simulation shown as example for this paper and according to variations made in consumption habits is obtained a consumption of 170,13 kWh, which allows to point out that model represents consumption of residential users from socioeconomic level 4, since average for this type of residential stratum is 175 kWh (Superintendencia de servicios públicos domiciliarios, 2016), and according to stochastic elements included in model there is a variation in consumption of 2.25%. It should be noted that each time that another simulation is performed with same parameters; the consumption is going to be different for stochastic nature of model proposed.

Consumption Appliances Groups

	Day Consum	% Day	Mount Energy
Lighting Energy	1,06 KWh	18,76 %	31,91 KWh
Fridge Energy	1,35 KWh	23,78 %	40,46 KWh
Entretainment Energy	0,55 KWh	9,70 %	16,50 KWh
Kitchen Energy	0,21 KWh	3,77 %	6,41 KWh
Heat Energy	1,31 KWh	23,17 %	39,41 KWh
Clothing Energy	0,15 KWh	2,57 %	4,36 KWh
Shower Energy	6,70e-3 KWh	0,12 %	0,20 KWh
Miscellaneous Energy	1,03 KWh	18,15 %	30,88 KWh
TOTAL ENERGY	5,67 KWh		170,13 KWh

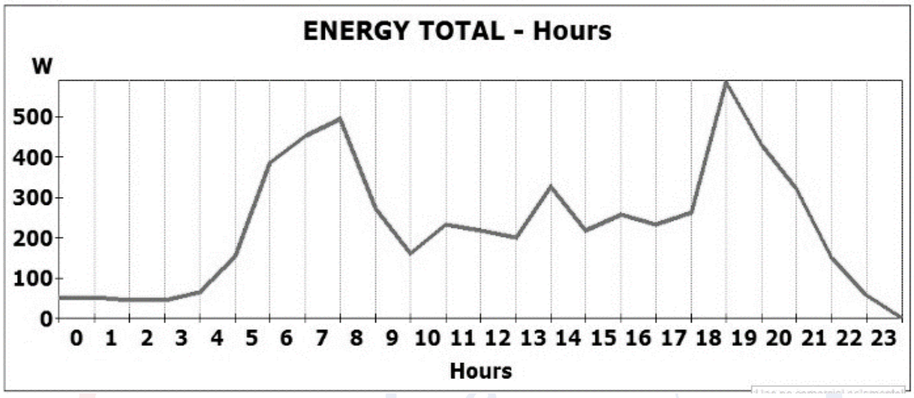

Figure 8. Demand curve all devices analyzed

Conclusions

The possibility of residential users that vary their electrical energy consumption habits has a direct impact on projection for demand curve; however this is achieved on aspects basis related to: knowledge of energy resource, habitual consumption behaviors and behavior on electric energy use. But such changes in consumption habits should be based on aspects related to incorporation of dynamic knowledge of energy resource and everything that surrounds it.

The model design is made through methodology application where there are two important aspects: theoretical reasons raised by different authors who have developed proposals for demand curves related to the consumption habits, knowledge management, and implementation of a survey in which data was obtained in a case study with different aspects based on consumption habits of socioeconomic level 4; according to the example given this methodology can be replicated to other leves and contributes to the same model developed.

In model development elements based on stochastic features were incorporated, which allows input data to be processed in a random way to obtain different demand curves according to variation in consumer habits parameters and knowledge management, so that can perform many simulations on the same parameters to present average power, and its standard deviation.

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Management System Prototype to Contribute with Energetic Efficiency of an Electric Iron

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Abstract

In this paper, a management system prototype in an electric iron is presented with the purpose of monitoring tension, current, energy and costs parameters, besides of controlling the real time turning on and off using a web page. Its objective is to reduce electric energy consumption to contribute with energy efficiency processes, without decreasing user's life quality. The prototype was developed with essential hardware and software components. Regarding hardware, Arduino® plaque was implemented along with Ethernet Shield card, which allows to have an IP direction and as an effect, a bidirectional communication, additionally it is joined to a data acquisition system that takes measures of the well calibrated electrical parameters. Regarding the software, a web application was developed using a set of languages, which makes electrical measures monitoring and control possible, by using PLC power line communication. Internet of things is used in this investigation since there is work on smarts devices and there is user-technology interaction, with the aim of giving accurate information that allows to take decisions that improve the life quality and that the population acquires higher awareness on electric energy saving.

Keywords: Internet of Things, Arduino®, Power Line Communication, Electric Iron

1. Introduction

Lots of residences actually count with domestic systems which are considered as the beginning of domestic technification, using "elements that provide some automatization level" (Snyder, Gunther, & Griffin, 2012). Technology advances such as "Internet of things", makes that devices can be remotely managed with internet connection trough a virtual platform. (Méndez, 2015). In order to have interaction between objects using internet, an internet protocol (IP) is required so it can be integral part of system with the objective of monitoring and controlling them, which allows that similar networks exchange information among them (Luis & Ortiz, 2012). Internet protocol (IP) is potential allows technological convergence to use a single infrastructure and lend multiple services (Luis & Ortiz, 2012).

Given the worldwide concern about the growing energy demand and climatic change, energetic sector has focused its efforts on energetic efficiency (Agencia Chilena de Eficiencia Energetica, 2013). In order to achieve its goal, energy efficiency requires the most advanced technology to control residential devices from any electronic appliance.
A study made in Ecuador found that one of the most common home accident worldwide is caused by electric iron (Llivisaca, 2010). Which is why an electric iron prototype was made with purpose of monitoring parameters as tension, current, energy, cost, position and movement, besides controlling the real time turning off through a web page. The objective is to reduce energy consumption by increasing user's lifestyle quality developing energy efficiency processes, all the above with Internet of Things, which incorporates smart devices with purpose of providing information that allows decision making (Alcaraz, 2016).

2. State of Art

Taking into account that there is no such thing as "Smart iron or IP" in the market, sockets are analyzed, they develop actions over the charges connected to network, such as an iron, with purpose of verifying its state through a control application and turning it on and off remotely (Acosta & Padilla, 2015). This devices facilitate having control over daily routines by controlling each home appliance, so homes become more dynamic, functional and appropriate for modern lifestyles, this devices let users control in a smart way their home devices (Edimax, 2016). Some socket devices offered in the market are shown in Table 1.

Table 1. Characteristics from Sockets offered in market

Brand	Characteristics	Integrated energy measure	Requires Android App	Timer
Energy ego	Turns on and off devices individually, real time monitoring	Yes	Yes	Yes
Edimax	Turns on and off, manual or programmed control, email notification	No	Yes	Yes
TP-Link	Easy configuration, real time monitoring, consumption summary, control from any place through internet	Yes	Yes	Yes
Belkin	Connects devices to Wifi network, personalized state program, controls on and off turning	Yes	Yes	Yes
Wattio	Devices consumption control, avoids unnneccesary consumption, alerts on anormal consumption.	Yes	Yes	No

Taking into account these devices and evaluating each of their characteristics, the following lacks for user were identified:

- The functioning of these sockets is directed to a huge amount of home appliances, which generates an extra cost when buying many sockets.
- Devices that integrate communication modules do it through a mobile device app, which is not appropriate for other type of devices
- There is no control, monitor and supervision of a single device equally, which means that there is no general information of all the devices at the same time for the user.

The prototype proposed in this paper offers the possibility of turning on and off an electric iron, besides of observing the real time energy consumption, allowing the users to know the cost of consumed energy in different periods, likewise, the functioning of prototype allows anyone to use it without installing any application because it was developed using HTTP protocol.

3. Materials and methods

This section shows how the prototype was implemented for the measuring and control system, beginning with selection of the required devices according to design, development and construction.

3.1. Device Selection

The following main components were stablished to select devices: PLC communication, hardware platform, Ethernet, energy measurer, current sensor, tensile tester, actuator and inertial sensor. It is shown below the way which they were selected:

PLC Communication Adaptor

PLC (Power Line Communication) technology is capable of transmiting data through the electric network, which is why it can be extended or share Internet connection to any PLC receptor located in same electric network (Serna, 2011). Among the existing products in market adaptors such as Powerline 1200 from Netgear, Powerline AV500Nano from Tplink or Powerline PLEK 500 from Cisco were found. After developed study, Powerline AV500 Nano (Tp-Link, 2016) was chosen because of its versatility, low cost and fast data transference which is enough for prototype, it equally gives the possibility of being a Plug and Play system, which eases the operation and functioning of this adaptor.

Hardware Platform

In order to implement the design surrounding and measuring system simulation with Arduino® it is necessary to stablish which boards exist, among which are Arduino® One, Yun, Leonardo, Due, Mega, Nano, among others. The analyzed boards offer benefits according to the type of micro controller they use, type of port, memory, voltage outputs, digital pins, analog pins, among others. For the energy measure application for an iron, the most appropriate one was Arduino Nano due to its compact size, and it also has an adequate memory for application and the possibility of obtaining an SPI (Serial Peripheral Interface) communication with other devices (Estados Unidos Patente nº US7069352 B2, 2006).

Ethernet

The local area network technology (LAN) Ethernet was designed to transport data with high speed and short distances and it is adjusted to applications where local communication media must carry a dense traffic of packaged data (Gracia Marin, 2016).
The methodology used in the design was divided in analyzing two board types that can give Arduino® internet connection, considering characteristics such as price, dimensions, data transfer speed, Ethernet Shield plaques and ENC28J60, when initial tests were made on ENC28J60, it behaved properly, but as the code increased proportionally to memory, it did not develop the process nicely. Besides, Ethernet Shield gave much more memory, which helped to improve data manipulation remotely due to the better send and reception of data that this plaque provides.

Power Meter

Based on the huge amount of meters that Analog Devices (Analog Devices, 2016) enterprise offers, and analyzing variables as rules, types of measures, main characteristics, among others. It was decided that ADE 7763 was the measure circuit to be used, it consists of a digital integral chip that creates an interface with some current sensor that has 2 channels (current and voltage), each one with a programmable earning amplifier and error range lower than 0,1% in energy measure. Likewise, it counts with a temperature sensor to help with apparent energy measure, active energy, voltage signal and effective values both current and voltage. ADE 7763 has tension and phase digital calibration so as a serial interphase compatible for SPI communication.

Current sensor

As told in (González, 2008) the current sensor turns current magnitude in a distribution line into an equivalent current level. There are different types of current sensors, which differentiate because of their dynamic range and bandwidth, which is why the four most common sensors are: "Shunt" resistance which provides an accurate and direct measure of current (Meneghini, Cester, Mura, Zanoni, & Meneghesso, 2014). Current Trasformer (TC) which transforms primary is current into the one of the secondary of less value (Enriquez, 2015). Hall Effect sensor which is based on current is fall through a lead (Donato, Pulvirenti, Capponi, & Scarcella, 2016), and Rogowski Coil that consists on a coil rolled in a nonmetallic material nucleus (Enriquez, 2015).

Hall Effect current sensor is used in this application because Rogowski bulb and TC is comparable with it, additionally Shunt Resistance is heating does not make it a reasonable option. ACS 714 was the chosen current sensor mainly because it offers different measure ranges among which are ±5, ±20, ±30 Amps.

Tension Measurement element.

Tension divider is a measurement method designed to measure high tensions, it is a circuit that distributes one source's tension in two or more impedances connected in series, it is composed by passive elements as resistances and capacitors that help to measure impulse type signals, direct current and alternate current (Universidad Distrital Francisco José de Caldas, 2010).

Actuator

The relay is defined as device that works to produce certain modifications as some electrical circuit conditions affect it. Lots of electrical devices adapt to this definition, from electromechanical relays up to contactors, the first ones are compact, which means they do not have mobile parts and they are even designed by one single piece with numerous terminals, among them there are. Triacs, that can work with CA and CC, but they will not stop current flows unless it falls under the threshold (París, 2003). It was decided to work with SFK-112DM electromechanical relay for the electric iron, it supports up to 20A.

Inertial Sensor

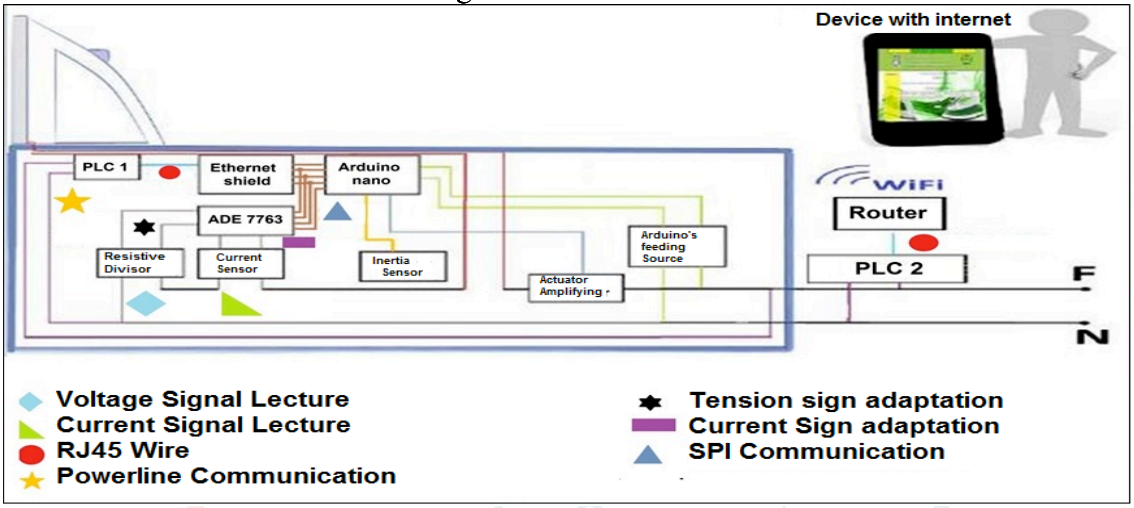
Analysis were made over inertial sensors that are based on acceleration and angular speed variations which are obtained through an accelerometer who provides the acceleration caused by a movement through the framework edge and gyroscope shows how an angle changes in time (Espín, 2010).

According to this, five types of accelerometers, gyroscopes or accelerometer-gyroscope were analyzed among which are L3GD20 sensor, MMA 7455, MPU 6050 and ADXL345, taking into account electric, economic, number of edges and other characteristics, it was decided to work with MPU-6050 because it has a fusion between two sensors with an error margin smaller than others, so the best characteristics can be taken from each one of them and achieve an easier work with Arduino®.

3.2. Design

Figure 1, shows graphically the scheme of electric iron where tension, current and energy signals are taken and adequate, a relay is used as actuator and Ethernet with PLC to transfer data, the MPU-6050 sensor with the objective of knowing its position and state placing it with rest of components inside, simultaneously a modification was made for the relay because the current that Arduino® should provide was higher than 20mA, which is why a transistor was used to make an adequate circuit.

Figure 1 Iron Scheme



Source: authors

3.3. Development

The following section explains the development to implement the proposed prototype. It was fundamental to use ADE 7763 and ACS714 current sensor for measurement processes, so as Arduino®'s algorithm. Arduino®'s SPI library offers four modes, and based on ADE 7763's (Analog Devices, 2016) datasheet, which stablishes SPI serial communication times, where the clock must start in a low level and MOSI can start in a high or low level, Arduino®'s mode one(1) was chosen.

The algorithm developed for this prototype stablishes bits order starting with the most significant bit, assigning data sending mode in mode one (1). Afterwards, SPI divisor clock was established to act over PIN 11 which activates ADE7763. Then, there is a pause in program to read bytes, and measured tension value is given. Finally, ADE7763 is deactivated with a pause in program. It is important to highlight that current, tension and energy measures need a measure calibration by a linear regression.

Regarding the accelerometer-gyroscope sensor, an algorithm was implemented on Arduino®'s Sketch which aims to detect that the electric iron is or is not in movement and if it is vertical or horizontal so one can take actions on the power off.

```
/*SENSOR*/
 SPI.setDataMode(SPI_MODE0);
 imu.read_all();
 g0= imu.gyroscope_data[0] ;
 g1= imu.gyroscope_data[1] ;
 g2= imu.gyroscope_data[2] ;
 a0= imu.accelerometer_data[0] ;
 a1= imu.accelerometer_data[1] ;
 a2= imu.accelerometer_data[2] ;
  if (g0>0 ) //|| AY>-21
      {           est="si";          }
    else if (g0<-2)
      {           est="si";       }
    else
      {           est="no";       }
    if (a0<-0.89)
      {           pos="horizontal";          }
    else if (g1<-0)
      {           pos="horizontal";       }
    else
      {           pos="vertical";       }
      Serial.print("   Movimiento = ");
      Serial.print(est);
      Serial.print(", Posicion = ");
      Serial.println(pos);
```

Ethernet Shield plaque is connected through a RJ45 wire with a PLC inside home electric network, likewise home's router is connected to another PLC with the objective of visualizing information inside the local network. Finally, the output signal of an Arduino®'s digital "pin" was modified so the relay's coil could be activated in order to have control over prototype, for this case it was necessary to implement a 2N2222 (Datasheetcatalog, 2016) transistor so the current was appropriate for actuator.

4. Tests and Results

Tests were developed at Universidad Distrital, initially changing tension and current levels in different time periods. Table 2 shows tension values measured with the network analyzer for network parameter register measures (PQA824) (HT Instruments, 2016) and the interval shown in Arduino®'s serial monitor initially showed dimensionless values, which is why a linear regression was made with Arduino®'s and PQA data for calibration.

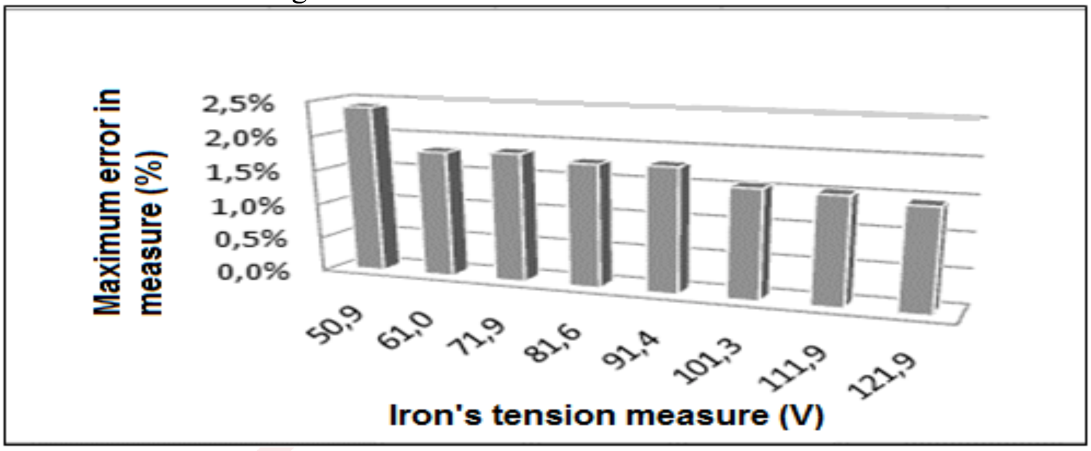
Table 2. Tension Values

Multimeter Tension	Arduino's Tension (V)			Error (%)		Max Error(%)
	Min	Max	Average	Min	Max	
50,9	49,66	51,14	50,40	2,4%	0,5%	2,4%
61,0	59,88	61,36	60,62	1,8%	0,6%	1,8%
71,9	71,22	73,28	72,25	1,0%	1,8%	1,8%
81,6	80,98	83,07	82,02	0,8%	1,8%	1,8%
91,4	90,88	93,00	91,94	0,5%	1,8%	1,8%
101,3	100,10	102,87	101,48	1,2%	1,5%	1,5%
111,9	110,97	113,60	112,28	0,8%	1,5%	1,5%
121,9	122,02	123,66	122,84	0,1%	1,4%	1,4%

Source: Authors, 2016.

Maximum perceptual error is 1,8% for values between 60V and 100V, in the other hand, with values higher tan 100V error decreases around 0,4%, which shows that for low tension values between 110V and 120V a maximum error of 1,5% is expected as shown in Figure 2.

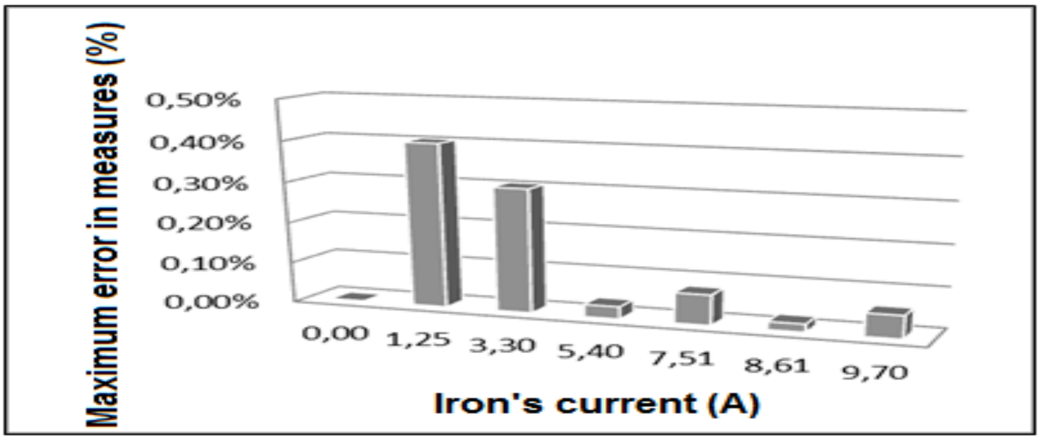
Figure 2. Tension measures maximum error



Source: Authors, 2016.

In Figure 3, measures highest and lowest error is 0, 9% and 0, 1% respectively for different current values, error do not beat 1% estimating that difference between Arduino's and multimeter measures was minimal. Results obtained are really similar to the ones shown by multimeter since its precision does not beat 1%.

Figure 3. Current Measures Error.



Source: Authors, 2016.

Since ADE 7763 measures energy and not power, it was necessary to develop energy measures at different times for calibration. In order to validate energy, energy had to increase at same time as PQA and Arduino®'s. To facilitate prototype's energy measures, two time intervals are observed, the first one PQA's energy values were 30Wh, and the values measured by Arduino® changed to 30.74Wh.

5. Conclusions

Protocols let the user monitor and supervise continuously the system with the objective of controlling its functioning through any device with internet access. This will let the user administrate this device more properly so it is energetically efficient thanks to benefits offered by powerline communication (PLC). Through an IP protocol used to monitor tension, current and energy parameters, electric iron's behavior becomes easier to control for the users who count with internet access, so control over the device can be taken from different places just by indicating the IP direction using the preferred internet explorer.

The developed prototype along with the proposed interphase allow interaction between residential user and web platform, because current, tension, energy consumption and an electric iron's price can be controlled from a local or external network through internet. This is a huge advantage comparing to other products offered in the market because they do not take into account the user for saving and use energy efficiently at home, this qualities make this interphase a fundamental tool to monitor energy consumption and control an electric iron.

Regarding monitoring, calibration of current, tension and energy of prototype was fundamental, in this case the calibrations were made with linear regressions, due to errors increasing significantly, likewise, it is necessary to develop many measurements in dragged on times because in short times measures error tends to grow. According to the developed tests, obtained values are trustable, which gives trust to the user so he can include this type of devices for home's energetic management in the close future.

As home is one of the most important places for people, this prototype offers as a plus, security by avoiding a fire caused by a plugged home device by a neglect, making it a more trustable product and increasing people lifestyle.

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Oil Producers, Refiners and Renewable Energy Consumers: Correlation to the Wealth, Competitiveness, Peace and Happiness of Populations

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Abstract

A popular perception suggests that nations with abundant natural resources will ultimately demonstrate stronger economic performance. Studies investigating this perception, however, showed conflicting results.

Fossil energy resources abundance (oil), processing capacity of energy resources (oil refining) and use of renewable energy technology from forty five countries, were correlated with four socio-economic indicators. The indicators included the gross national income (GNI) per capita, the global competitiveness index (GCI), the happiness index and the peace index.

We demonstrated weak correlations between the crude oil production per capita and GNI per capita ($r=0.392$, $p=0.01$) but no correlations were observed between crude oil production and the other indicators. A strong positive correlation was detected between the amount of refined products per capita and GNI per capita ($r=+0.875$, $p<.0001$), GCI ($r=0.602$, $p<0.0001$) and happiness index ($r=0.612$, $p<0.0001$). Strong positive correlations existed between the renewable energy consumption per capita and each of the GNI per capita ($r=0.681$, $p<0.0001$), happiness index ($r=0.611$, $p<0.0001$) and peace index ($r=0.709$, $p<0.001$).

The abundance of oil reserves does not make nations wealthier or happier. Processing of fossil fuels correlate strongly to the wealth and happiness of nations. The utilization of renewable energy technologies is associated with improved economic and social performance.

Keywords: Crude oil production; oil refining; renewable energy; socio-economic indicators

Introduction

The relation between the abundance of natural resources in a particular nation and its economic growth is an interesting concept in global economy. Popular perceptions suggest that nations with abundant natural resources will ultimately demonstrate stronger economic performance. However, this assumption needed to be scientifically tested. Therefore, several studies have been conducted to test the credibility of this hypothesis. Different studies yielded conflicting results.

Auty (1980) studied the rates of economic development in eight resource rich developing countries and analyzed the factors affecting the economic performance in these countries. Interestingly, he demonstrated that resource rich countries showed slow economic growth. In a larger study, Sachs and Warner (1995) investigated the relation between the economic growth rate and the ratio of natural resources (agricultural, mineral and hydrocarbons) exports to Gross Domestic Product (GDP) in 92 countries from 1970 through 1989. This study also showed a negative correlation between the abundance of natural resources and economic growth (Sachs and Warner, 1995). Using Bayesian Averaging of Classical Estimates (BACE), Doppelhofer et al (2000) analyzed the factors influencing economic growth and found that the amount of exports from mining activities inversely correlated with a nation's economic growth supporting the findings of Sala I Martin (1997). Based on these findings, the term "The curse of natural resources" was coined by Sachs and Warner (2001) who argued that the "curse" cannot be explained by geography or climate.

Advocates of the curse of natural resources have tried to offer reasons behind that strange phenomenon. Sachs and Warner, 2001 showed that several casual and empirical correlations prove the inverse correlation between abundance of natural resources and economic performance. Gylfason (2001) and Stijns (2006) attributed that curse to four factors, namely the Dutch disease; rent seeking, over confidence and neglect of education. The "Dutch disease" is a term used to describe the negative implications of the sudden and dramatic increase in a nation's wealth, a phenomenon that usually occurs after the discovery of vast natural resource reserves or a large increase in the price of a given resource. This results in decline in non-resource exports and an increase in imports. In some natural resource rich countries, rent seeking occurs when the government utilizes all its resources to achieve economic gains (such as aid or grants) from other countries or organizations without creating benefits for its population. Some resource rich nations develop a false sense of economic security, thanks to the abundance of their natural resources. As a result, these governments may fail to adopt good sound economic policies. This overconfidence may also result in less spending on education. The people in resource rich countries tend to engage in low skill intensive occupations related to the exploitation of natural resources.

However, the validity of the" curse" was questioned by Brunnschweiler (2007) who considers that the "curse" might be a misinterpretation resulting from the use of the ratio of primary exports to GDP as resource abundance measures which might yield misleading results. Thus, Brunnschweiler (2007) used the per capita mineral and total natural resource wealth which he considers a more accurate and representative measure. He correlated it with economic growth during the period 1970-2000 and observed that a statistically significant positive correlation exists between the two parameters. The correlation became highly significant with mineral resources. Lederman and Maloney (2003), using the Leamer's net natural resource exports per worker as a measure of resource abundance, observed a positive effect of natural resources abundance on economic growth. Davis (1995) who used the share of mineral exports in total merchandise exports found a positive correlation between resource abundance and economic growth.

Due to the depletion of fossil fuel resources and the large increase in demand and prices, many countries have focused on the gradual shift towards renewable energy resources to ensure energy independence. The causal relationship between renewable energy consumption and economic growth is intriguing and has been investigated in some studies which yielded different conclusions that can be grouped into four categories. The first category is sometimes referred to as the "feedback hypothesis", whereby renewable energy consumption and economic growth are interdependent and interrelated. The second category is termed the "growth hypothesis", whereby renewable energy consumption is among the factors that result in economic growth. The third category, the "conservation hypothesis", suggests that economic growth causes an increase in renewable energy consumption. The "neutrality hypothesis", however, denies the existence of any causal relationship between renewable energy consumption and economic growth (Omari et al, 2015).

To date, the relation between abundance of natural resources or renewable energy and the nation's economical performance and social status has not been fully understood due to the diversity of economic measures and indicators used in previous studies and the non-homogenous methods of analysis. Therefore, we designed the current study to investigate the relations between three economic enablers, namely crude oil production, refining technology and renewable energy consumption to specific socioeconomic indicators.

Study Methodology:

Data source

In the current study, we derived the economic enablers' data from different sources. The data for crude oil production was derived from the Organization of Petroleum Exporting Countries (OPEC) report: "World Crude Oil Production by Country". The amount of refined products data was obtained from the OPEC's "World Output of Refined Petroleum Products by Country". The renewable energy consumption data was generated from British Petroleum (BP) report: "Statistical Review of World Energy". The population data for various countries presented in the study were obtained from the World Bank and national sources.

Socio-economic indicators

In the current study, we aimed to specifically measure the countries' economic performance, institutional development, population satisfaction and political stability. Although there is no single best indicator to reliably estimate the socio-economic status of a given country, we selected four indicators that we believe will help our specific research question. .

The four indicators are:

I. **Gross national income per capita (GNI per capita) Purchasing Power Parity (PPP):** GNI is defined as the summation of the value of goods produced in that nation, as well as the product taxes collected by the government and the incomes or salaries received by residents from abroad. The GNI per capita is calculated by dividing the gross national income (GNI) of a particular country by its population. We used the World Bank GNI per capita, PPP data for 2013.

II. **Global competitiveness index (GCI)**: GCI is a measure of a country's productivity level determined by analyzing a set of factors related to that country's institutions and policies. Specifically, the GCI is a weighted average of the 12 pillars of competitiveness which include infrastructure, macroeconomic environment, health and education and technological readiness, among others. The results of this analysis are reported as a number ranging between 1 and 7, with 7 being the highest and 1 the lowest. The GCI is estimated for most countries and published as part of the Global Competitiveness Report semiannually by the World Economic Forum (WEF).

III. **World Happiness index:** The world happiness index is a survey that studies a certain population's satisfaction with the prevailing conditions in the country. Specifically, the respondents are asked whether they are "happy with their lives" and not the related concept of emotional happiness. We obtained the happiness index data for the included countries from the "World Happiness Report" by the United Nations Sustainable Development Solutions Network.

IV. **Global Peace index:** The global peace index is an indicator of a country's peace, security and stability. The peace index is determined by three factors, namely the security enjoyed by the population, the country's involvement in internal, regional or international conflicts, and the level of the country's militarization. As the peace index increases, the country becomes less "peaceful". In the current study, we derived the global peace index from the 2014 annual report by the Institute for Economics and Peace. To maintain consistency, we used the inverse of the global peace index. The inverse of the global peace index increases as the country becomes more "peaceful".

Countries selection

Based on OPEC's "World Crude Oil Production by Country", we identified the largest 45 crude oil producers and included them in our study. Similarly, the largest 45 oil refiners were identified and selected based on OPEC's "World Output of Refined Petroleum Products by Country". Using BP's "Statistical Review of World Energy", we identified the largest 45 consumers of renewable energy resources namely wind, geothermal, solar, biomass and waste in 2013 and included them in the analysis.

Data processing and correlations

To achieve accurate measures of the economic enablers, the crude oil production, amount of refined products and renewable energy consumption for each country were divided by the population to express them as per capita values.

The crude oil production per capita for the 45 producers was then correlated with the GNI per capita, the GCI, the happiness index and peace indicator. The amount of refined products per capita for 45 refiners was also correlated with the four socio-economic indicators. We also correlated the renewable energy consumption per capita for the largest 45 consumers with the four socio-economic indicators. Countries for which socio-economic indicators were not available were excluded from the analysis.

Statistical analysis

All of the correlations were performed using Spearman analysis technique with SPSS statistics software (IBM SPSS statistics version 20). For each correlation, the correlation coefficient (r) as well as the p-value was calculated. The criteria for determining the strength of the correlations are based on the guidelines of (Evans 1996), summarized in **Table 1.**

Table 1 Criteria for identifying the strength of the correlation (Evans 1996)

Correlation coefficient	Correlation strength
±0.00-±0.19	Very Weak
±0.20-±0.39	Weak
±0.40-±0.59	Moderate
±0.60-±0.79	Strong
±0.80-±1.0	Very Strong

Results

<u>Oil Production</u>

The crude oil production per capita of the largest 45 producers was first correlated with the four socio-economic indicators, namely GNI per capita, GCI, happiness index and peace index (**Fig. 1).** A significant positive correlation ($r=0.392$, $p=0.01$) was observed between oil production per capita and GNI per capita. The correlation

between oil production per capita and GCI was insignificant (r=-0.022; p=0.888). In addition, the correlation between oil production per capita and happiness index was positive though very weak (r=0.144) and insignificant (p=0.364). No correlation could be observed between crude oil production per capita and the peace indicator (**Fig. 1).**
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Oil Refining

The volume of refined products of the largest 45 oil refiners was next correlated with the three socio-economic indicators (**Fig. 2).** A very strong positive correlation was observed between the amount of refined products per capita and GNI per capita (r=+0.875) that is also statistically significant (p<.0001). In addition, strong positive correlations were observed between the amount of refined products per capita and each of the GCI (r=0.602) and happiness index (r=0.612). Both correlations were also statistically significant (p<0.0001).

A moderate positive direct correlation (r=0.520) which was statistically significant (p<0.001) was observed between the amount of refined products per capita and the peace indicator.

Renewable energy

The results of the correlations between renewable energy consumption per capita and the three socio-economic indicators are summarized in **Fig. 3**. Strong positive correlations existed between the renewable energy consumption per capita and each of the GNI per capita (r=0.681) and happiness index (r=0.611). These two correlations are also statistically significant (p<0.0001). The correlation between renewable energy consumption per capita and GCI, however, was moderate (r=0.538) but statistically significant (p<0.0001). A strong positive (r=0.709) statistically significant (p<0.001) correlation was observed between renewable energy consumption per capita and peace indicator.

All correlations are summarized in **Table 2.**

Table 2 Summary of correlations with the socio-economic indicators

	Wealth	Competitiveness	Happiness	Peace
Oil production per capita	Weak Positive	Very weak Negative	Very weak Positive	None
Volume of refined products per capita	Very strong Positive	Strong Positive	Strong Positive	Moderate Positive
Renewable energy consumption per capita	Strong Positive	Moderate Positive	Strong Positive	Strong Positive

The crude oil production per capita of the largest 45 producers was then correlated with both the volume of refined products per capita as well as the renewable energy consumption per capita **Fig. 4.** The correlation between crude oil production per capita and volume of refined products per capita was positive but weak (r=0.386) and statistically insignificant (p=0.062). A moderate negative correlation was observed between crude oil production per capita and renewable energy consumption per capita (r=-0.549). This correlation was statistically significant (p=0.005).

Discussion:

In the current study, we investigated the relationship between three economic enablers (crude oil production, amount of refined products and renewable energy consumption) and four socio-economic indicators (GNI per capita, GCI, happiness and peace index). We demonstrated weak positive correlations between crude oil production per capita and the socio-economic indicators GNI per capita and happiness for the largest crude oil producers. Thus, our findings do not support the "curse of natural resources" hypothesis which assumes that the abundance of mineral and oil resources has a negative impact on economic development. If such "curse" is valid, it would have been expected to get negative correlations between crude oil production per capita and the economic indicator, GNI per capita, which is not the case in this analysis. Although we found a negative correlation between crude oil production and GCI, such correlation was very weak and not statistically significant suggesting that the abundance of fossil energy resources did not make nations more economically competitive. Our findings do not support the findings of Sachs and Warner (1995), Auty (1980) and Doppelhofer et al (2000) in favor of the "curse of natural resources" assumption.

The lack of strong correlations between crude oil production per capita and the tested socio-economic indicators, however, is an interesting intriguing point. According to popular perceptions, crude oil is an expensive and vital commodity that should bring a large influx of money into the producing nations resulting in economic growth. However, the current study does not provide any evidence that crude oil production may be associated with or stimulate economic growth. The lack of strong correlations between these parameters may be attributed to several factors. First, some oil producing nations do not possess adequate refining capabilities. As a result, these nations are forced to sell their crude oil production to other countries with efficient refining capabilities and then purchase the refined products at a higher price. As has been previously suggested by Gylfason (2001) and Stijns (2006), the abundance of crude oil reserves may provide the governments of resource rich nations with over confidence and a false sense of economic security which prevent these governments from adopting sound economic policies or invest in the countries' infrastructure and projects for people welfare .

In contrast, our study showed strong positive correlations between the quantities of refined products per capita and the socio-economic indicators (GNI per capita, GCI and happiness) implying that nations that posses and invest in refining technology tend to be wealthy and economically competitive with stronger institutions and happier populations. Thus, the possession of knowledge and technology to process hydrocarbons seems more important for economic development than the abundance of the resource itself. Petroleum refining nations buy crude oil resources at relatively low prices from oil producing nations and then sell the refined products to these nations at a higher price resulting in actual profits. We also detected a statistically significant positive correlation between the amount of refined products per capita and the peace index. Constructing and operating oil refineries requires large investments and research which are more likely available in politically stable nations.

In contrast to the absence of significant correlations between crude oil production and the tested socio-economic indicators, we demonstrated statistically significant strong positive correlations between renewable energy consumption per capita and each of GNI per capita, happiness and GCI. This is an interesting finding although it is not clear whether the country's wealth encourages exploitation of renewable resources or if utilization of renewable energy has a positive economic impact and increases country's wealth. Both speculations seem plausible. The adoption of renewable energy technology requires large investments that can only be provided by a wealthy country capable of meeting its population energy needs through renewable recourses resulting in an ultimate increase in renewable energy consumption. The increased use of renewable energy resources would decrease the demand on expensive imported fossil fuels resulting in cost savings that may be directed to income generating projects.

Apergis and Payne (2010 a) studied the economic growth and renewable energy consumption for thirteen countries in Eurasia by analyzing the economic performance data for these countries over a period of 15 years (1992 to 2007) using GDP, labor force and real gross capital formation as determinants of economic growth. Their results support the "feedback hypothesis" which suggests that renewable energy consumption and economic growth are both interdependent and interrelated. In another study, Apergis and Payne (2010 b) analyzed the economic development and renewable energy consumption in 20 OECD countries during the period 1985 to 2005. They also showed that the "feedback theory" may better explain the causal relationship between the two parameters. Sadorsky (2009) supports the "conservation theory" in his analysis of renewable energy consumption in emerging economies. In this study, Sadorsky concludes that an increase in the income per capita causes a significant increase in renewable energy consumption

However, Menegaki (2011) suggested the "neutrality hypothesis" as he could not detect a relation between renewable energy consumption and economic growth (GDP) when he analyzed the renewable energy consumption in 27 countries in Europe during the period from 1997 to 2007.

We demonstrated a positive, strong and statistically significant correlation between the peace index and renewable energy consumption per capita. To our knowledge, the relation between the two parameters has not been previously studied. Nevertheless, one may speculate that peace and political stability encourage development of extensive industries resulting in higher energy demands. Consequently, non-traditional, cost effective, clean renewable sources of energy are critical. It is also possible to claim that renewable energy consumption fosters political stability and peace. Renewable energy resources provide a secure energy resource to nations and reduce their economic dependence on fossil fuels that are imported from unstable nations. In other words, this “energy independence” ensures the political stability of a nation and protects it from engaging in international conflicts aimed at securing its energy resource.

Interestingly, correlating crude oil production per capita with renewable energy consumption per capita in the largest crude oil producers, showed a statistically significant negative correlation. It seems that in major oil producers, crude oil still represents a secure and cheap source of energy. Thus, such countries have little incentive to invest in renewable energy resources that require large capital expenditure and new technologies. Furthermore, rich oil producers do not adopt contingency plans for future decline in oil resources.

The current study not only analyzed economic performance but incorporated social indicators that have not been previously analyzed such as the GCI, happiness index and peace index. Thus, our findings provided more insight on the relation of socio-economic status and different economic enablers. Also, we did not restrict our analysis to the crude oil production but we extended it to refining products and renewable energy. However, our study could not ascertain the causal direction between some tested parameters which need future research on more countries.

Conclusions:

The abundance of fossil fuels is not necessarily associated with economic growth, institutional development, happiness and political stability. In fact, other factors are better predictors of social and economic performance. Possession of refining infrastructure and consumption of renewable energy resources are directly correlated with the indices GNI per capita, GCI, happiness and peace index. In oil rich countries, the abundance of fossil fuels hampers the development of renewable energy.

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Figures

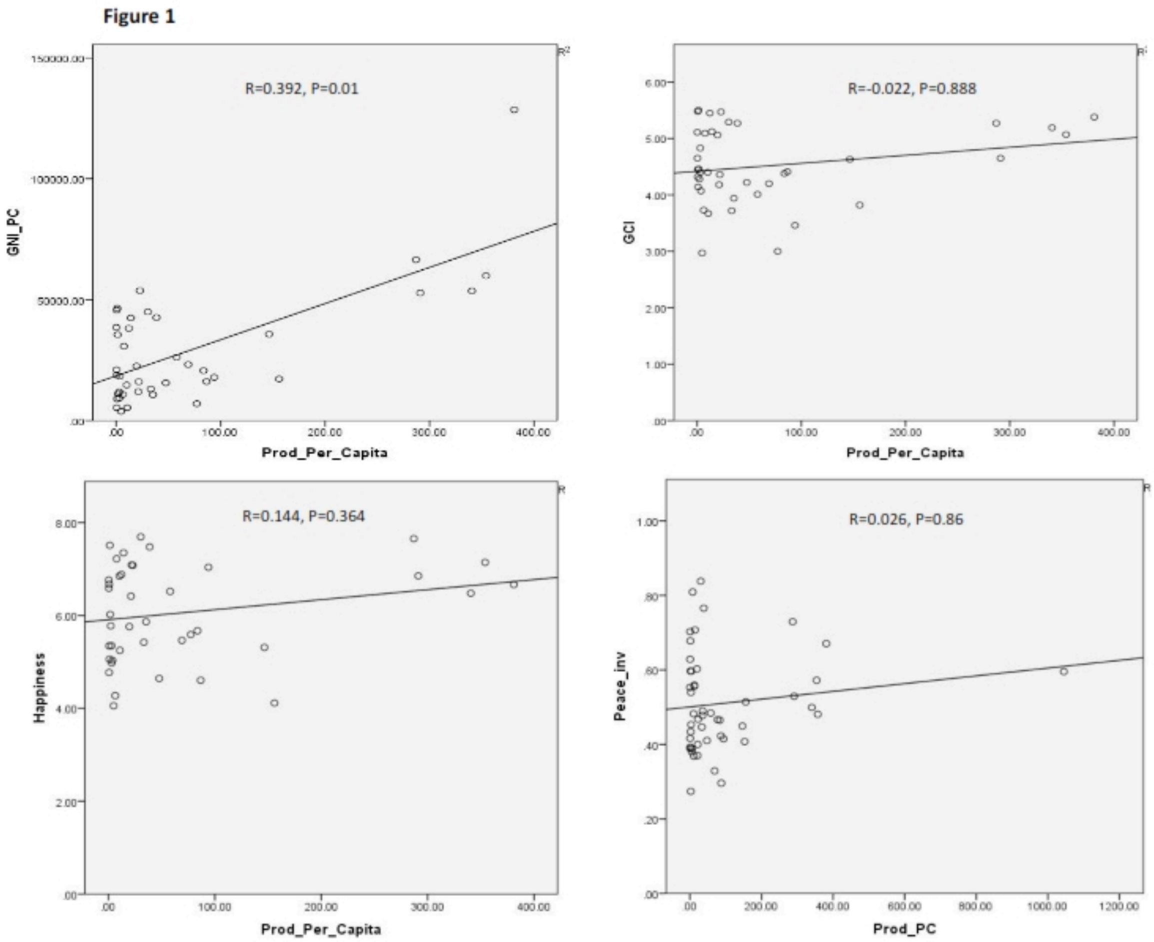

Figure 1: Correlation between crude oil production per capita and the four socio-economic indicators (GNI per capita, GCI, happiness index and peace index). A weak correlation was observed between the crude oil production per capita and GNI per capita (r=0.392, p=0.01) but no correlations were observed between crude oil production and GCI (r=-0.022, p=0.888), happiness index (r=0.144, p=0.364) and peace index (r=0.026, p=0.86).

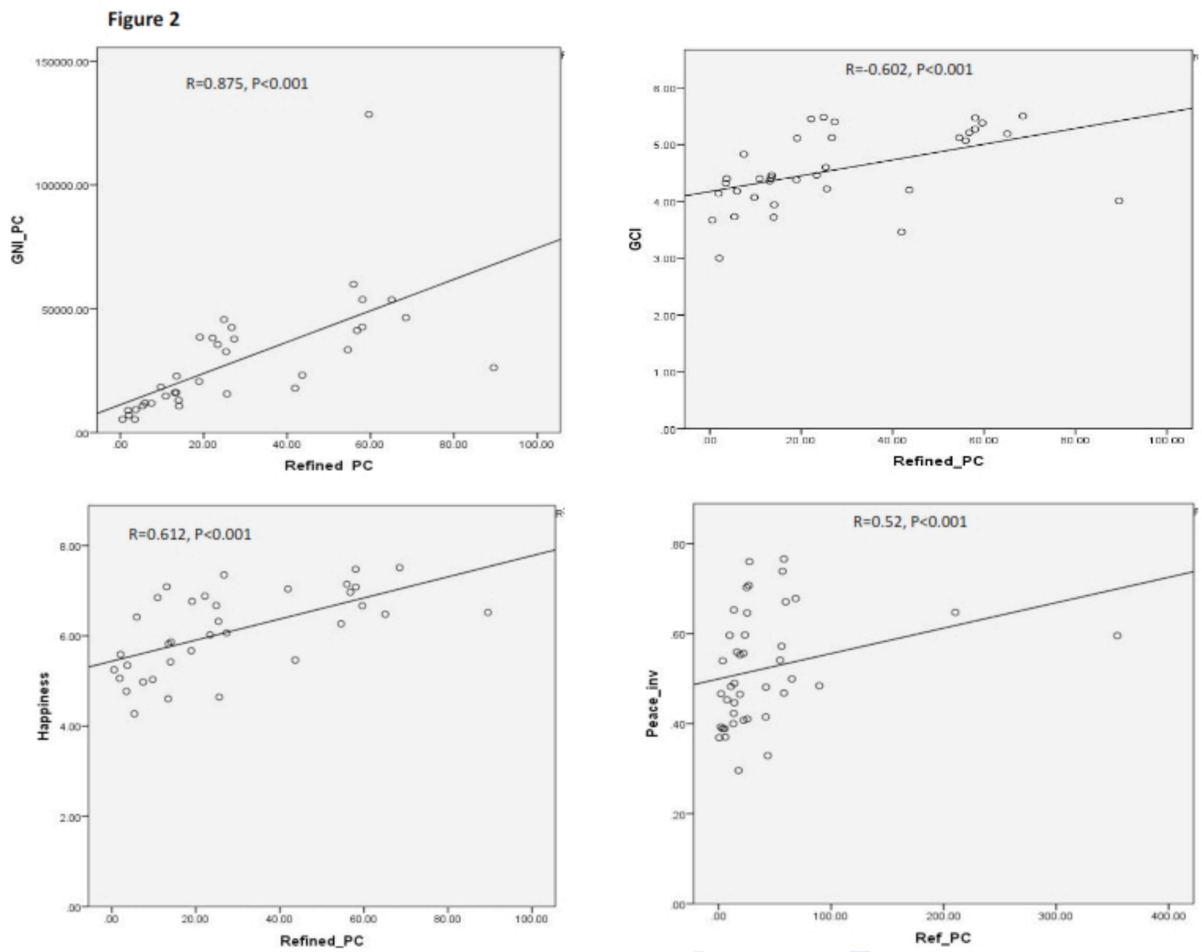

Figure 2: Correlation between amount of refined products per capita and the four socio-economic indicators (GNI per capita, GCI, happiness index and peace index). A strong positive correlation was detected between the amount of refined products per capita and GNI per capita (r=+0.875, p<.0001), GCI (r=0.602, p<0.0001) and happiness index (r=0.612, p<0.0001). A positive direct correlation was observed between the amount of refined products per capita and the peace indicator r=0.520, p<0.001).

Figure 3`

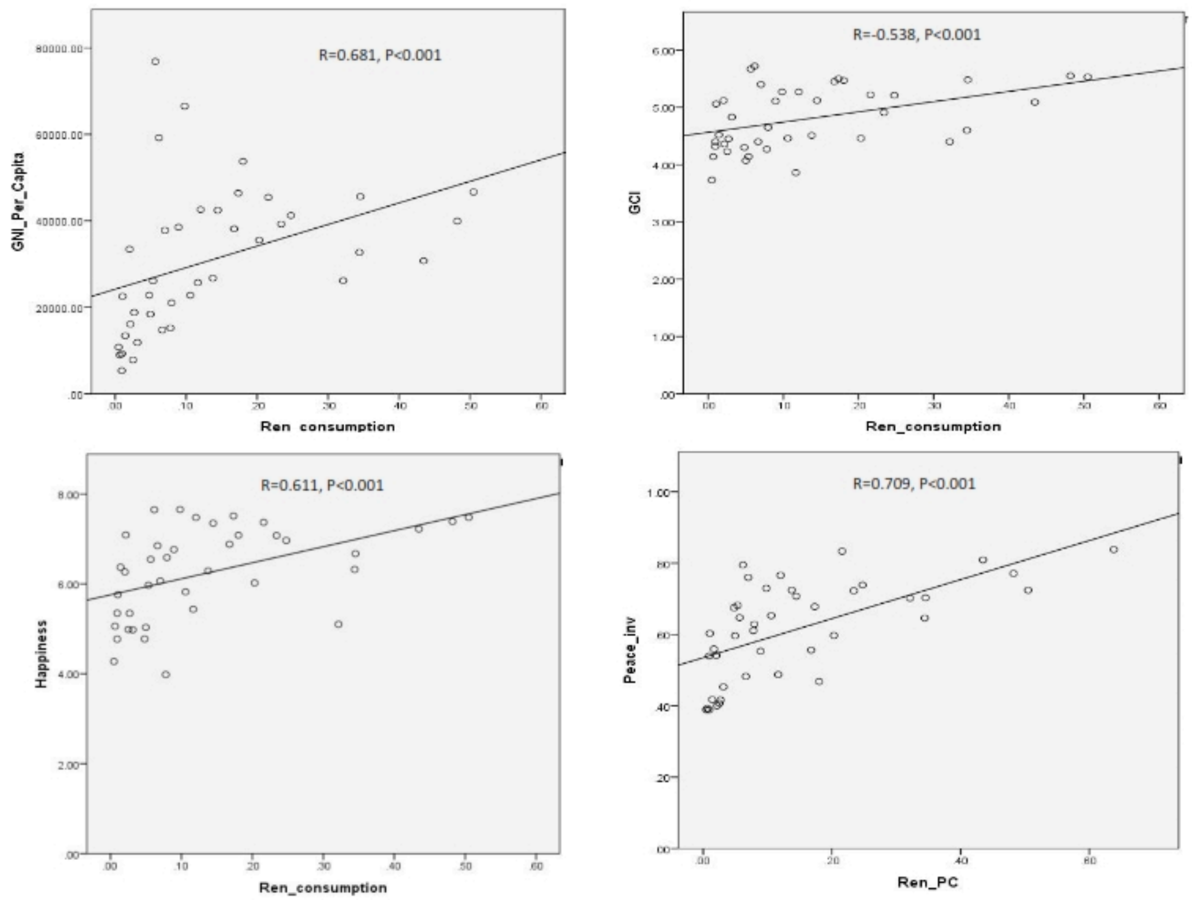

Figure 3: Correlation between renewable energy consumption per capita and the four socio-economic indicators (GNI per capita, GCI, happiness index and peace index). Strong positive correlations existed between the renewable energy consumption per capita and each of the GNI per capita (r=0.681, p<0.0001), happiness index (r=0.611, p<0.0001) and peace index (r=0.709, p<0.001). The correlation between renewable energy consumption per capita and GCI, however, was moderate (r=0.538, p<0.0001).

Figure 4

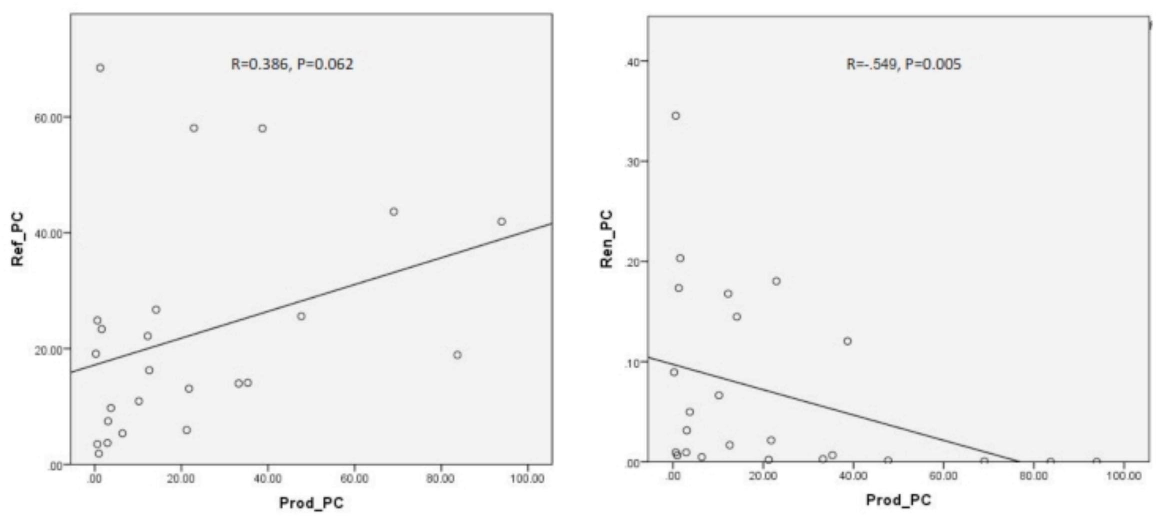

Figure 4: Correlation between the crude oil production per capita of the largest 45 producers and both the volume of refined products per capita as well as the renewable energy consumption per capita A moderate negative correlation was observed between crude oil production per capita and renewable energy consumption per capita (r=-0.549, p=0.005). The correlation between crude oil production per capita and volume of refined products per capita was positive but weak (r=0.386, p=0.062).

Microenvironment of HMGB1 "Clusters": A Potential Drug Target for Cancer and Diabetes

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Abstract
The quest for potential therapeutic strategies to treat inflammatory diseases represents one of the topical progresses the medical sciences field. High Mobility Group Box 1 (HMGB1) is a late mediator of myriads of pathophysiological diseases such as cancer and diabetes, which makes it a potential target for drug development. Despite its intracellular role in controlling DNA expression and architectural assembly, the HMGB1 which is released by damaged cells interact with cell surface receptors such as Receptor for Advanced Glycation End-products (RAGE) and Toll-like Receptor (TLR), subsequently activating signal cascades which then induces various pro-inflammatory reactions. In connection with its DNA-related biological functions, it appears to be necessary for HMGB1 to form clusters. We found that this self-association is influenced by specific physiochemical factors: ionic strength, pH, metal ions especially zinc, and redox environment. The HMGB1 cluster possibly influences its interaction with the receptors and the concomitant inflammatory responses. It is also expected that future study can also address the possibility of other physiochemical factors such as formaldehyde in changing HMGB1 structure and whether it may induce cluster formation. This may be an important effort to understand the molecular mechanism of the effect of formaldehyde towards HMGB1, since formaldehyde is a carcinogen and largely used as an illegal food preserving agent, especially in eastern world.

Cell microenvironment and diseases

Microenvironment is a term used to describe a specific place within the habitat of a microorganism where it lives and carries out its biological functions (Madigan & Martinko, 2006). Controlling cell microenvironment is crucial in determining its behavior (Barthes et al., 2014). One of the regulators of the microenvironment is physiochemical conditions which can change rapidly (Madigan & Martinko, 2006). Any disorders or failure to control the microenvironment and/or physiochemical factors may result in genetic instability, irregular pattern of cell necrosis or differentiation, and changes in cellular signals and metabolism. These are the determining aspects of human diseases and disorders (Barthes et al., 2014; Kang et al., 2014). The microenvironment of a single cell also consists of its surrounding cells, as well as proteins. For example, tumor microenvironment is established from interactions between malignant and normal cells, which may account for .50% of the mass of the whole tumor (Balkwill, Capasso, & Hagemann, 2012). Although the non-malignant cells are speculated to promote tumor formation at all stages of carcinogenesis, their exact biological functions are still under detailed investigation (Hanahan & Coussens, 2012).

Examination of several different aspects of the tumor microenvironment, instead of just targeting the malignant cells during cancer treatment, is increasingly considered to be important (Balkwill et al., 2012). In particular, the examination of the molecular bases may offer more insights of the shifts between tumor state and activation of immune system (Balkwill et al., 2012), wound healing and inflammation (Hanahan & Coussens, 2012), which subsequently may lead to the development of new diagnostic biomarkers (Kang et al., 2014). High Mobility Group Box 1 (HMGB1) protein is significantly involved in chronic pathophysiological diseases including cancer, diabetes and Alzheimer's disease, by various mechanisms such as by binding to its receptors (Sims, Rowe, Rietdijk, Herbst, & Coyle, 2010). Thus, understanding the molecular mechanism of HMGB1 may lead to the discovery of potential therapeutic target to block tumor growth and development, as well as for the treatment of other diseases (Kang et al., 2014).

HMGB1: between structure and function

HMGB1, a highly conserved protein, is frequently found in the nucleus of almost all eukaryotic cells (Ito & Maruyama, 2011). Inside the cell, HMGB1 serves as a protein that modifies DNA structure and promotes protein assembly (Scaffidi, Misteli, & Bianchi, 2002). However, extracellular HMGB1 possess different function altogether. HMGB1 is released from the tumor cells and the surrounding cells under hypoxia or other environmental stimuli (Kang et al., 2014). HMGB1 forms a complex with DNA, lipids and pro-inflammatory cytokines, which subsequently binds to the cell surface receptors such as Receptor of Advanced Glycation End products (RAGE) (Sims et al., 2010) and Toll-like Receptor (TLR) (Yang et al., 2010) to induce inflammation. By interacting with HMGB1, TLR9 mediates the release of HMGB1 from nucleus (Kierdorf & Fritz, 2013). TLR4 specifically stimulates the production of reactive oxygen species (ROS), subsequently promotes hypoxia-induced HMGB1 secretion (Leventhal & Schroppel, 2012). The dual functions of HMGB1 is illustrated in Figure 1.

HMGB1 was claimed to be significantly expressed in certain primary tumors, for example melanoma and colon, prostate, pancreatic, and breast cancers (Musumeci, Roviello, & Montesarchio, 2014). The interaction of HMGB1 and RAGE is considered to be a crucial factor for the tumor cells growth, motility and invasive migration by inducing tumor survival (Luan et al., 2010). Other than cancer, patients of Diabetes type 2 were reported to have high levels of serum HMGB1 which subsequently activate TLR2 and progress the pro-inflammatory state (Dasu et al., 2010). HMGB1 is also found to be upregulated in other diseases involving cell necrosis, such as Alzheimer's disease (Musumeci et al., 2014).

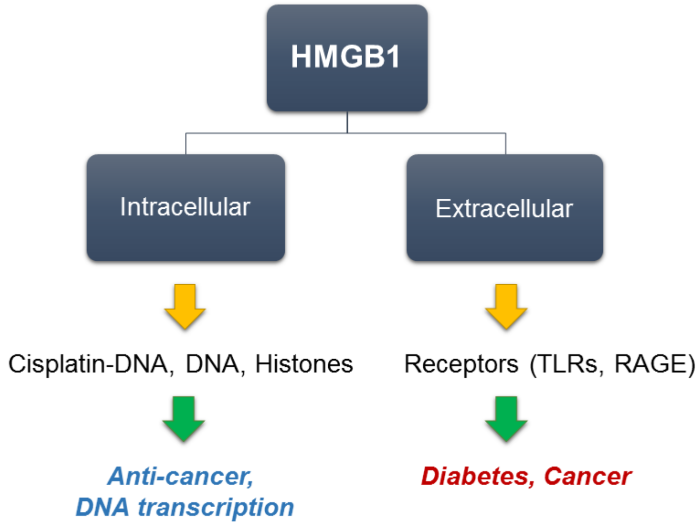

Figure 1. Intracellular and Extracellular Functions of HMGB1

Structurally, HMGB1 consists of two box-like regions, termed Box A and Box B, as described in Figure 2. Both boxes are important in DNA recognition. However, they have different functions. Box A binds distorted DNA, while Box B assists in bending DNA (Stott, Watson, Howe, Grossmann, & Thomas, 2010). Closely related in function with the boxes is the acidic C-terminus tail (Figure 2). The tail has a highly negative charge because it consists of only glutamic acid and aspartic acid residues. The acidic tail assists several DNA-related functions such as stimulation of DNA transcription (Watson, Stott, & Thomas, 2007). The tail has been shown to establish an extensive contact with the DNA-binding faces of both HMG boxes, which then triggers the collapse of HMGB1 structure and prevents the boxes from binding DNA (Stott et al., 2010).

HMGB1 is sensitive towards reduction and oxidation (redox) environment due to its three cysteine residues, namely Cys23, Cys45, and Cys106 (Janko et al., 2014), as described in Figure 2. Previous studies demonstrated that the presence of disulfide bond and/or free cysteine residues, or in other words: the different redox states of HMGB1, play a very crucial role towards HMGB1 localization (D. Tang et al., 2010), the change of its activities including the control of its pro-inflammatory activity (Janko et al., 2014), and even determining the interaction partner of HMGB1 (Yang et al., 2012). A disulfide bond between Cys23 and Cys45 of HMGB1 is rapidly formed in their oxidized state. The glutathione and thioredoxin systems in the cellular environment take turn in alternating the redox states of HMGB1, which varies in different cell compartments (Sahu, Debnath, Takayama, & Iwahara, 2008). On the other hand, the Cys106 residue is in its free, reduced state and was frequently showed to aid HMGB1 in binding to its receptors (Yang, Antoine, Andersson, & Tracey, 2013). Consequently, the reduction or oxidation of the cysteine residues determines the specific physiological impact of the interaction between HMGB1 and each of its receptors. For example, the oxidation of all cysteine residues, or Cys106 alone, or substitution of any of the cysteine residues will prevent TLR4-dependent signaling (Yang et al., 2013), regulate the autophagic flux and translocation of HMGB1 itself (D. Tang et al., 2010). Through the interaction with RAGE, the reduced HMGB1 was reported to specifically mediate autophagy (D. Tang, Billiar, & Lotze, 2012). Recent study demonstrated that oxidation of the free Cys106 hinders the pro-inflammatory activity of HMGB1 and promotes immune tolerance (Janko et al., 2014).

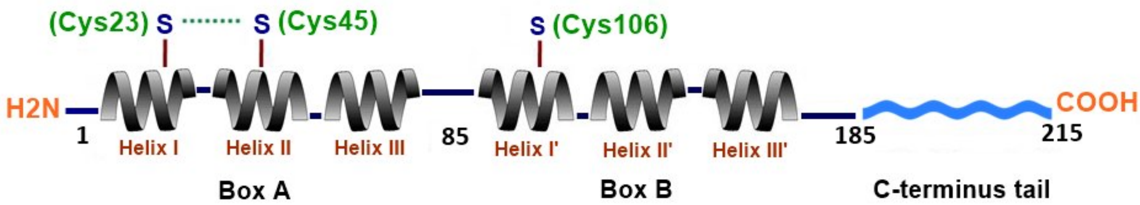

Figure 2. Illustration of HMGB1 Structure.

Structural change of HMGB1 depends on certain physiochemical microenvironment

Proteins represent one of the main components of cell microenvironment, and are paramount for cellular functions. It is known that differentiated cells have myriads of protein expression profile, which is specific to the type of the cells (Barthes et al., 2014). This is important in determining the level of protein expression which subsequently regulates the cell functions and, in cases such as mutation, may causes many types of diseases (Barthes et al., 2014). To carry out their functions, proteins must undergo chemical modification. Such alterations of proteins are crucial in regulating cellular signals and the functions of the protein itself (Liu, Chan, & Chan, 2016). The chemical modifications on protein conformation heavily affect the interactions between proteins. One of the crucial structural changes is the capability of each protein to form oligomer (Ali & Imperiali, 2005), or clusters, in which the protein interacts with itself. It has been suggested that oligomers comprises roughly one third of the cellular proteins. Oligomers also implied to be favored due to its higher activity because it increases the number of active sites, and it has more resistance to degradation (Ali & Imperiali, 2005).

Proteins commonly interact with themselves before binding to their specific partner. This activity is largely influenced by the physiochemical factors of its microenvironment, and promotes a large variety of cellular functions or even diseases. In the disease states, the composition of microenvironment may change, and under that condition protein-protein interactions takes place (Xie et al., 2008). For an instance, two RAGE molecules, or dimer, binds a tetramer of S100B and enhances neurite extension and neuron survival (Ostendorp et al., 2007). A physiochemical factor, Ca^{2+}, is important for the interaction of S100B tetramer with RAGE, where the tetramer exposes a protein-protein interaction site upon Ca^{2+} binding (Ostendorp et al., 2007). RAGE interacts with AGE, which promotes the complications of diabetes, in the presence of D-(--)-Fructose. The expression of D-(--)-Fructose is increasing in some tissues of diabetic patients and it is about 8-fold more reactive than glucose (Xie et al., 2008).

HMGB1 was assumed to form cluster to mediate the structural modification of DNA, when in 1978 it was discovered as tetramers in the rat liver cytosol (Duguet & de Recondo, 1978). The cluster of HMGB1 appears as beads, containing about 20 HMGB1 monomers, which entangled with SV40 DNA (Bonne, Duguet, & de Recondo, 1980). Interestingly, the topic of HMGB1 oligomers is not well developed since those discoveries. The subsequent different studies raised contradictive results as to whether HMGB1 self-associates or not. Based on the existing evidences and the molecular structure of HMGB1 itself, we were interested to conduct research on the self-association of HMGB1 and the possible influences from its environment. Closer examination of the dipolar nature of HMGB1 caused by the polycationic N-terminal part and the polyanionic acidic tail (Fages, Nolo, Huttunen, Eskelinen, & Rauvala, 2000), results in a speculation that HMGB1 may be sensitive towards the modulation of ionic strength in its immediate environment. In fact, we found that increasing ionic strength reduced the strength of HMGB1 tetramer, and the tetramer was more affected by changes of ionic strength than HMGB1 dimer (Anggayasti, Mancera, Bottomley, & Helmerhorst, 2016). Besides ionic strength, pH is one of the physiochemical factors which affect HMGB1 self-association due to its highly acidic C-terminus tail (Figure 2). The rate of HMGB1 self-association gradually increased when the pH value decreased from 7.4. The highest rate of self-association was shown at pH 4.8, however, there was no signal at pH 4.0 (Anggayasti et al., 2016). The effect of lowering the pH value on the extent of HMGB1 cluster formation may have connection with disease states since, for an instance, it is known that during the case of severe diabetes, pH value of blood plasma gets lower than 7.4, which is referred to as acidosis (Nelson, 2008). We also found that the inclusion of low dosage Zn^{2+} promotes HMGB1 tetramer formation (Anggayasti et al., 2016). It possibly ties up with the function of HMGB1 in DNA transcription and subsequently cell proliferation, since Zn^{2+} is associated with those biological functions and is indeed commonly associated with DNA-binding proteins (MacDonald, 2000). Last but not least, the results in our study showed that in a more oxidized condition, which mimics extracellular environment, HMGB1 predominantly exists as tetramer, whereas in a more reduced condition, such as in intracellular environment, more dimer species were detected (Anggayasti et al., 2016). It corresponds to the discussion in the previous section that HMGB1 quickly responds towards the change of its redox environment, which varies in different cell compartments. These findings is summarized in illustration in Figure 3, where we concluded that different cell compartments results in different physiochemical conditions, which promotes the formation of different size of HMGB1 oligomers.

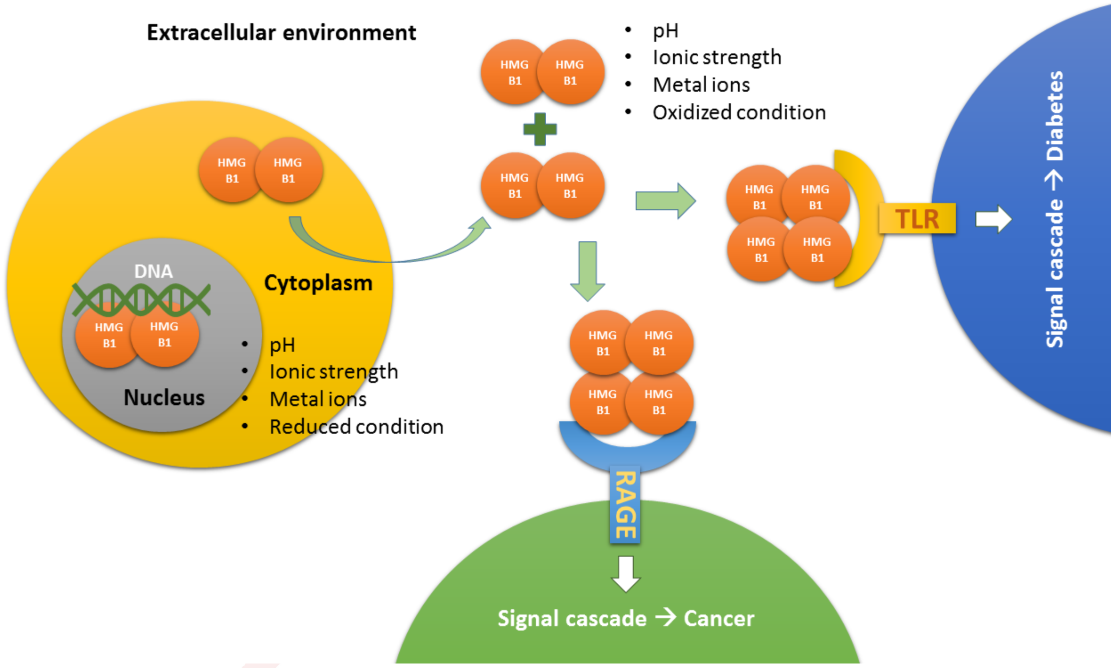

Figure 3. The Projections of HMGB1 Cluster Size, Inside and Outside Cell.

Application of the findings on eastern-world food problems

Formaldehyde is naturally produced in cells, thus it is commonly found in food products. Shiitake mushrooms contain formaldehyde between 40 to 380 mg/kg (X. Tang et al., 2009). Various fresh marine products have natural formaldehyde concentration of 2.177±1.414 mg/kg (Wang, Lee, & Ho, 2007). In fact, human biochemical functions continuously produce residual endogenous formaldehyde. However, low level of formaldehyde detoxification function in mouse model could turn the endogenous formaldehyde to be highly toxic (Ortega-Atienza, Rubis, McCarthy, & Zhitkovich, 2016). WHO International Agency for Research on Cancer officially classify formaldehyde as a Class I carcinogen (Fenech, Nersesyan, & Knasmueller, 2016). Various studies have shown that formaldehyde is significantly connected to cancer, neurotoxicity, and other pathophysiologic effects (Ortega-Atienza et al., 2016).

Formaldehyde becomes a threat since it is used illegally in eastern world to extend the shelf-life of food. Interestingly, the inappropriate use of formaldehyde was recorded as far back as the early 1900 at Indianapolis, United States of America, where the chemical was added to preserve milk given to the infants in an orphan asylum, causing death of three infants (Correspondent, 1900). Currently, it is still common to discover that marine products in markets across China were illegally treated with synthetic formaldehyde preservatives, with extreme formaldehyde concentration range between 300 to 4250 mg/kg (X. Tang et al., 2009). In Indonesia, despite the widespread occurrence of formaldehyde-laced food products across the country in late 2005 (Tamindael, 2011), such case reemerged again in 2011. Formaldehyde was found together, although not in combination with, an antiseptic solution known as borax and a coloring agent rhodamine B (Tamindael, 2011). In 2014, the similar scandal was reported in a large scale within a noodle factory (Correspondent, 2014). Although government authorities has made warnings and officially passed the Food

Law in 2012 (Correspondent, 2014), it seems that there is a little guarantee that formaldehyde abuse will not happen again. Other than the documented cases in China and Indonesia, illegal application of formaldehyde still happens throughout Asian region, such as Vietnam, Thailand, and even Bangladesh (Correspondent, 2009).

In molecular level, recent studies have proposed that formaldehyde is closely related to protein damage. Formaldehyde is suspected to trigger leukocyte genotoxicity, which is assumed to cover several symptoms. In general, the suggested symptoms involved DNA and/or protein damage, which subsequently disrupts nuclear division during mitosis. DNA-protein crosslinks and inflammation-induced ROS formation contribute to the aforementioned damages (Fenech et al., 2016). Other than that, it was found that formaldehyde could promote aggregation of proteins when it is applied to cells, regardless of the cell cycle phases. Interestingly, formaldehyde contributes to the damage of both nuclear and cytoplasmic proteins (Ortega-Atienza et al., 2016). A recent study proposed that formaldehyde can condense with free cysteine in the extracellular fluid of *Escherichia coli*, especially when the cysteine is exposed to oxidative stress. This study also reported that formaldehyde also interacts with cysteine within polypeptide or protein, subsequently results to structural change (Liu et al., 2016).

Natural physiochemical factors in cell microenvironment are the determining factor in modification of protein structure and function, however, the presence of external chemicals are also proven to modify protein architectural assembly. Therefore, in connection with our research findings on the effect of redox states of the cysteine residues of HMGB1, it may be of interest to further investigate whether formaldehyde would interact with HMGB1. Considering its carcinogen property and its ability to induce protein aggregation, which are also related closely to the characteristics of HMGB1, formaldehyde may potentially interact with the cysteine residues of HMGB1, and even promote its self-association. If this research is carried on in the future, it is expected that the results would contribute to enhance the understanding of molecular mechanism of cancer in regards to HMGB1, and may provide an insight on the effect of adding formaldehyde on food which is still quite commonly happen in Asia.

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Numerical Simulation of Heat And Mass Transfer in Adsorbent Bed with Rectangular Fins

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Abstract
A transient two-dimensional numerical model of coupled heat and mass transfers in adsorbent bed of a silica gel/water adsorption chiller system is presented for a plat bed with rectangular fins through the finite element method (FEM) simulations. The bed transient transport behaviors are investigated for all four cycle phases. In the model, a linear driving force equation is used to account for the intra-particle mass transfer resistance. Meanwhile, the refrigerant vapor superficial velocity describing the adsorbate flows is calculated by Darcy's law. The effects of bed configurations including the space of fins and the height of fins on SCP and COP are investigated. The results show that bed transfer processes are enhanced through extended surfaces of fins shape. Furthermore, at a given fins height, SCP increases with the increase in fins number, while at a fixed fins number it decreases as the fins height increases.

Keywords: Adsorbent bed Numerical simulation heat and mass transfers COP SCP

1. Introduction

Adsorption cooling has received much attention in recent years due to its low environmental pollution. This technology has no ozone layers depletion potential and global warming potential; moreover it can make use of low temperature thermal source to realize refrigeration directly. Adsorption cooling has many possible uses in the field of refrigeration and air conditioning. However, the values of the specific cooling power (SCP) and coefficient of performance (COP) are much lower than that expected for vapor compression cycles since the poor heat transfer of the adsorbent bed.

One way to improve the heat transfer of the adsorbent bed is to enhance the thermal conductivity of the adsorbent. For instance, Guilleminot [1]added the Metal or graphite powders even foam metal with good thermal conductivity into adsorbent. Gacciola G el al.[2]used PTFE as the agglomerant to solidify the activated carbon powders, then the effective thermal conductivity of adsorbent were improved to the range from 0.13 to 0.20 W/(m·K)

Cause the main thermal resistance focuses on the side of adsorbent, so increasing the interfacial area for metal-adsorbent contact is the most economic and efficient method to solve this problem. For instance, Guilleminot and Meunier[3] developed a two-dimensional numerical model for an adsorption chiller which equipped annular fins, through the model considered the distribution of temperature, but all the mass transfer resistances of the bed were neglected. Chua et al.[4] numerically analyzed a two-bed, silica gel/water adsorption chiller with annular fins. However the interparticle resistances was not considered.

Gong et al[5]. established an adsorption chiller with annular fins filled with the composite adsorbent that mixing lithium chloride and silica gel. A mathematical model was also developed to analyze the heat and mass transfer in the bed, even though the intra particle mass transfer resistance was considered, the pressure assumed to be constant throughout the bed.

Ilis et al. [6]presented a transient two-dimensional model to represent the heat and mass transfer in an annular adsorbent bed assisted with axial fins. Through ignoring the distribution of the pressure in the bed, the model was simplified by neglecting the convective effects of refrigerant vapor throughout the bed. meanwhile, the governing equations were non-dimensionalised to reduce the mumber of governing parameters, and the bed performance was examined based on the four non-dimensional groups

Yang [7]developed a model on heat and mass transfer in an adsorbent bed with annular fins by using a lumped parameter method to discuss temperature variation and adsorbate distribution. San modeled a multi-bed adsorption heat pump with a plate-fins heat exchangers to calculate the optimum cycle time corresponding to the maximum specific cooling power.

Zhang and Wang[8] developed a three-dimensional model for investigating the pressure and gas flow through the bed using the LDF model for intraparticle mass transport. The relationships of coefficient of performance (COP), specific cooling power (SCP) and longitudinal fins were examined. They found that both COP and

SCP are improved by using longitudinal fins. Li et al. numerical investigated the optimum fins spacing and height. It is found that using the optimized fins spacing and height in the adsorber can produce 2 times cold heat output as much as the previous system.

In fact, there are some detailed researches has been investigated, such as Hamid Niazamnd [9]et al. performed a transient two-dimensional numerical model of combined heat and mass transfer in the adsorbent bed of a silica gel/water with annular fins. Temperature, Velocity of refrigeration vapor and concentration field inside the bed were examined in detail. However, both Li Zhi Zhang's and Hamid Niazmnd's researches, The governing equations contained the heat transfer coefficient at the interface between the metal tube and thermal fluid calculating by the correlation from Dittus and Boelter, but the correlation is just viable in the circular tube, and it is possible that there is no correlation in the existing literatures for what tube in your research with special structure. Actually, it can be detailedly and correctly calculated by the method of conjugate heat transfer.

This literature review shows that no study has been performed by considering the conjugate heat transfer at the interface between the metal tube and thermal fluid

In this paper, a two-dimensional symmetric non-equilibrium mode which takes into account both the internal and the external mass transfer resistance in the adsorbent of an adsorption cooling system.is proposed. The influences of the bed configurations such as the spaces, height and thickness of fins on the system performance are significantly investigated through the finite element method (FEM) simulations.

2. Mathematical model

A diagrammatic drawing of heat exchanger with fins as an adsorbent bed is shown in Fig.1.heating and cooling required for the adsorbent are supplied by thermal fluid through a metal tube. The spaces between fins are filled with adsorbent. Furthermore, the parameter values and operating conditions used in this model is shown in Table.1.

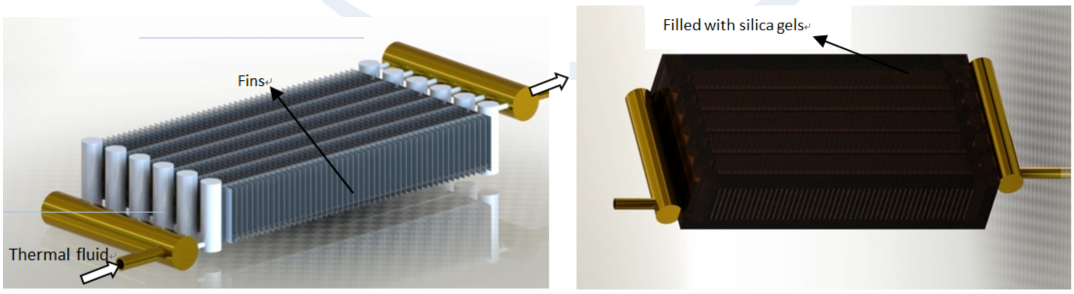


Fig.1 adsorbent bed

Table1. The parameter values and operating conditions

Parameter	Symbol	Value
Length of adsorbent bed	L	120mm
Height of metal tube	H_c	12mm
Fins thickness	δ	1mm
Thermal fluid average velocity	u_f	0.2m/s
Initial pressure	P_0	1000Pa
Initial temperature	T_0	30℃
Inlet thermal fluid temperature during heating	$T_{f,hot}$	70℃
Inlet thermal fluid temperature during cooling	$T_{f,cool}$	30℃
Density of adsorbent	ρ_s	2129kg/m^3
Specific heat of adsorbent	C_{ps}	921 J/(kgK)
Density of gaseous adsorbate	ρ_g	2129 kg/m^3
Specific heat of gaseous adsorbate	C_{pg}	1907 J/(kgK)
Viscosity of gaseous adsorbate	μ_g	10.2E-6 N s/m^2
Heat of adsorption	ΔH	2.37E6 J/kg
Particle diameter	d_p	20μm
Porosity of the particle	θ_p	0.46
Porosity of bed	θ_b	0.36
Equivalent thermal conductivity of the bed	λ_{eq}	0.198 W/(mK)
condensing pressure	P_c	3169Pa
evaporating pressure	P_e	1227Pa

2.1 Assumption

To calculating the heat and mass transfer of adsorbent bed, some assumptions are made:

1. The adsorbed phase and refrigerant vapor are considered as liquid and ideal gas respectively.
2.The particles in the adsorbent bed are standard spherical with uniform size, shape and porosity.
3. There are no heat loss through chamber walls.
4. The only variable thermo physical property of the adsorbent bed parameter is the density of adsorbate gas.
5. The thermal resistance between surface of fins and the adsorbent is neglected.

2.2 Governing equations

Based on above assumptions, the governing equations are as follows:
The conservation of energy for the thermal fluid can be written as:

$$(\rho C_p)_f \frac{\partial T_f}{\partial t} + \rho_f C_{pf} \boldsymbol{U} \cdot \nabla T_f = k_f \nabla T_f$$

The conservation of energy for the metal tube and fins is:

$$(\rho C_p)_m \frac{\partial T_m}{\partial t} = k_m \nabla T_m$$

Energy balance for adsorbent is:

$$(\rho C_p)_{eff} \frac{\partial T_b}{\partial t} + \rho_g C_{pg} \boldsymbol{U}_g \cdot \nabla T_b = k_{eff} \nabla T_b + \rho_b \Delta H \frac{\partial W}{\partial t}$$

where $(\rho C_p)_{eff}$ is the total heat capacity:

$$(\rho C_p)_{eff} = \theta_b \rho_b C_{b,p} + (1 - \theta_b) \rho C_p$$

$$k_{eff} = \theta_b k_b + (1 - \theta_b) k_p$$

and the intra-particle mass transfer resistance is considered using the linear dirving force model(Sakoda and Suzuki) $\frac{dW}{dt} = 15 D_{so} \exp\left(-\frac{E_a}{R_u T_b}\right) / (R_p^2 (W^* - W))$

in which D_{so} is a pre-exponent constant and E_a is the activation energy of surface diffusion with the value if 2.54E-4$m^2 s^{-1}$ and 4.2E4 J mol^{-1} respectively.
W^* is the equilibrium uptake at temperature T_b and pressure P.

$$W^* = \frac{1.6E12 \cdot C_w}{[1 + (2E - 12 \cdot C_w)^{1.1}]^{1/1.1}}$$

$$C_w = P exp(\frac{\Delta H}{RT_b})$$

where ΔH is the isosteric heat adsorption.
The refrigerant vapor superficial velocity is calculated by Darcy's law:

$$\boldsymbol{U}_g = -\frac{K_{app}}{\mu} \nabla \boldsymbol{P}$$

where the K_{app} is calculated by the following equations(Bird et al., 1960;Lee and Thodos,1983;Ruthven,1984):

$$k_{app} = k_d + \frac{\theta_p \mu}{\tau P} D_{eq}$$

$$k_d = \frac{\theta_b^3 d_p^2}{150(1 - \theta_b)^2}$$

$$D_{eq} = \left(\frac{1}{0.02628 \frac{\sqrt{T_b^3 / M}}{P \sigma^2 \Omega}} + \frac{1}{18.5 d_{pore} \sqrt{T_b / M}}\right)^{-1}$$

$$d_{pore} = 0.6166 d_p$$

$$\tau = \theta_b^{-0.4}$$

where $\sigma = 2.641$ and $\Omega = 2.236$.

$$P = \rho_g R T_b / M$$

2.3 Initial and boundary conditions

$T_f\big|_{z=0} = T_{fhot}$ during the heating

$T_f\big|_{z=0} = T_{fcool}$ during the cooling

$P_y\big|_{y=h} = P_e$ when connected to the evaporator

$P_y\big|_{y=h} = P_c$ when connected to the condenser

$P_y\big|_{y=h} = P_b$ when closed

P_b is calculated by the ideal gas state equation

2.4 Performances

The heat that the adsorber absorbed during a cycle is

$$Q_{in} = \int_0^{t2} (\rho u A C_p)_f (T_{fin} - T_{fout}) dt$$

The mass flow rate of water vapor is calculated by

$$\dot{m}_w = \oiint_{\Sigma} \rho_g \, \boldsymbol{U}_g dS$$

Which S is area.

The heat extracted from the evaporator is

$$Q_e = \int_{t3}^{t4} \dot{m}_w [L_w - C_{p_f}(T_c - T_e)] dt$$

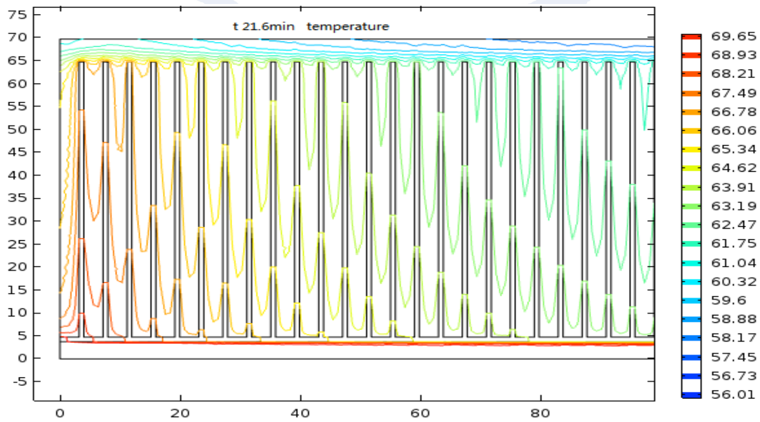
So the coefficient of performance

$$\mathrm{COP} = \frac{Q_e}{Q_{in}}$$

The specific cooling power

$$\mathrm{SCP} = \frac{Q_e}{m_b t_{cycle}}$$

3. Results and discussion



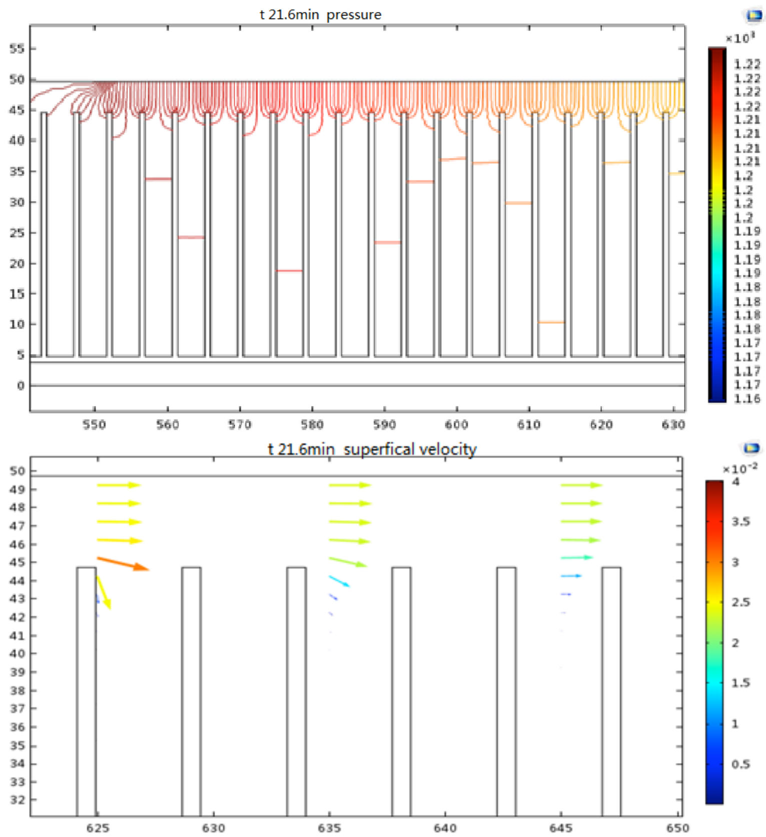
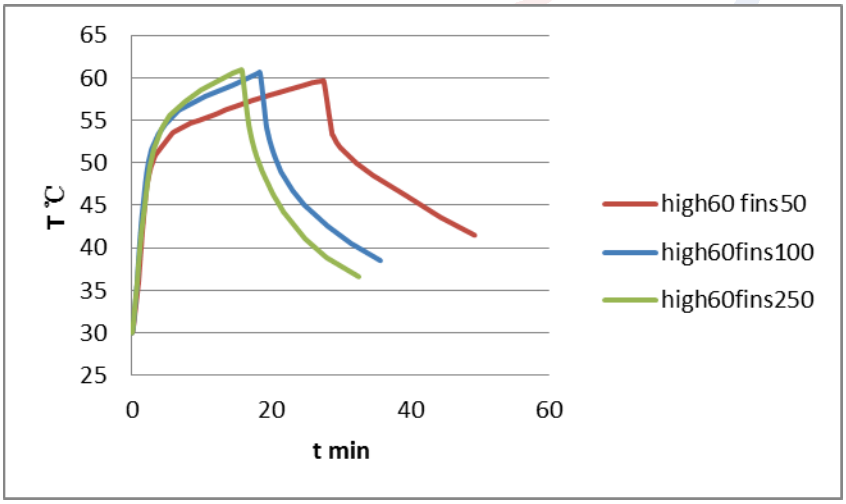
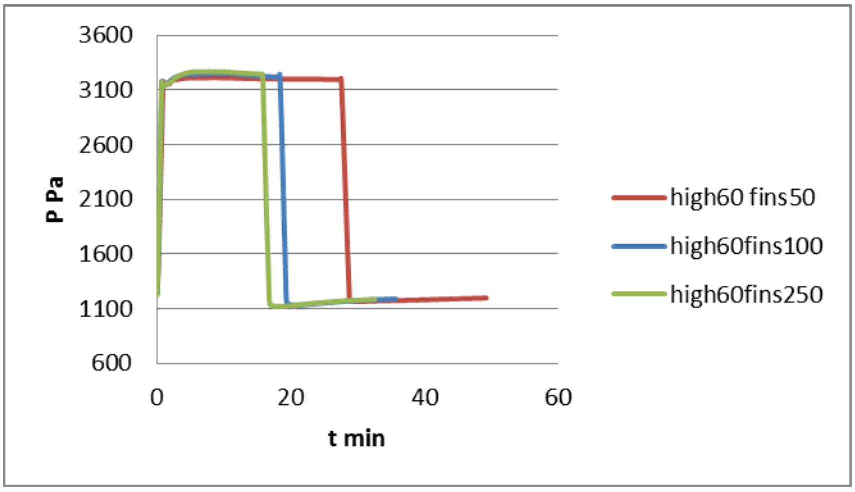


Fig.2 Flow field and pressure distribution of adsorbent bed

The heat and mass transfer in adsorbent bed is calculated by the software COMSOL Multiphysics. The effects of fin height and spacing on the bed performance are discussed in this study as follows.



a



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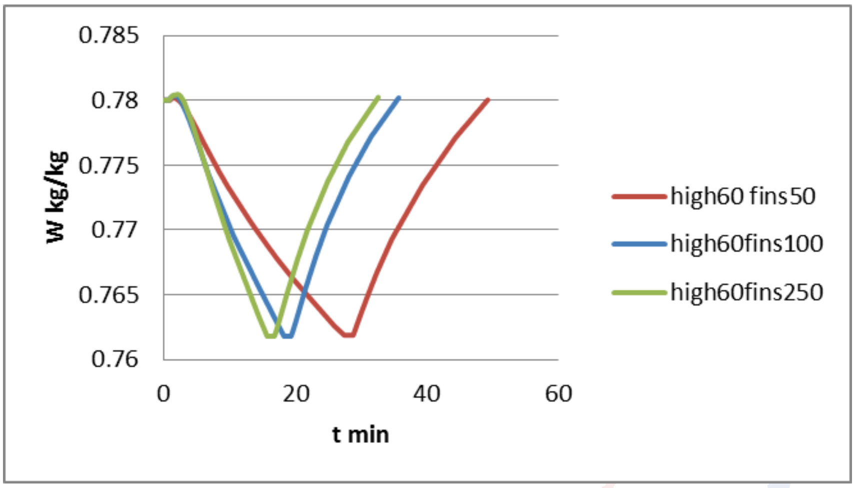
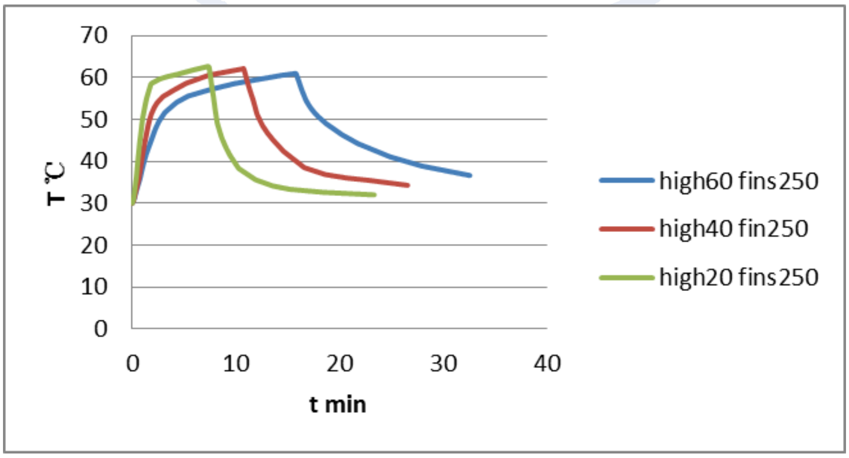


c

Fig.3 Comparing the time variations of the averaged bed for different numbers of fins (a) temperature, (b) pressure for bed and (c) average adsorbed amount



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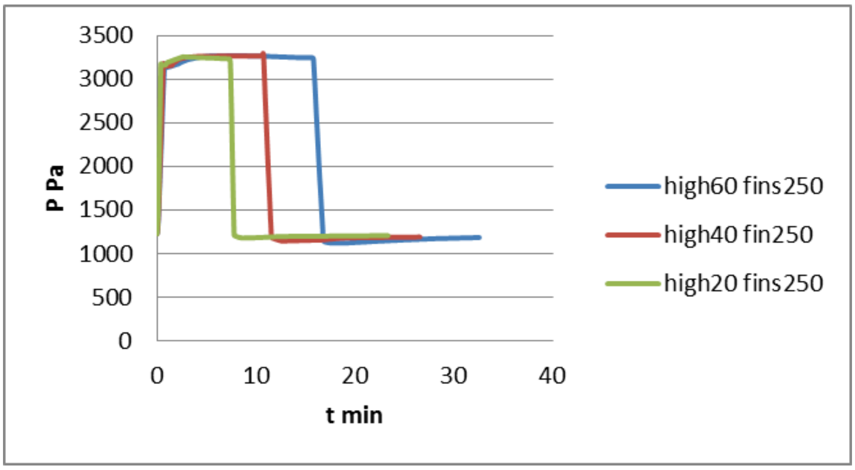

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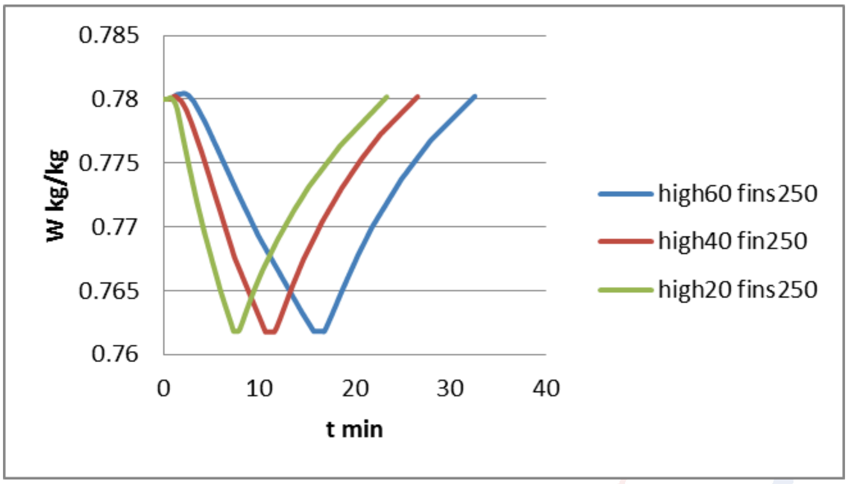
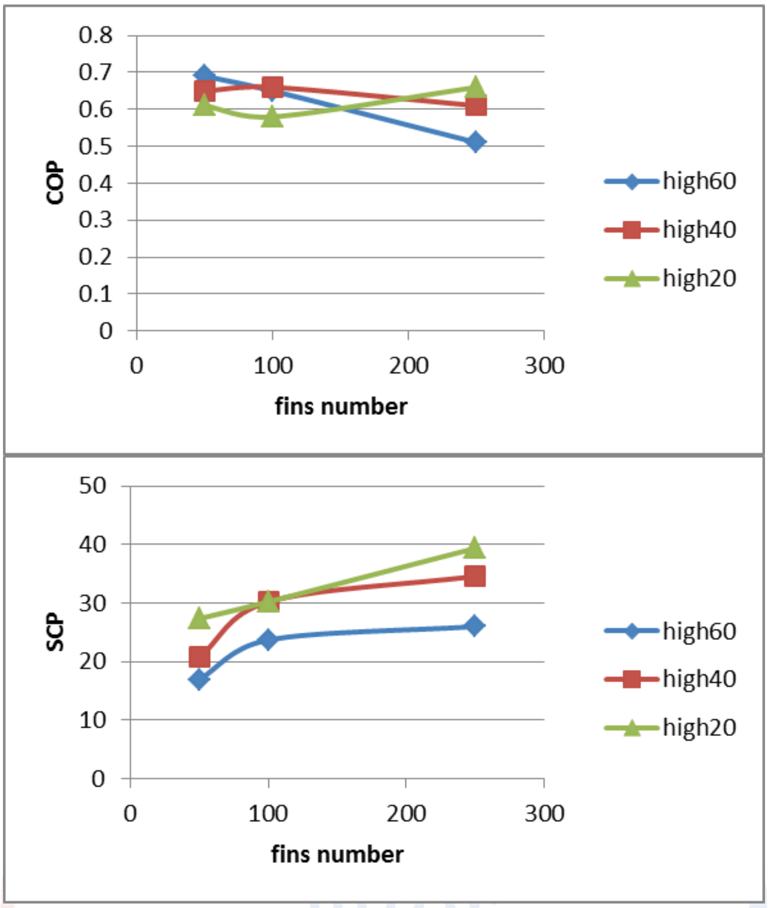


c

Fig.4 Comparing the time variations of the averaged bed for different height of fins (a) temperature, (b) pressure for bed and (c) average adsorbed amount

Form Fig.3 and Fig.4, it is clear that the cycle time is effected by fins geometry parameters acutely. The value of cycle time increase with the height of fins and decease with the number of fins. As we all known, the value of cycle time directly influents the SCP of chiller system. So in order to discuss the influence of geometry of fins on performance coefficients, it is necessary to demonstrate the COP and SCP as Fig.5 showed.



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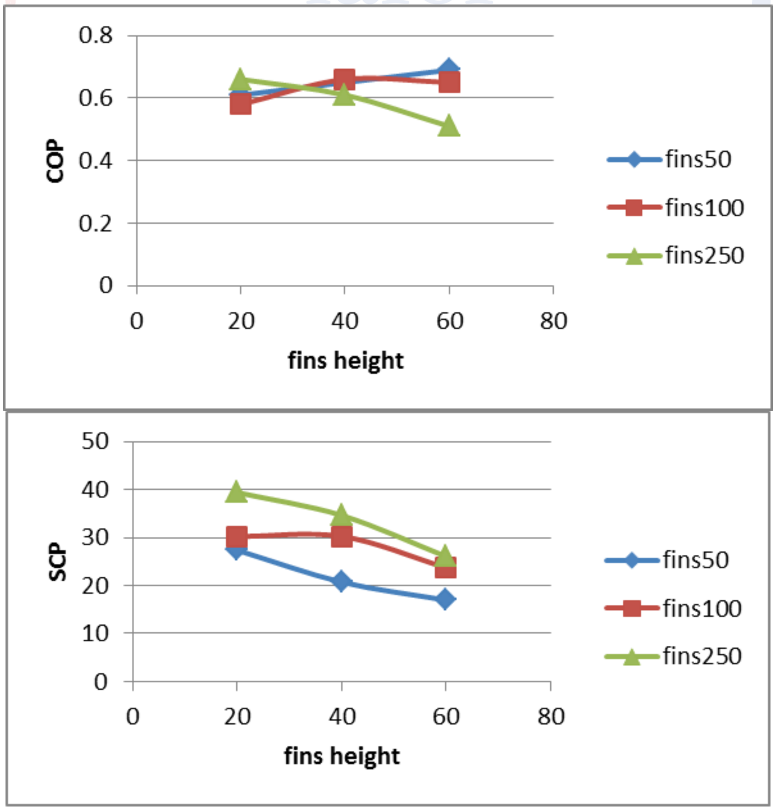

b

Fig.5 (a)variations of the COP and SCP with fins numbers with different fins height. (b) Variations of the COP and SCP with fins height with different fins numbers.

It is obvious that the SCP increase with the fins numbers but decrease with the fin height. This can be clear explained by the cycle time as Fig.3 and Fig.4. The COP decreases with the decrement of fins numbers except at the condition which fins height is 20mm. in addition, the COP increases with the fin height except at the condition which fins number is 250. Therefor there is an optimization point considering the balance between COP and SCP.

4. Conclusion

This paper presents a transient two dimensional modeling of a silica gel/water adsorption chiller employing fins to enhance transfer processes. The model can be employed to test the conditions with different geometry of fins such as height and spcing (fins numbers). The cycle time, SCP and COP is also calculated in this paper.

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Energy and Exergy Analysis of Evacuated Tubes Solar Air Collector With Micro-Heat Pipes Arrays (MHPA)

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Abstract

Solar air collector (SAC) occupies an important place among solar air heating systems because of simpler structure and lower manufacturing costs compared with a solar water collector. In order to improve the performance of SAC, micro-heat pipe arrays (MHPA) technique has been introduced in the presented study. MHPA looks like a flat aluminum plate with several independent micro-heat pipes in it, which owned extremely high heat transfer efficiency based on the phrase change heat transfer.

In this study, a type of evacuated tubes solar air collector (ETSAC) with MHPA is investigated based on exergy analysis. ETSAC with MHPA mainly comprises with several heat-collecting units, an air duct and a fan. Each heat-collecting unit is made up of a glass evacuated tube, an MHPA and a set of fins attached on the condenser section of MHPA. Solar energy is absorbed and transferred by the collecting unit, and the air can be heated do not need flow into the evacuated tube directly, but just rely on the convective heat transfer occurred in the air duct between the air and condenser fins.

A detailed parametric study is conducted to examine the effects of various operation parameters on energy and exergy efficiencies. Results indicated that the energy efficiency of the collector is approximately 64% and corresponding exergy efficiency is about 53%. Exergy efficiency can be used as the main criterion to evaluate the performance of MHPA-ETSAC. As an energy saving and emission reduction product, MHPA-ETSAC provide a new approach.

Keywords: micro-heat pipe arrays, solar air collector, exergy efficiency, energy saving, emission reduction

1. Introduction

Facing energy security and ecological environmental challenges, using the renewable energy is one of the solutions for that. Solar energy is security, clean and inexhaustible without pollution for the environment. Solar heat energy utilization technology as a vital aspect was investigated by many scholars and experts in recent years. In North and Northwest areas of China, solar energy resource is very abundant, with huge using potential shown as Fig.1 [1]. However, the heating means of remote rural areas of these areas is burning biomass and fossil fuels mainly. There are problems exist, which is environmental pollution and low efficiency of the device. If solar energy of these areas can be used efficiently, indoor thermal environment of these areas can be improved.

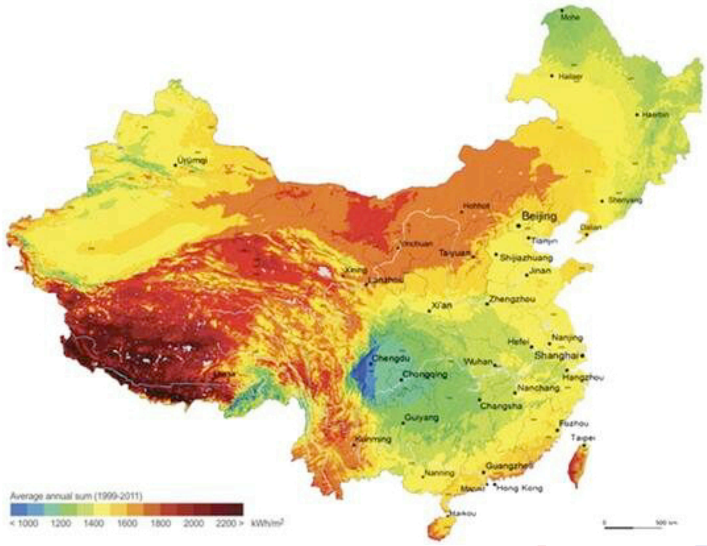

Figure 1: Solar energy distribution of China.

Solar air collectors being inherently simple are cheap and most widely used collection devices [2]. Solar air collector has been employed to deliver heated air at low to moderate temperatures for space heating, crop drying, and several industrial applications [3].The common types of solar air collectors are flat plate type, evacuated tubes type and focus type [4]. Flat plate solar air collector owns characteristics of simple structure, easy processing and low cost but with high heat loss. Evacuated tubes type has excellent heat insulation performance and can improve heat collection temperature and efficiency, but with high pressure drop. The focus type can obtain high outlet temperature, but with lower efficiency, complex system and commonly requires high investment. Thus, many ideas and attempts have been done to improve the performance of solar air collectors.

Enhancing the heat transfer of the absorber plate for a flat plate is the common method. The use of an artificial rough surface can significantly improve fluid flow and heat transfer performance, and different types of roughness elements were observed in previous studies [5-12]. Apart from the flat-plate collector, other types of solar air collectors have also been investigated by experts. Türk Toğrul and Pehlivan [13] studied the efficiency of a solar air collector with a conical concentrator which can track the sun at different time. Abdullah and Bassiouny [14] proposed a flexible cylinder type solar air collector, which thermal efficiency decreases linearly with the parameter $\Delta T/I_c$. A novel evacuated tubular solar air collector combined with simplified CPC to provide air with high and moderate temperatures was proposed by Liu et al. [15]. The maximum air outlet temperature exceeds 170^{o}C at the air volume rate of 7.6 m^3/h in winter. A tubular solar air collector with inner intubation was investigated by Yuan et al. [16], the collector with a good thermal performance but with more fan power input. In order to increase the efficiency and decrease the pressure drop, a new solar air collector based on micro-heat pipe arrays has been proposed by Zhu et al. [4].

An experimental investigation is required to be carried out on the thermal performance of the collector. Thus, an experimental investigation is conducted in the present study to determine the effects of air flow rate and different seasons on the thermal efficiency of the Evacuated Tubes Solar Air collector. The pressure drop of the collector is also studied experimentally. This paper carried out an investigation of the collector proposed by Zhu et al. [4] in view of energy and exergy analysis to evaluate the performance.

2. Experimental procedure

In order to study the performance of the proposed collector, an experimental system is carried out. The experimental system includes two parts: the collector and the testing system.

2.1 ETSAC with micro-heat pipes arrays

The evacuated tubes solar air collector (ETSAC) with micro-heat pipes arrays (MHPA) is proposed in the present paper. ETSAC with MHPA is mainly consist of MHPA, several evacuated tubes, air duct and a fan. MHPA is a kind of high efficient heat transfer component which works rely on phase change. The shape is aluminum alloy plate. Within each plate has dozens of independent operation micro-heat pipe, which can be widely used in a variety of thermal problems. The temperature difference between the evaporator section and the condenser section is less than 1℃ [17]. As shown in Fig.2, It looks like an aluminum sheet, and there has some liquid material in its several independent micro-channels.

It can be seen as two sections when it is working in solar air collector. The bottom section with heat in is evaporation section, and the top section is called condensation section. MHPA can works automatically when the heat in put in the evaporation section. The liquid material evaporated as vapor and goes up along with the wall of each heat pipe channels when it absorber heat. In the condensation section, the heat released, the vapor condensed into liquid and flows back to the evaporation section depend on the gravity and capillary force. The process is continuous and ongoing.

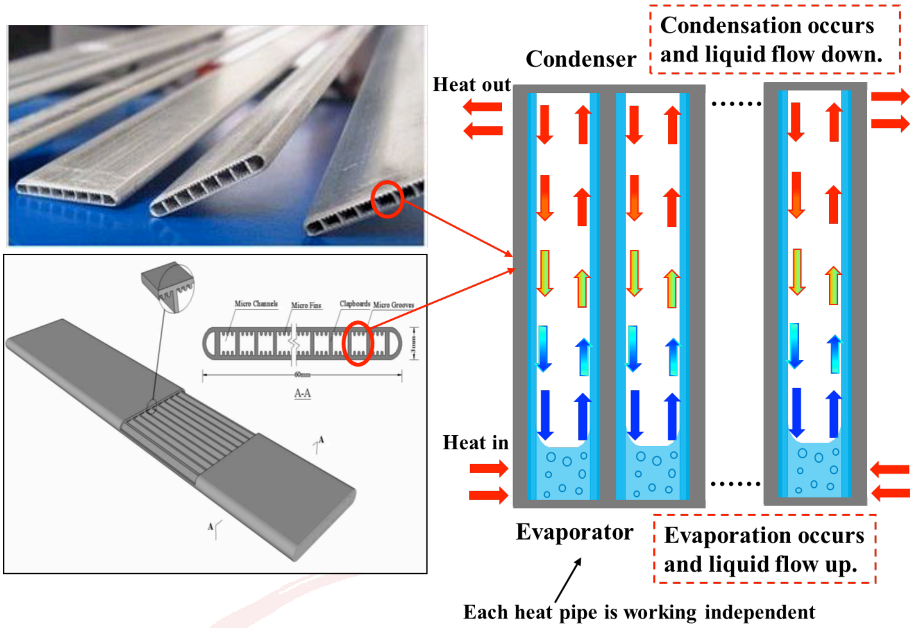

Figure 2: Micro-heat pipe arrays.

The structure of ETSAC with MHPA studied in this paper is shown in Figure 3. It is made up of by 15 collecting core units, an air duct and a fan. Each core unit consists of aluminum fin, MHPA and an evacuated tube. Evacuated tube act as the role of absorb solar energy by the absorber film attached on it. Evaporation section of MHPA is inserted in the tube. Evaporation section of MHPA is the heat transfer component to transfer heat from evacuated tube to the condenser section. In the condenser section, the aluminum fin is attached on it to extend heat exchange area. The condenser section with fin makes heat exchange with air flow in the air duct. And working principle of the collecting core unit is showed in Figure 4.

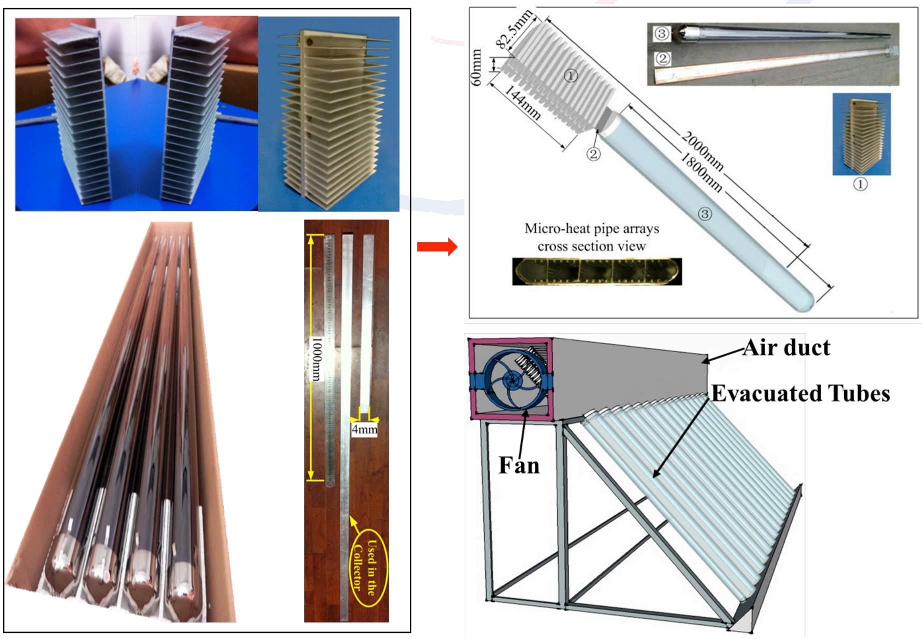

Figure 3: Structure of ETSAC with micro-heat pipes arrays (MHPA).

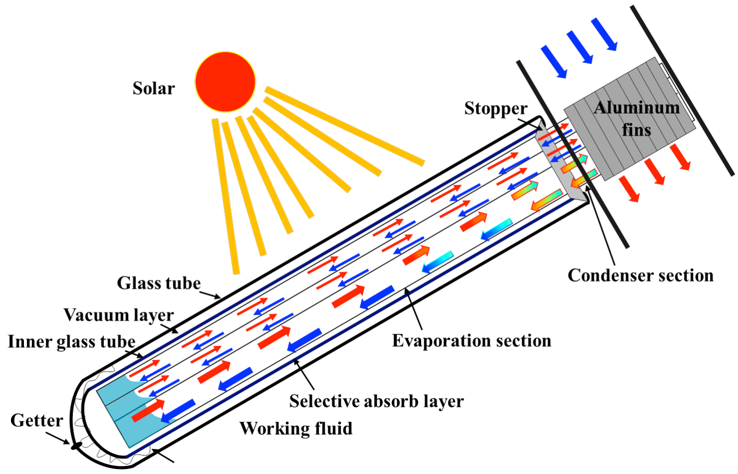

Figure 4: Working principle of the collecting unit.

2.2 Testing system

The experimental platform was constructed in Beijing University of Technology; the area surrounding the experimental platform is open and unsheltered. The experimental test system includes a new solar air collector, an axial flow fan, and other test instruments, including a weather station (total radiation meter, temperature and humidity sensor, and wind vane), thermal resistors, thermocouples, an Agilent data acquisition instrument, and a computer. Inlet and outlet air temperatures were measured with four well-insulated thermal resistors installed evenly on the cross section of the dust inlet and outlet at corresponding positions along the direction of air flow.

2.3 Data reduction

The instantaneous thermal efficiency of collector were calculated from the experimental data for each flow rate from daytime measurements using the equations below,

$$S = I\tau\alpha \cdot A \tag{1}$$

$$Q_u = c_p m(t_o - t_i) \tag{2}$$

$$\eta = \frac{Q_u}{S} \tag{3}$$

The exergy can be calculated as,

$$\Delta \mathrm{E} = \mathrm{m}\left[\left(h_o - h_i\right) - T_\mathrm{a}\left(s_o - s_i\right)\right] \tag{4}$$

$$\Delta \mathrm{E} = \mathrm{mC_p}\left[\left(T_o - T_i\right) - T_\mathrm{a}\mathrm{In}\frac{T_o}{T_i}\right] \tag{5}$$

Exergy efficiency of the collector can be express as:

$$\eta_{\mathrm{ex}} = \frac{\Delta E}{A_c I} = \frac{\Delta E}{C_\mathrm{p}\mathrm{m}\left(T_o - T_i\right)} \cdot \frac{C_\mathrm{p}\mathrm{m}\left(T_o - T_i\right)}{A_c I} \tag{6}$$

Where, m-mass flow rate of air, kg/s; A_c-total net collector area, m^2 ; T_o-outlet temperature, °C; T_i -inlet temperature, °C; c_p-specific heat of air, kJ/(kg· K); I- solar radiation, W/m^2; Q- volume flow rate, m^3/h; Ta- ambient temperature, °C; ΔT-temperature difference, °C; ΔP- pressure drop, Pa; ΔI- solar radiation difference, W/m^2; Q_u - useful energy gain, W/m^2; ΔE- Exergy difference;h- enthalpy, kJ/kg; S-entropy, kJ/kg·K; η_{th}- thermal efficiency; η_{ex}- exergy efficiency.

2.4 Uncertainty

The relative uncertainty of thermal efficiency was determined by the related independent variables, and the error for thermal efficiency was obtained through the error propagation method [4]. The data recording type and uncertainty analysis based on the precision of the equipment used during the experiment are illustrated in Table 2. The error estimation of thermal efficiency depends mostly on the thermal resistance errors at eight points and on the accuracy of the other parameters. Considering the relative errors of the individual factors, the relative error of efficiency was calculated using the following equations [4]:

$$\Delta\eta = \left[\left(\frac{\partial\eta}{\partial\dot{Q}} \Delta\dot{Q} \right)^2 + \left(\frac{\partial\eta}{\partial T_o} \Delta T_o \right)^2 + \left(\frac{\partial\eta}{\partial T_i} \Delta T_i \right)^2 + \left(\frac{\partial\eta}{\partial I} \Delta I \right)^2 \right]^{1/2} \quad (5)$$

where $\Delta\eta$, $\Delta\dot{Q}$, ΔT_o, ΔT_i, and ΔI are the uncertainties of η, $\dot{Q}$, T_o, T_i, and I, respectively. The precision of the measurements and calculated variables are shown in Table 1. The experiments were conducted under different weather conditions. Therefore, the uncertainty value of η was 7.73%.

Table 1 Precisions of the measurements of different testing equipment

Instrument	Model Specifications	Precision
Data acquisition instrument	Agilent 34970A	-
Total radiation meter	TRT-2	<2%
Thermocouple	WRNK-191	I
Thermal resistance	Pt100	A, 0.15 °C
Hot bulb anemometer	ZRQF-F30J	±4%U
Differential manometer	Testo512	5%U

3. Results and discussions

Tests were conducted in 2013, Beijing University of Technology ((latitude: N39.9°, longitude: E116. 3°)), under sunny conditions. The instantaneous thermal efficiency of solar air collector was calculated from the experimental data for each flow rate of daytime. The variables measured by the thermal resistors and thermocouples were recorded at time intervals of 10 s. These variables include inlet and outlet temperatures of the working fluid flowing through the solar air collector, ambient temperature. Fig.5 showed the weather parameters on Mar.13 with the air velocity of 1.4 m/s. It can be found that the ambient temperature range from 4.1~10.8 ℃,and the average value is 7.4℃. Solar radiation range from 441~951W/m^2, and the average value reached 771 W/m^2. Outlet temperature range from 11.1~17.8 ℃. The variation of thermal efficiency and exergy efficiency is showed in Fig.6 Energy efficiency is about 49~82%, the average value is 62%, and exergy efficiency is ranged between 37.9~64%，the average value is 46.3%.

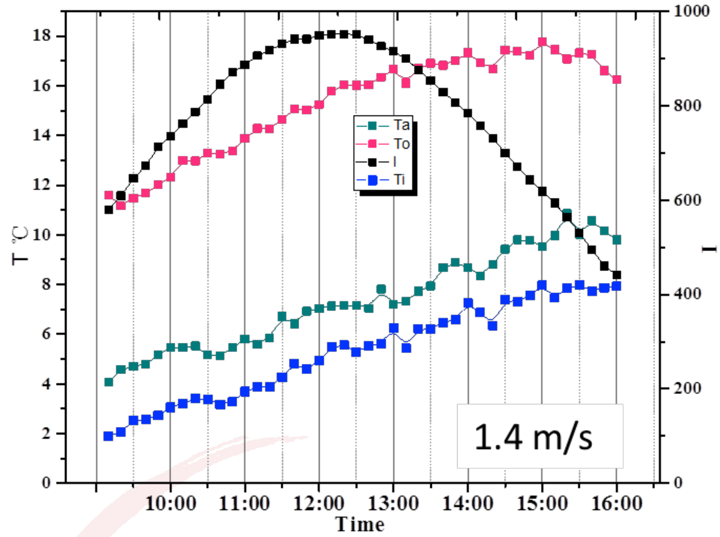

Fig. 5: Variations of /I/ηth / ηex versus time. (2013/Mar/13)

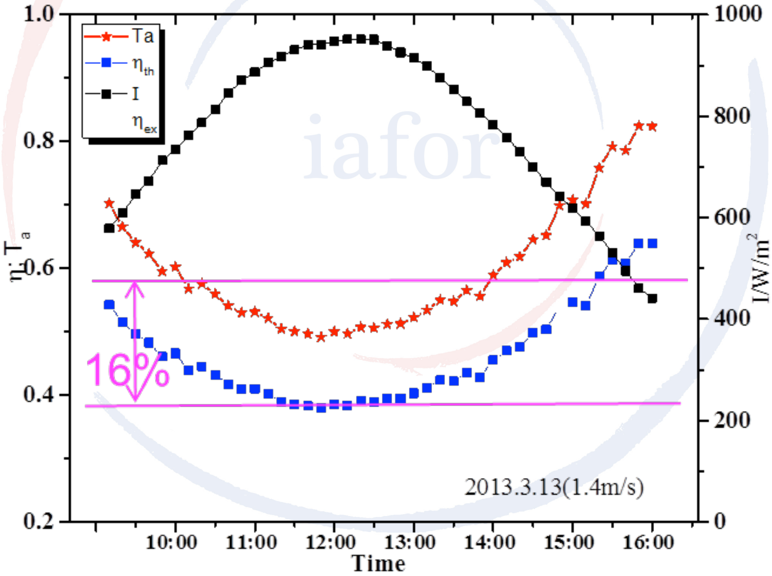

Fig. 6: Variations of Ta/I/ηth / ηex versus time. (2013/Mar/13)

Fig.7 showed the weather parameters on Apr. 16 with the air velocity of 1.2 m/s. It can be found that the ambient temperature range from 14~21 ℃,and the average value is 7.4℃. Solar radiation range from 375~870 W/m^2, and the average value reached 695 W/m^2. Outlet temperature range from 24.8~32.5℃. The variation of thermal efficiency and exergy efficiency is showed in Fig.8. Energy thermal efficiency is about 64%, and exergy efficiency is 53%.

The external parameter influence the thermal performance of the collector involves solar radiation, inlet temperature, air velocity, and the ambient temperature. The internal parameter influence the performance of the collector involves the structure, the material, as well as the insulation condition of the collector. The air temperature difference decreases with the increase in mass flow rate and flow velocity because of the increase in the heat capacity of air at the same solar input. The EVTSAC with high thermal efficiency and low pressure drop can be utilized in room heating and agricultural products drying. The temperature level of the collector can be controlled by adjusting the flow rate. Increasing the number of collecting core units can also increase the outlet temperature, if necessary.

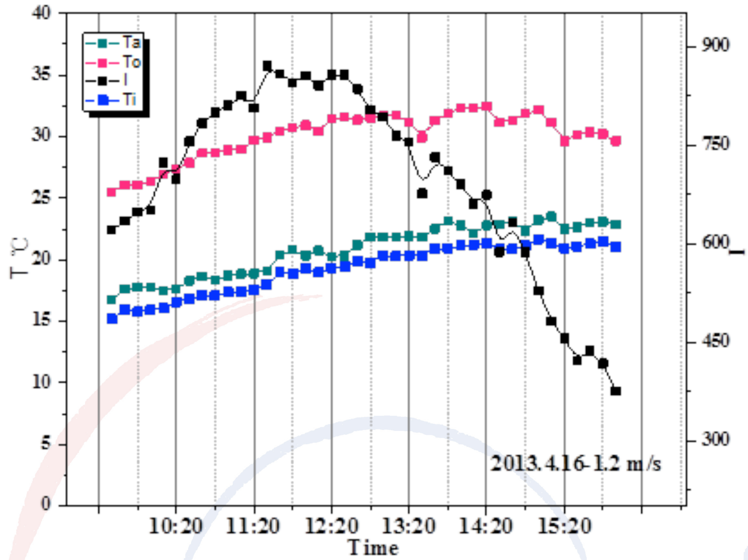

Fig. 7: Variations of /I/ηth / ηex versus time. (2013/Apr/16)

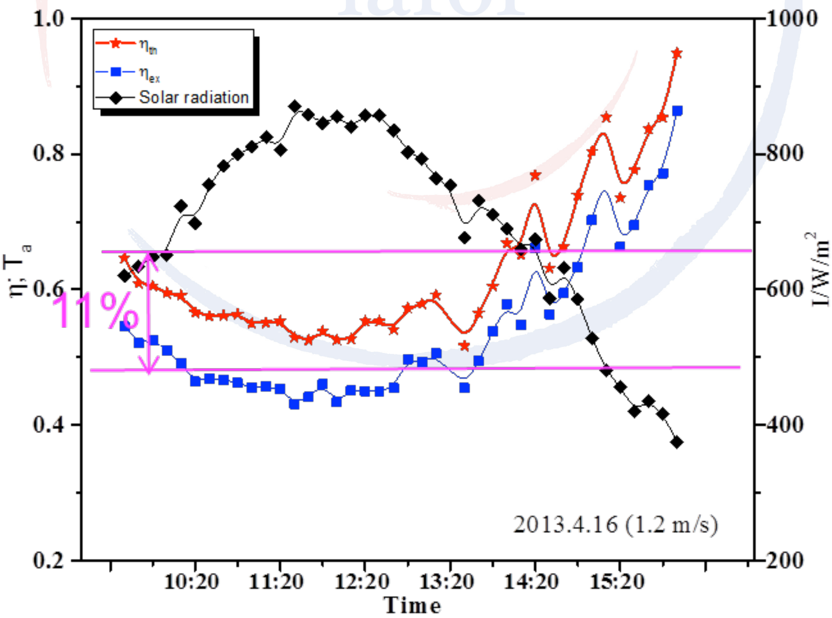

Fig. 8: Variations of Ta/I/ηth / ηex versus time. (2013/Apr/16)

Compared with Fig. 6 and Fig. 8, it can be found that the difference between η_{th} and η_{ex} is 16% and 11%, respectively. The difference between η_{th} and η_{ex} is decreased which is because of the decreasing in velocity provided by fan power. The phenomenon of that can be found in in Fig.9 and Fig.10 clearly. Generally, increasing the flow rate is an effective way to improve the thermal performance of a solar air collector, but it can result a high input of fan power. The variation of exergy efficiency $\eta_{ex,}$ remind us it isn't an effective method always, it is based on the quality of the energy gained and the power input. The power input is the reflection of the flow resistance, the pressure drop of the air duct.

Fig. 9 is the variations of η_{th} and η_{ex}. Thermal efficiency and exergy efficiency significantly increases as the air flow rate increases. Further increase in velocity leads to a decrease in exergy efficiency due to the increase of fan power and heat loss. The result reveals that 1.2 m/s is the optimal flow velocity for the present MHPA-solar air collector.

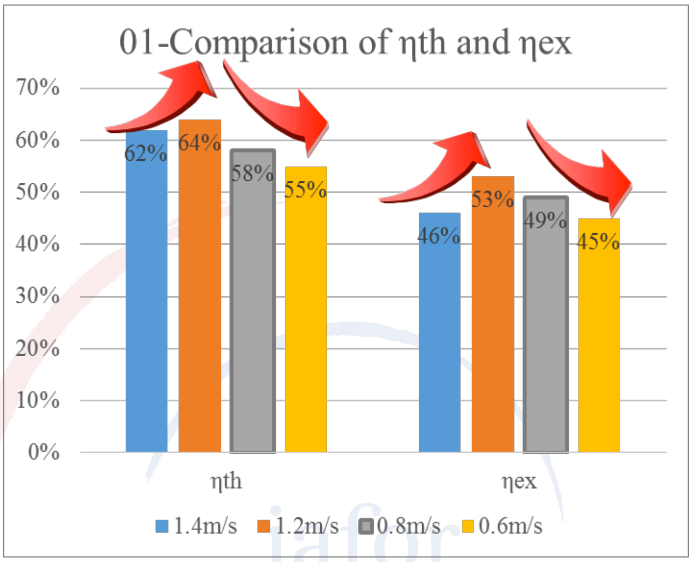

Fig. 9: Variations of ηth / ηex.

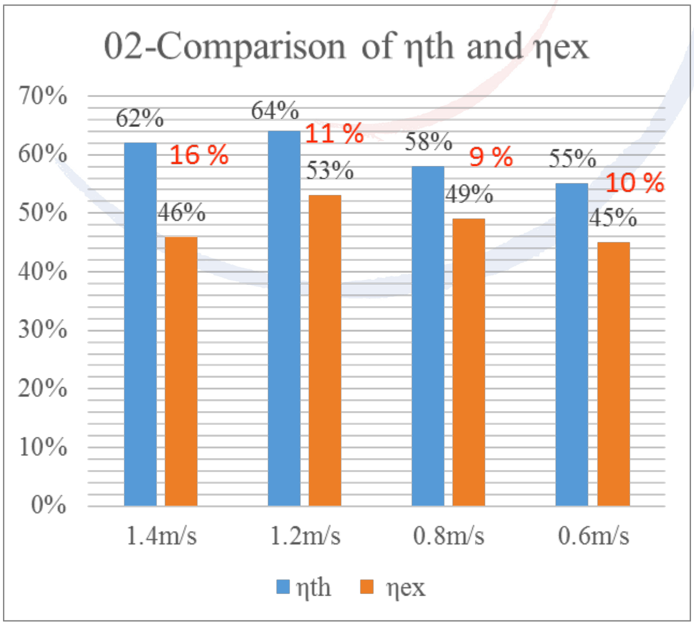

Fig. 10: Variations of ηth/ηex vs air velocity.

In the MHPA-evacuated tubes SAC, the air flow is not direct contact with heat absorbing tube and the heat transfer form is indirect heat exchange which relies on the phase change heat transfer of the liquid in MHPA. Reduce the flow resistance, with low fan power.

Pressure drop of MHPA-Evacuated Tubes SAC is less than 25 Pascal [4], shown as in Fig.11. In the new technology, air is not direct contact with heat absorbing tube, and the heat transfer form is indirect heat exchange which relies on the phase change heat transfer of the liquid in MHPA. Reduce the flow resistance, with low fan power.

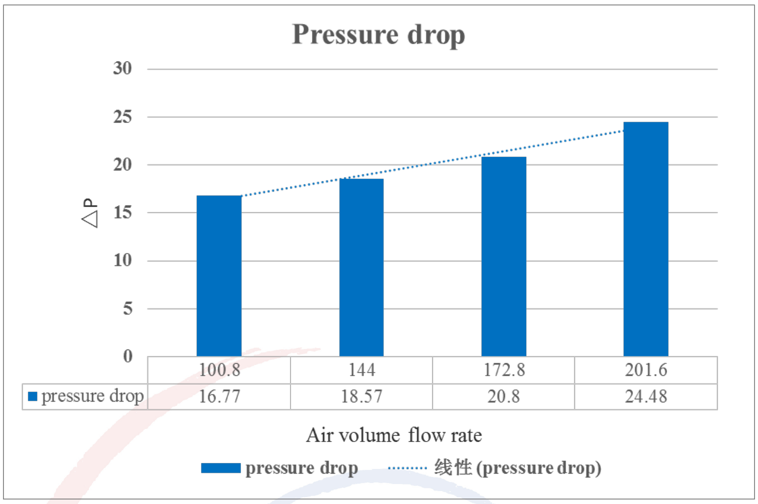

Fig. 11: Pressure drop of the EVSAC with MHPA.

4. Conclusion

In this paper, the energy and exergy performance of EVSAC with MHPA is presented. The heat collecting component is the micro-heat pipe arrays (MHPA). To study the thermal performance of the solar air collector, a series of tests were conducted in 2013 in Beijing, China. The test data were analyzed from the aspects of energy thermal performance and exergy performance. The MHPA-EVSAC presents a good performance with the weather in Beijing. The average thermal efficiency is 64% and exergy efficiency is 53% for the EVSAC. Test results can also serve as an important basis for understanding the performance of the EVSAC with MHPA. Exergy efficiency can be used as one of the main criterion to evaluate the performance of MHPA-ETSAC.

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The Relevance and Impact of Professional Counselling on Land Use and Management for Environmental Sustainability: The Benue Experience in Nigeria

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Abstract
This paper would report the relevance and impact of professional counseling on development and land use in Nigeria. In Benue State, urban and rural dwellers numbering 520 were provided with structured questionnaire. Indices used in the study included mode of development and land use, educational level, settlement and age of respondents. The analytical study reveals that 29% rural participants and 22% are urban dwellers believed in professional planning before land could be used and developed. These participants in the study believed in professional counselling to avoid land misuse.
The effect of counseling or planning by professional on development and land use is still not felt. This because there still exists arable farming that is done indiscriminately close to road pavements. In addition, there is misplacement of priority on land use especially where mineral resources exist. Owners of land based on the current land-tenure system prefer using them for arable farming. Relevant agencies are not involved in decision making over land use. Turning land that is viable for mineral resource development to an arable farming land as presently being practiced requires professional counseling to change the trend. Its either professional counsellors are not enough or they have not made themselves available for consultation.

Keywords: Professional counseling, mineral resources, agricultural yield, land use, management, land development, Land use planning, sustainable development.

Introduction

Professional counseling or land use planning to achieve development and sustainable land use in Nigeria has become essential because of the abnormalities so far recorded and observed on development and land use in Benue State, Nigeria (Denga, 1989., Fresco et al, 1992). Land is a section of the surface of the earth comprising all physicochemical and biological attributes that influence resource use.

This refers to soil, spatial variability of landscape, climate, hydrology, vegetation and fauna (Demeke, 2001). Enhancement in land management inclusive drainage and mechanical activities. Land use means the utilization of the land for agricultural and forestry, settlements, industrial sites, construction, horticultural, exploration and several anthropogenic activities (Hes and van Lier, 1999).

Sustainable land use is the ability to achieve the spatial spreading of the different uses to secure biodiversity ecological-balance of the entire system (De Wrachien, 2001). Land use sustainability associates technology, policies and activities aimed at integrating socio-economic principles with environmental concerns (Fleischhauer and Efer, 1998).

Therefore, planners of land use or professional counsellors involved in land use sustainable planning needs to recognize this as a process aimed at integrating environmental, socio-economic, political and ethical principles in land management, for productivity and generational equity. Development and land use sustainable planning requires an understanding of the criteria for apportioning land for a use inclusive construction and utilization of renewable and non-renewable resources (Davidson,1980).

To achieve this, regulatory policies should be based on realities at local level and community-based management of natural resources (Scarascia, 1999). The environmental, social and economic effect of such regulatory policies should be examined before implementation. Professional planners of land use would require this knowledge for land use advise that is well articulated.

Land use planning involves the methodical examination of land and water bodies, based on economic and social considerations (Izakovicova, 2012). This is aimed at selecting option and adopting the use of land that is best options. It is aimed at putting into practice land uses that will best reflect the desires of the people while safeguarding resources for the future (van Lier, 1996).

The guiding principle behind professional counsellors or land planners should be the need for change, the need for improved management and different pattern of land use engineered by changing circumstances (Lindgren, 1985). This means that land use planning is a continuous process, aimed at making the best use of land resources. Professional counselling or planning is necessary because of the hazards that could accompany improper development and land use.

These include a. desertification viz land clearing, b. erosion engineered by interventions, c. air pollution caused by gas flaring and burning of grasses during dry season, d. contamination of ground water caused by the application of fertilizer on arable lands e. failure of soil caused by foundation of buildings [Hamdy and De Wrachien, 1999] Some of these land use irregularities observed in Benue State Nigeria.

The building foundation failure observe at some sections of Igumale town and Benue Polytechnic engineering complex are evidences of land development without proper professional counselling. in Nigeria. Previous author stated that one task required in the management of land is the integration of data on land resources with information on social economic and human resources development (Adesina and Amamoo, 1992).

In this regard, professional counsellors could provide the following: training needs required in land use forecasting and administration; advance formal and informal practical training programs via extension services to skills and support land users' proficiencies; improve the competences of decision makers at all stages, involved in the planning of land use programs (Wolde-Giorgis,1999).

Information on proper land use could be obtained through soil characterization viz the use of air photos, topographical and geological maps (Yokoi, 2000). Classification of soil into various fractions is then carried out (Egirani and Otor, 2001). Formulation and implementation of strategic policies on planning for the use of land entails collection, processing and dissemination of reliable information. Also, it involves utilization of modern land investigation technologies, aimed at creating sound scientific understanding for appropriate decision making. The creation of an effective collaborative system can enhance collection process and information exchange to reduce overlap.

The aim and scope of the present investigation is to provide the public perception of the relevance of professional planning on the development and use of land in Benue State, Nigeria. This was limited to a structured questionnaire administered on 520 urban and rural respondents in Benue State of Nigeria. This is because of the pattern of the development and use of land, its implication on the socio-economic and mineral resource development in Nigeria.

The objectives include determination of respondent in support of land use before professional counseling; respondents in support of land development after professional counseling; respondents in support of development and land use after professional counseling and respondents not in support of professional counseling before development and land use (Figures 1 and2).

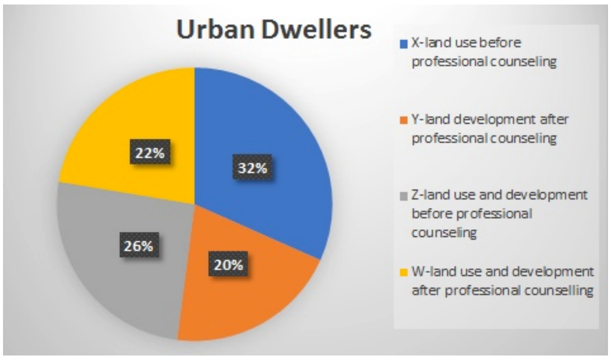

Figure 1: % respondents of Urban Dwellers on land use and development in Benue State, Nigeria

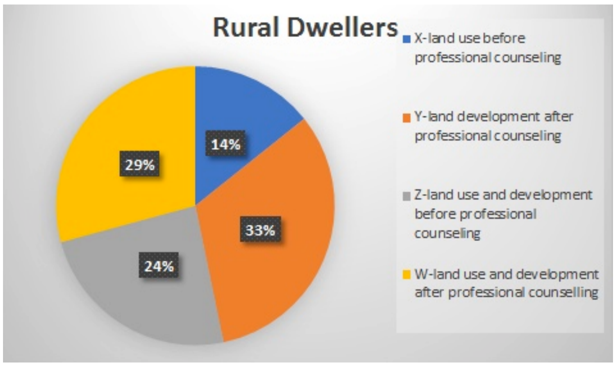

Figure 2: % respondents of Rural Dwellers on land use and development in Benue State, Nigeria.

Conclusion

Available results show that 29% of rural respondents and 22% urban dwellers are opposed to the idea of professional planning before development and land use. They believed that government should be directly involved in development and land use viz motivations by government in the form of good services, policy formulation. This could result in the funding of mineral resource, agricultural research and land development projects. However, it should be noted that some of the participants in this study believed in the participation of individuals and private organization in effective development and land use in Nigeria.

About 32% of urban respondents and 14% rural dwellers believed that professional counseling is necessary before land use but not necessarily before development. This value is different from the 20% of urban dwellers and 33% of rural dwellers who are in support of development and land use only after professional counseling. This may be linked to the high cost of land development projects when compared with the less financial input required in peasant farming. However, professional planners are liable to project durability. About 26% urban respondents and 24% rural respondents believed that planning by professionals is necessary before development and land use. However, these respondents believed that professional planning is not recognized by government. For this reason, its exercise is not appropriate and effective.

If planning for land use is not common, it is either because professional planners are not sufficient or the participation of planners in development and land use is not encouraged by government. This could also mean that the services of professional planners have not been made known to the public. Statistically, correlations that are positively imperfect exist between urban and rural correspondents on development and land use after professional counseling. This is because urban respondents blame too long bureaucracy by government a source of low level of development and land use. Rural respondents blame the cheap use of land for arable farming as the bane for the current level of development of land using professional counseling. The claim that 90% of the survey participants believe in professional counseling before development and land use is not statistically legitimate. This is because at level of significance of 1%, the statistical value of 5.0 as against 2.33 is highly significant.

Therefore, most the Benue people have recognized the relevance of professional counseling on development and land use. However, it is true that professional counseling has not created any impact on development and land use.

This may be assigned to the fact that there may not be sufficient professional counselors that their activities are recognized by government. Therefore, those who exercise professional counseling related to development and land use are discouraged. Professional counselors on the other hand are not known by the public. Therefore, professional counselors need be trained to cope with this emerging trend of land management. They should also be provided with some government incentives and be encouraged to make themselves relevant to the public.

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DEA-Based Green Positioning Strategy by Unified Efficiency Measure for the US Coal-fired Electricity Products

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Abstract
Consumers are facing a wide range of electricity products especially in a fully liberalized market. Consumers need information about their concerns such as environmental consciousness whether the energy they currently use is unsustainable since governmental regulators have paid serious attention to corporate efforts for environmental protection. Therefore, marketing efforts in enhancing green product image need not only information about operational performance but also environmental performance evaluated by unified efficiency scales indicating environmental sustainability. The purpose of this study are: (1) to propose conceptual framework of green positioning strategy to enhance product image using unified efficiency scores measured by DEA (Data Envelopment Analysis) model under natural and managerial disposability, and (2) to show the relationship between unified efficiency measures and their corresponding effective type of information which can be used by marketers. This study applied the proposed approach to discuss green-imaged positioning of the US electricity products generated by bituminous and sub-bituminous coal. This study finds that (1) the competitiveness of the market of coal electricity under managerial disposability is higher than natural disposability from positioning perspective, and (2) electricity products generated by sub-bituminous coal have limited type of information to use in marketing efforts under natural disposability. Thus, it is recommended that the US coal-fired power industry should phase out sub-bituminous electricity because it will benefit both the competition of coal electricity market and the future sustainable economic growth in the US power industry.

Keywords:DEA-based Green Positioning, Unified Efficiency Measure, Electricity Product Differentiation

Introduction

The full liberalization of Japanese electricity market has started since April 1, 2016. It is obvious that the utilization of electricity has become a major concern of households in Japan, especially after the deregulation. There are plenty of lessons to be learned from the opening of domestic electricity market in Britain (in 1999), Germany (in 1998), and the United States (in 1996), and so on. It has been generally considered that both power industry and consumers have benefited from greater competition compared with the former monopolies' power-generation market. Consumers facing a wide range of options need product information about their concerns such as environmental matters, rates/prices, available alternatives, etc. Moreover, environmental consciousness among consumers regarding the energy they currently use is not sustainable since governmental regulators have paid serious attention to corporate efforts for environmental protection. Thus, the greater competition in electricity retail market requires suppliers to offer more attractive green-imaged products differentiated by efficiency or by improvements in productivity from environmental perspective.

Therefore, marketing efforts in product positioning need not only information about operational performance but also that of environmental performance measured by unified efficiency (UE) measures indicating comparable information among competitors under a certain strategy (i.e. natural and managerial disposability). A product positioning (Kaul and Rao, 1995) is a marketing strategy. The green-imaged product positioning is a newly developed marketing strategy in enhancing green image of consumers based on their competitive advantages.

Many previous studies have discussed efficiency measures about productivities and benchmarking (targeting) to enhance economic and environmental performance by using Data Envelopment Analysis (DEA) environmental assessment. The conventional use of identifying target frontier might have been discussed with an expectation of improvements without losing the reality; however, marketing use of information based on unified efficiency measure has not yet been discussed.

The purpose of this study is (1) to propose conceptual framework of green positioning strategy for electricity products by a new use of unified efficiency scales measured by DEA model under natural and managerial disposability and (2) to show the relationship between efficiency measures and their implications of current efficiency level and characteristics of target frontier such as variable/constant return to scale (RTS) under natural disposability, variable/constant damage to scale (DTS) under managerial disposability, scale efficiencies (SE) implying environmental sustainability (i.e. Moldan, et al., 2012), and the corresponding type of information which can be used by marketers. This study also shows its application to data about the US coal power generating industry.

Literature Review

It is widely known that electricity generated from power plants using green sources (e.g. renewable) is more expensive than electricity generated from those using conventional grey sources (e.g. coal). Sundt and Rehdanz (2015) have shown that consumers' willingness to pay (WTP) for green electricity differs by energy source. Kaenzig et al., (2013) have shown that electricity consumers in full deregulated Germany market are willing to pay a premium of about 16% of average household electricity cost per a month in switching to use green power. Kristrom & Kiran (2014) have also demonstrated that a premium (WTP) increased from 4%, 2011 to 10%, 2014 (OECD, 2011, 2014). Thus, type of source is a crucial factor in enhancing their green image. Consumers' WTP also differs when their personal characteristics such as gender, age, education, and salary are accounted for (Zarnikau, 2003; Sundt and Rehdanz, 2015), which means that the role of marketing efforts in targeting became more important after the deregulation in energy market. According to Zarnikau (2003), greater information not only about energy resource options such as green energy but also about energy efficiency increase the public's WTP.

Pichert and Katsikopoulos (2008) provided empirical evidence that the reasons for consumers' choice of their electricity products: price considerations (71%), environmental considerations (62%) and both (44%) were frequently found as the reason to motivate their choice. As discussed by Woo et al., (2014), differentiated products in electricity pricing are able not only to encourage consumers' conservation actions by discouraging consumption but also to induce consumers to more effectively and efficiently satisfy their demands in an environmentally friendly way.

Wang et al., (2014) have discussed that because of a large amount of CO2 emission, the energy industry is the best investment target in developing corporate sustainability among seven industrial sectors, such as consumer discretionary, consumer staples, energy, healthcare, industrials, information technology and materials. Thus, in deregulated electricity markets, the differentiated products which induced consumers should well match with eco/green (environmental friendly) image in marketing. Therefore, it is important for marketers to appeal their green image to consumers by using information regarding their productivity, capacity management and green technology. Those performance level of production activities can be evaluated by DEA-based assessment technique (Sueyoshi and Goto, 2016). The DEA-based unified efficiency measure (operational and environmental performance) has been discussed in the industry producing marketable outputs without ignoring undesirable outputs regarding environmental protection (Yan and Pollitt, 2009). This study was newly developed and extended from the idea based on unified efficiency measures partly discussed in Sueyoshi and Goto (2016).

Methodology

Figure 1 visually describes the structure of the approach proposed in this study. This study discuss (1) how to interpret unified efficiency measures for marketing communication, (2) how to enhance consumers' green product image by marketing efforts, and (3) the relationship between efficiency scores and type of information based on DEA.

As depicted in the top of Figure 1, in production factors regarding coal electricity, it might be easy to classify outputs into two categories, desirable and undesirable, such as electricity and its byproducts (GHG and acid gases). It is true that there are researchers who have discussed the desirability of outputs. For example, Pichert and Katsikopoulos (2008) have called gray electricity generated from conventional energy sources such as coal or atomic power, in contrast with green electricity generated from renewable sources including solar energy, biomass, geothermal and wind energy, without discussing any measurement scales. However, as discussed by Liu et al., (2015), we cannot simply classify the coal as an undesirable input just because of the production of the pollutant emissions, as long as input is able to produce desirable outputs. The environmental desirability of input also depends on many factors such as capacity, technology, and regional non-discretionary factors. Therefore, the desirability of input, needs to conduct deliberations on numerical index such as unified efficiency measures evaluated by DEA environmental assessment from various viewpoints.

From production factors to identify two types of congestions by capacity limitation or eco-technology innovation, the upper half of the Figure 1, has discussed in the previous study (Sueyoshi and Goto, 2016), so that this study newly discusses the lower area with extending their study toward marketing positioning.

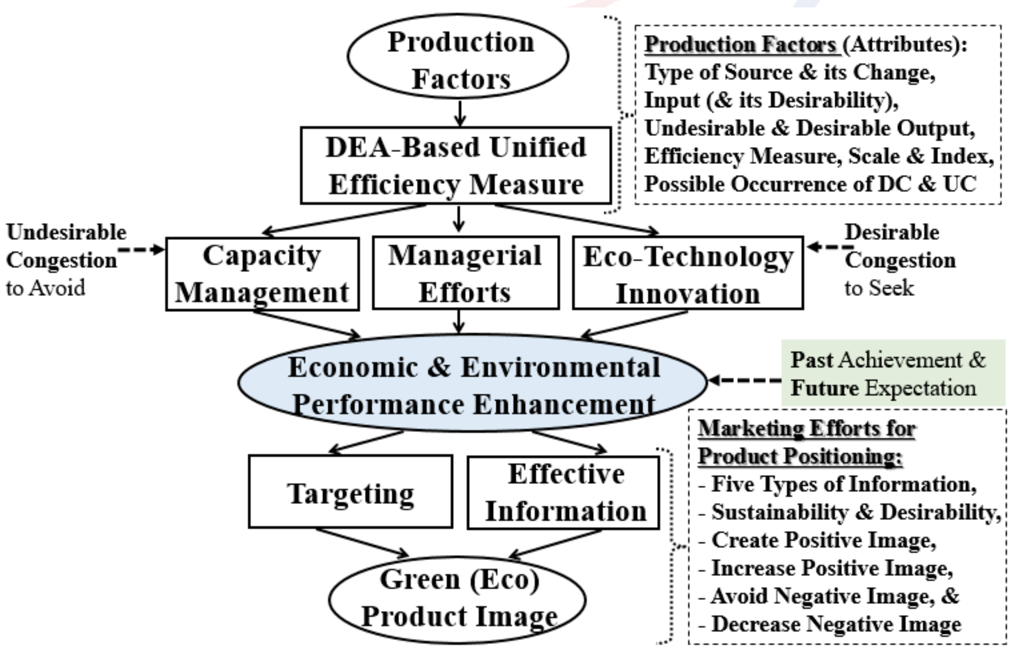

Figure 1: Conceptual Framework of Green-imaged Positioning Strategy

Assume that there are j=1,…,n decision-making units (DMUs: productivity to be evaluated). These can be electricity brands, products, electricity-generating units, companies or plants. The performance level of production activities of each DMU, which is evaluated by DEA environmental assessment, referred to as "an efficiency measure". The efficiency measure is characterized by production activities that utilize inputs to yield desirable and undesirable outputs. The efficiency measure is also characterized by a structure of the model. There are many types of efficiency measure because which performance level is measured by (1) a combination of production factors, (2) a definition of desirability of input/output and (3) a model based on a strategy/concept such as natural/managerial disposability, a radial/non-radial and an input/output orientation. Efficiency measures are conventionally used by inefficient DMUs to follow/replicate target frontier (best practice) to enhance their productivity.

Unified efficiency measures under natural and managerial disposability UEN and UEM

Natural disposability is a concept/strategy that fits with the scope of conventional use of DEA, where an inefficient DMU decreases some components of an input vector but increases some components of a desirable output vector. The decrease of the input vector leads to a reduction on undesirable outputs, focusing upon a managerial effort to improve the operational performance of the DMU.

Managerial disposability is a concept/strategy, considering managerial performance for sustainable economic growth where an inefficient DMU increases the amount of input and increases the amount of desirable output but reduces undesirable outputs by a managerial effort such as using high quality resources, utilizing new green technology that can reduce pollution.

VRTS and VDTS

Unified (operational and environmental) production and pollution possibility sets, both of which express the concept of natural (N) and managerial (M) disposability by the two types of output vectors and an input vector, respectively, are described as follows:

$$P_V^N(X) = \left\{(G,B): G \le \sum_j^n G_j\lambda_j, B \ge \sum_j^n B_j\lambda_j, X \ge \sum_j^n X_j\lambda_j, \sum_j^n \lambda_j = 1 \& \lambda_j \ge 0, j = 1, \dots, n\right\} \&$$
$$P_V^M(X) = \left\{(G,B): G \le \sum_j^n G_j\lambda_j, B \ge \sum_j^n B_j\lambda_j, X \le \sum_j^n X_j\lambda_j, \sum_j^n \lambda_j = 1 \& \lambda_j \ge 0, j = 1, \dots, n\right\}$$
…(1)

where $X \in R_+^m$ is an input vector with m components, $G \in R_+^s$ is an input vector with s components, $B \in R_+^h$ is an input vector with h components. $P_V^N(X)$ stands for production and pollution possibility set that are structured by natural disposability and $P_V^M(X)$ is for those of managerial disposability. The subscript (V) stands for variable RTS (Return to Scale) or variable DTS (Damage to Scale) because the side constraint $\left(\sum_j^n \lambda_j = 1\right)$ is incorporated into the two axiomatic expressions. The difference between the two disposability concepts is that efficiency frontier for desirable outputs locates above or on all observations, while efficiency frontier for undesirable outputs locates below or on all observations. Sueyoshi and Goto (2012) provided a detailed description on RTS and DTS in DEA environmental assessment.

CRTS and CDTS

The unified efficiency measure of constant RTS (CRTS) and the constant DTS (CDTS) are described as follows:

$P_c^N(X) = \{(G,B): G \leq \sum_j^n G_j\lambda_j, B \geq \sum_j^n B_j\lambda_j, X \geq \sum_j^n X_j\lambda_j, \lambda_j \geq 0, j = 1,\ldots,n\}$ &
$P_c^M(X) = \{(G,B): G \leq \sum_j^n G_j\lambda_j, B \geq \sum_j^n B_j\lambda_j, X \leq \sum_j^n X_j\lambda_j, \lambda_j \geq 0, j = 1,\ldots,n\}$

…(2)

where the two equations $\left(\sum_j^n \lambda_j = 1\right)$ drop from $P_V^N(X)$ & $P_V^M(X)$ by assuming constant RTS and DTS. The subscript (c) is used to express CRTS and CDTS.

UEN Model (VRTS, CRTS and SEN)

The j-th DMU $(j = 1,\ldots,n)$ uses a column vector of inputs (X_j) in order to yield not only a column vector of desirable outputs (G_j) but also a column vector of undesirable outputs (B_j), where $X_j = (x_{1j}, x_{2j},\ldots,x_{mj})^T$, $G_j = (g_{1j}, g_{2j},\ldots,g_{sj})^T$ and $B_j = (b_{1j}, b_{2j},\ldots,b_{hj})^T$, these are referred to as production factors. Here the superscript T indicates a vector transpose. It is assumed that $X_j > 0$, $G_j > 0$ and $B_j > 0$ for all $j = 1,\ldots,n$, where all components of the three vectors are strictly positive. The data ranges for adjustment are determined by the upper and lower bounds on inputs and those of production factors are as follows:

$R_i^x = (m+s+h)^{-1}\left(max\{x_{ij}|j = 1,\ldots,n\} - min\{x_{ij}|j = 1,\ldots,n\}\right)^{-1}$,
$R_r^g = (m+s+h)^{-1}\left(max\{g_{rj}|j = 1,\ldots,n\} - min\{g_{rj}|j = 1,\ldots,n\}\right)^{-1}$ and
$R_f^b = (m+s+h)^{-1}\left(max\{b_{fj}|j = 1,\ldots,n\} - min\{b_{fj}|j = 1,\ldots,n\}\right)^{-1}$.
…(3)

The following DEA model (4) measures the unified efficiency of the k-th DMU under natural disposability:

$$
\begin{aligned}
& Maximize\ \xi + \varepsilon_s\left[\sum_{i=1}^m R_i^x d_i^{x-} + \sum_{r=1}^s R_r^g d_r^g + \sum_{f=1}^h R_f^b d_f^b\right] \\
& s.t.\quad \sum_{j=1}^n x_{ij}\lambda_j + d_i^{x-} = x_{ik} \quad (i = 1,\ldots,m), \\
& \qquad \sum_{j=1}^n g_{rj}\lambda_j - d_r^g - \xi g_{rk} = g_{rk} \quad (r = 1,\ldots,s), \\
& \qquad \sum_{j=1}^n b_{fj}\lambda_j + d_f^b + \xi b_{fk} = b_{fk} \quad (f = 1,\ldots,h), \\
& \qquad \sum_{j=1}^n \lambda_j = 1, \\
& \qquad \lambda_j \geq 0 \quad (j = 1,\ldots,n), \xi:\ \text{URS},\ d_i^{x-} \geq 0\ (i = 1,\ldots,m), \\
& \qquad d_r^g \geq 0\ (r = 1,\ldots,s), \text{ and } d_f^b \geq 0\ (f = 1,\ldots,h)
\end{aligned}
$$

…(4)

Here, d_i^{x-}, d_r^g, and d_f^b are all slack variables related to inputs, desirable and undesirable outputs, respectively. The $\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_n)^T$, an unknown vector, is often referred to as structural variables. They are used for connecting all the production factors by a convex combination under variable RTS (VRTS). The above model (4) considers only single-sided input deviations $\left(d_i^{x-} = x_{ik} - \sum_{j=1}^n x_{ij}\lambda_j\right)$ for all inputs $(i = 1, \ldots, m)$ in order to attain the status of natural disposability. A scalar value (ξ) stands for an inefficiency score that measures a distance between an efficiency frontier and observed vectors on three production factors. The ε_s is a very small number (non-Archimedean number: 0.0001 is used) indicating the relative importance between the inefficiency score and the sum of slacks.

A unified efficiency score $(UEN_V^*: VRTS)$ of the k-th DMU under natural disposability becomes:

$$UEN_V^* = 1 - \left[\xi^* + \varepsilon_s\left(\sum_{i=1}^m R_i^x d_i^{x-*} + \sum_{r=1}^s R_r^g d_r^{g*} + \sum_{f=1}^h R_f^b d_f^{b*}\right)\right]$$
…(5)

All slacks are determined on the optimality of the model (4). The unified efficiency is obtained by radial model as follows:

$$d_i^{x-*} = x_{ik} - \sum_{j=1}^n x_{ij}\lambda_j^*,\ d_r^{g*} = \sum_{j=1}^n g_{rj}\lambda_j^* - (1+\xi^*)g_{rk}\ \&$$
$$d_f^{b*} = -\sum_{j=1}^n b_{fj}\lambda_j^* + (1-\xi^*)b_{fk}.$$
…(6)

As mentioned previously, this study attains a unified efficiency under constant RTS $(UEN_c^*: CRTS)$ with the structural equation $\left(\sum_j^n \lambda_j = 1\right)$ dropped from Model (4). These two models are used in this study in order to discuss positioning strategy under the natural disposability. This study measures the level of unified efficiency under both natural disposability and CRTS by

$$UEN_c^* = 1 - \left[\xi^* + \varepsilon_s\left(\sum_{i=1}^m R_i^x d_i^{x-*} + \sum_{r=1}^s R_r^g d_r^{g*} + \sum_{f=1}^h R_f^b d_f^{b*}\right)\right] \quad \ldots(7)$$

The scale efficiency measures are obtained by

$$SEN^* = UEN_c^* \,/\, UEN_v^* \quad \ldots(8)$$

Scale efficiency indicates how each DMU carefully manages its operational size under natural disposability. The higher score in these efficiency measures indicates the better scale management under natural disposability.

UEM Model (VDTS, CDTS and SEM)

The strategy under managerial disposability is that a DMU considers a regulation change on industrial pollutions as a new business opportunity. To attain the status of managerial disposability, the DMU increases some components of an input vector in order to increase some components of a desirable output vector and simultaneously decrease those of an undesirable output vector without worsening the other components. The concept is not a conventional use of DEA in which DMUs enhance their operational performance by reducing input components. The concept of DEA assessment under managerial disposability provides us with an opportunity to change from the conventional production-based performance evaluation to the new environment conscious performance assessment toward the development of environmental sustainability. As mentioned previously, the difference between the models under natural and managerial disposability is that the first group of constraints, related to input components in Model (4). Therefore the unified efficiency of the k-th DMU under managerial disposability is measured by the following DEA model:

$$\begin{aligned} &Maximize\ \xi + \varepsilon_s\left[\sum_{i=1}^{m} R_i^x d_i^{x-} + \sum_{r=1}^{s} R_r^g d_r^g + \sum_{f=1}^{h} R_f^b d_f^b\right] \\ &s.t.\quad \sum_{j=1}^{n} x_{ij}\lambda_j - d_i^{x+} = x_{ik} \quad (i = 1, \dots, m), \\ &\qquad \sum_{j=1}^{n} g_{rj}\lambda_j - d_r^g - \xi g_{rk} = g_{rk} \quad (r = 1, \dots, s), \\ &\qquad \sum_{j=1}^{n} b_{fj}\lambda_j + d_f^b + \xi b_{fk} = b_{fk} \quad (f = 1, \dots, h), \\ &\qquad \sum_{j=1}^{n} \lambda_j = 1, \\ &\qquad \lambda_j \geq 0 \quad (j = 1, \dots, n), \xi:\ \text{URS},\ d_i^{x+} \geq 0\ (i = 1, \dots, m), \\ &\qquad d_r^g \geq 0\ (r = 1, \dots, s), \text{ and } d_f^b \geq 0\ (f = 1, \dots, h) \end{aligned}$$
…(9)

A unified efficiency score $(UEM_V^*: VDTS)$ of the k-th DMU under managerial disposability is as follows:

$$UEM_V^* = 1 - \left[\xi^* + \varepsilon_s\left(\sum_{i=1}^{m} R_i^x d_i^{x-*} + \sum_{r=1}^{s} R_r^g d_r^{g*} + \sum_{f=1}^{h} R_f^b d_f^{b*}\right)\right]$$
…(10)

To attain unified efficiency under constant DTS $(UEM_c^*: CDTS)$, the equation $\left(\sum_j^n \lambda_j = 1\right)$ is dropped from Model (9). The level of unified efficiency under both managerial disposability and CDTS is measured by:

$$UEM_c^* = 1 - \left[\xi^* + \varepsilon_s\left(\sum_{i=1}^{m} R_i^x d_i^{x-*} + \sum_{r=1}^{s} R_r^g d_r^{g*} + \sum_{f=1}^{h} R_f^b d_f^{b*}\right)\right]$$
…(11)

Where the optimal solution is obtained from Model (9) without $\sum_j^n \lambda_j = 1$. These variable/constant DTS model are used to discuss green positioning strategy under managerial disposability.

The scale efficiency measures are obtained by

$$SEM^* = UEM_c^* \,/\, UEM_v^*$$
…(12)

Green-Imaged Product Positioning by UEN & UEM

Product positioning is concerned primarily with changes in consumer image of product. There are two types of product positioning from the firm's point of view: repositioning of existing products and design of a new product (Kaul and Rao, 1995). The need to reposition or redesign an existing product could arise for several reasons: (1) the firm did not make an optimal decision earlier and thus needs to revise its decision; (2) the basic characteristics of the market (i.e. consumers, regulation, region etc.) have changed and thus the firm needs to reposition/redesign its existing products to meet the changing consumer tastes; (3) the firm might want to react to the entry or changed strategy of a competitor (see Kaul and Rao, 1995).

A household mostly selects only one electricity product so that marketers should avoid creating a second best image even though their performance is inefficient. Marketers carefully create good product image by using "fact-based" information to develop their positioning strategy based on competitors' situation.

Table 1 summarizes the relationship between efficiency scores of VRTS, CRTS, SEN, VDTS, CDTS, and SEM, and a DMU's current efficiency level (location) and its target frontier, and possible types of information based on DEA environmental assessment in green positioning. As shown in Table 1, there are sixteen cases from Category (1) to (16), because the following combination does not exist:

$$\text{"}UEN_c^* = 1.0 \;\&\; SEN^* < 1.0\text{" or "}UEM_c^* = 1.0 \;\&\; SEM^* < 1.0\text{"}$$

…(13)
This study also avoids identifying "increasing RTS/DTS" and "decreasing RTS/DTS" because of meaningless in green positioning.

Green positioning strategy starts from identifying the level of productivity and gap from efficiency/target frontier from environmental point of view (e.g. economy, ecology, and environmental protection/regulation etc.). Marketers also try to measure differences between their current and ideal product image in the competing market. Then, they try to create green image by using information based on the current efficiency types, previous/expected improvements related to managerial efforts by investing in green technology, and information about their scale efficiency implying its potential ability for environmental sustainability (Moldan, et al., 2012). This study summarizes four types of information regarding productivity as follows:

Type I: Efficient information based on DEA environmental assessment, the DMU is located on CRTS/CDTS frontier, the marketer can use the type of information indicating the best product/production regarding quality/productivity such as efficiency scores, input/output ratio or amount and sustainability to attract consumers. However, Type I excludes expected information such as the amount/rate of emissions reduction because the DMU is on the frontier and has no target frontier. Type I, for example, 0.5kg-CO_2 /kWh (kg CO_2 emitted per kWh of electricity generation), efficiency rank/class offered by rating agencies and so on.

Type II: Efficient information based on DEA environmental assessment, the DMU is on VRTS efficient/frontier but is not located on CRTS, which indicates increasing/decreasing RTS/DTS (I/D RTS or I/D DTS), the marketer can use efficient information in a limited situation/condition. Type II indicates efficient product/production with inefficient size of capacity to the market, which indicates "not sustainable". The DMU has no expected (target-frontier-based) information because it has no target frontier.

Type III: Expected information based on DEA environmental assessment, inefficient DMU has a disadvantage in their productivity so that they need to use the other type of information to enhance their green image such as an expected amount/rate of emissions reduction (or saved resources) by investing the same/similar green technology (or replicating strategy learned from target frontier). Type III information are numerical amounts/rates related to two different terms of expected self-improved production, for example, 12% CO2 reduction, 85 million ton of annual CO2 emissions reduction. It is obvious that marketers of inefficient DMUs should use Type III excluding information about competitors to avoid customers knowing and selecting better options.

Type IV: Sustainability information, when SEN/SEM is equal to unity indicating VRTS/VDTS equals CRTS/CDTS, an efficient/inefficient DMU has appropriate/enough size of capacity to the market. This means that the DMU potentially has a capacity in terms of sustainable operation; therefore the marketers can use this information as their competitive advantage. When SEN/SEM is below unity, the target frontier is not equal to CRTS/CDTS frontier which indicates the target frontier is equal to increasing/decreasing RTS, the marketers should avoid using information about their capacity and sustainability in green positioning strategy.

Thus, use of Type III and IV along with managerial efforts indicates target-frontier-based information. It is important for DMUs to pay attention not only to their scale efficiency but also to those of their competitors in order to seek their future advantages in the market competition. If target frontier is equal to CRTS frontier, the DMU has a potential of becoming CRTS-efficient DMU without considering frontier shift (i.e. see Oh, 2010).

Table 1: Category classifications, information type, target frontier and unified efficiency scores

Categ.	Efficiency Score						Current Location or Target Frontier		Possible Type of Information			
	UEN			UEM			N	M				
	VRTS	CRTS	SEN	VDTS	CDTS	SEM	Target Frontier	Target Frontier	N		M	
1)	=1.0	=1.0	=1.0	=1.0	=1.0	=1.0	on CRTS	on CDTS	I	IV	I	IV
2)	=1.0	=1.0	=1.0	<1.0	<1.0	=1.0	on CRTS	CDTS	I	IV	-	-
3)	=1.0	=1.0	=1.0	=1.0	<1.0	<1.0	on CRTS	on I/D DTS	I	IV	-	-
4)	=1.0	=1.0	=1.0	<1.0	<1.0	<1.0	on CRTS	I/D DTS	I	IV	-	-
5)	<1.0	<1.0	=1.0	=1.0	=1.0	=1.0	CRTS	on CDTS	-	-	I	IV
6)	<1.0	<1.0	=1.0	<1.0	<1.0	=1.0	CRTS	CDTS	-	III, IV	-	III, IV
7)	<1.0	<1.0	=1.0	=1.0	<1.0	<1.0	CRTS	on I/D DTS	-	III, IV	II	-
8)	<1.0	<1.0	=1.0	<1.0	<1.0	<1.0	CRTS	I/D DTS	-	III, IV	-	III
9)	=1.0	<1.0	<1.0	=1.0	=1.0	=1.0	on I/D RTS	on CDTS	-	-	I	IV
10)	<1.0	<1.0	<1.0	=1.0	=1.0	=1.0	I/D RTS	on CDTS	-	-	I	IV
11)	=1.0	<1.0	<1.0	<1.0	<1.0	=1.0	on I/D RTS	CDTS	II	-	-	III, IV
12)	<1.0	<1.0	<1.0	<1.0	<1.0	=1.0	I/D RTS	CDTS	-	III	-	III, IV
13)	=1.0	<1.0	<1.0	=1.0	<1.0	<1.0	on I/D RTS	on I/D DTS	II	-	II	-
14)	<1.0	<1.0	<1.0	=1.0	<1.0	<1.0	I/D RTS	on I/D DTS	-	III	II	-
15)	=1.0	<1.0	<1.0	<1.0	<1.0	<1.0	on I/D RTS	I/D DTS	II	-	-	III
16)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	I/D RTS	I/D DTS	-	III	-	III

Category (1) in Table 1 shows that both performances under natural and managerial disposability are on both CRTS and CDTS frontier. Marketers can attract customers by their efficiency and recognition as the best green (the most environment-friendly) product. Marketers can also appeal their scale efficiency implying appropriate/enough size of capacity for environmental sustainability. However, they have no target frontier so they have no information about expected amount of reduction/enhancement obtained by using DEA environmental assessment. Category (2), (3) and (4) show that the level of performance under natural disposability is on CRTS frontier, but that of under managerial disposability is inefficient in terms of CDTS. The rational for green positioning should use the type of information referring to efficient information under natural disposability rather than inefficient one under managerial disposability. Because inefficient information doesn't contribute in enhancing green image of product correspond to Category (2), (3) and (4). Category (5) indicates the opposite situation of Category (3). Category (6) shows that an inefficient DMU has an expected reduction of some components of input vector or undesirable output vector, or an expected increase in the amount of desirable output under natural disposability (Type III), if the DMU/product introduces same/similar strategy or managerial effort of its target frontier. Category (6) also shows that an inefficient DMU can use Type III regarding expected improvement by an increase of input and desirable output vector without worsening the level of undesirable outputs under managerial disposability. Moreover, the DMU can use Type IV implying its appropriate capacity for sustainable operation. Thus, the DMU corresponds to Category (6) can utilize Type III and IV under natural and managerial disposability. The other categories are almost in the same manners as Category (1) to (6).

Marketers in Category (1), (6), (7), (8), (11), (12), (13), (14), (15), or (16) can select from two types of disposability in developing their green positioning. However, it is recommended that marketers in Category (2), (3), or (4) should develop their green positioning under natural disposability, and positioning strategy in Category (5), (9), or (10) should be under managerial disposability.

Table 2: Type of DEA-based information and characteristics in green positioning

Type of Information	Characteristics/Attributes			
	Target-frontier -based	Past Achievement	Future Expectation	Sustainability
I		✔		✔
II		✔		
III	✔		✔	
IV	✔	✔	✔	✔

Thus, green product positioning in attracting consumers mostly depends upon marketing efforts by using such limited type of information (I-IV) based on DEA measurement, focusing on their advantages related to past/future environmental and operational enhancement/improvement. Table 2 summarizes DEA-based information and characteristics.

Data

According to the EIA's forecast (TODAY IN ENERGY by U.S. Energy Information Administration (EIA), released March 16, 2016:
http://www.eia.gov/todayinenergy/detail.cfm?id=25392), coal's share falls 32% of generation in the United States under the share of natural gas. The recent decline in the generation share of coal and the rise in the share of natural gas appears to have been primarily because of their prices (Electricity Monthly Update by EIA, released June 24, 2016:
http://www.eia.gov/electricity/monthly/update/archive/june2016/).

There are two types of coal called bituminous and subbituminous are mainly used by coal-fired power plants in the United Sates. Almost 48% of the coal produced in the United States is bituminous, while about 44% is subbituminous. The coal conversion produces undesirable outputs, such as Green-House Gases (GHG) and acid rain gases, which cause the climate change and damages on the environment. The GHG emissions include CO2 (carbon dioxide), CH4 (methane), N2O (nitrous oxide), HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF6 (sulfur hexafluoride). SO2 (sulfur dioxide) and NOx (various oxides of nitrogen) are also emissions produced by coal-fired power plants, which belong to the acid rain gases.

This study uses data set on 68 PJM's coal-fired power plants in 2010, which source is the database of Environmental Protection Agency (EPA) "eGRID year 2010" (http://www.epa.gov/energy/egrid). This study assumes 68 different electricity products (see Sueyoshi and Goto, 2016). In this study, each product is characterized by the following production factors:

Inputs
X1: the nameplate capacity (MW: Megawatt)
X2: the amount of annual heat input (MM Btu)

Desirable Output
G1: the amount of annual net generation (MWh: Megawatt hours)

Undesirable Outputs
B1: the annual amount of NOx emissions (tons)
B2: the annual amount of SO_2 emissions (tons)
B3: the annual amount of CO_2 emissions (tons)

As mentioned previously, "unit-less" data calculated by the equation (3) are used to avoid the situation where a large production factor dominates the others in the computational process of the DEA.

Results

Table 3 exhibits unified efficiency scores of 68 electricity products under natural and managerial disposability, and the corresponding type of category in Table 1. The number from 1b to 57b corresponds to products/DMUs with bituminous coal, and 58s to 68s are with sub-bituminous coal (the scores are partly discussed in Sueyoshi and Goto, 2016). Model (3), (4), (7) and (8) under natural disposability and Model (12), (13), (15) and (16) under managerial disposability are used to measure unified efficiency scores, VRTS, CRTS, SEN and VDTS, CRTS, SEM of each product. For example, product number b50 in Table 1, indicates Category (9), which indicates inefficient in terms of both CRTS and SEN under natural disposability but efficient in terms of VDTS, CDTS and SEM under managerial disposability, that the marketer should use information Type I and IV under managerial disposability to enhance its green image.

In order to discuss characteristics of the US coal electricity market, this study compared mean values of both under natural disposability and that of under managerial disposability.

(a) The mean (standard deviation) of VRTS and VDTS are 0.9518 (0.04922) and 0.9934 (0.011345). The mean of VDTS is higher than that of VRTS ($t(67)=7.511$, $p<.001$).
(b) The mean (standard deviation) of CRTS and CDTS are 0.9238 (0.092951) and 0.9901 (0.012459). The mean of CDTS is higher than that of CRTS ($t(67)=6.548$, $p<.001$).

The difference between unified efficiency measures under natural and managerial disposability is confirmed at the level of 1% significance of the paired t-test.

Table 3: Product number and category classifications

no.	UEN			UEM			Cat eg.	no.	UEN			UEM			Cat eg.
	VRTS	CRTS	SEN	VDTS	CDTS	SEM			VRTS	CRTS	SEN	VDTS	CDTS	SEM	
b1	0.9564	0.9555	0.9991	1.0000	0.9982	0.9982	14	b36	0.9076	0.9025	0.9944	0.9974	0.9964	0.9991	16
b2	0.9526	0.9522	0.9996	0.9811	0.9772	0.9960	16	b37	0.9676	0.9663	0.9987	1.0000	0.9992	0.9992	14
b3	0.9543	0.8256	0.8651	0.9969	0.9964	0.9995	16	b38	0.9820	0.9819	0.9999	0.9997	0.9994	0.9997	16
b4	0.9779	0.9761	0.9982	0.9782	0.9782	1.0000	12	b39	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1
b5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1	b40	0.9488	0.9477	0.9988	0.9976	0.9976	0.9999	16
b6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1	b41	0.8056	0.8034	0.9973	0.9971	0.9965	0.9994	16
b7	0.9852	0.9832	0.9981	1.0000	1.0000	1.0000	10	b42	0.9226	0.9145	0.9912	0.9965	0.9965	0.9999	16
b8	0.9990	0.9983	0.9993	1.0000	1.0000	1.0000	10	b43	0.9469	0.9389	0.9916	0.9974	0.9972	0.9998	16
b9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1	b44	0.9142	0.9119	0.9975	1.0000	0.9762	0.9762	14
b10	0.9234	0.9233	0.9999	1.0000	0.9768	0.9768	14	b45	1.0000	1.0000	1.0000	0.9997	0.9995	0.9997	4
b11	1.0000	0.7374	0.7374	0.9951	0.9947	0.9995	15	b46	0.8760	0.8678	0.9907	0.9964	0.9964	1.0000	12
b12	0.8441	0.8393	0.9943	0.9794	0.9754	0.9960	16	b47	0.9483	0.9478	0.9994	0.9946	0.9943	0.9997	16
b13	0.9647	0.9646	0.9999	0.9779	0.9777	0.9997	12	b48	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1
b14	0.8779	0.8759	0.9977	0.9866	0.9748	0.9881	16	b49	0.9778	0.9775	0.9997	0.9996	0.9996	1.0000	12
b15	0.9555	0.9545	0.9990	1.0000	0.9775	0.9775	14	b50	1.0000	0.4177	0.4177	1.0000	1.0000	1.0000	9
b16	1.0000	1.0000	1.0000	1.0000	0.9959	0.9959	3	b51	1.0000	0.9758	0.9758	1.0000	0.9933	0.9933	13
b17	1.0000	0.9523	0.9523	1.0000	0.9994	0.9994	13	b52	0.9786	0.9771	0.9984	1.0000	0.9890	0.9890	14
b18	0.9373	0.9317	0.9940	0.9992	0.9990	0.9998	16	b53	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1
b19	0.9652	0.9646	0.9993	0.9995	0.9991	0.9996	16	b54	1.0000	1.0000	1.0000	1.0000	0.9998	0.9998	3
b20	0.9757	0.9755	0.9999	0.9972	0.9782	0.9809	16	b55	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1
b21	0.9001	0.8881	0.9866	1.0000	0.9965	0.9965	14	b56	1.0000	0.9970	0.9970	1.0000	1.0000	1.0000	9
b22	0.8442	0.7757	0.9189	0.9948	0.9947	0.9999	16	b57	0.9585	0.9577	0.9992	1.0000	0.9780	0.9780	14
b23	0.9868	0.7867	0.7972	0.9967	0.9962	0.9995	16	s58	0.9069	0.9042	0.9971	0.9632	0.9631	1.0000	12
b24	0.9362	0.8021	0.8568	0.9755	0.9753	0.9998	16	s59	0.8997	0.8949	0.9947	1.0000	0.9637	0.9637	14
b25	1.0000	0.7331	0.7331	0.9961	0.9954	0.9994	15	s60	0.8741	0.8687	0.9938	0.9621	0.9620	0.9998	16
b26	1.0000	1.0000	1.0000	1.0000	0.9999	0.9999	3	s61	0.8965	0.8962	0.9996	0.9773	0.9761	0.9988	16
b27	0.9024	0.9021	0.9996	1.0000	0.9964	0.9964	14	s62	0.8884	0.8874	0.9989	0.9626	0.9612	0.9986	16
b28	0.9248	0.9237	0.9987	1.0000	1.0000	1.0000	10	s63	0.9035	0.9023	0.9986	0.9681	0.9681	1.0000	12
b29	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1	s64	0.8922	0.8918	0.9996	0.9601	0.9596	0.9994	16
b30	0.9581	0.9506	0.9922	0.9977	0.9977	0.9999	16	s65	0.9709	0.9621	0.9909	0.9784	0.9771	0.9987	16
b31	1.0000	0.9872	0.9872	1.0000	0.9999	0.9999	13	s66	0.9493	0.9469	0.9975	0.9770	0.9770	1.0000	12
b32	0.9404	0.9324	0.9915	1.0000	1.0000	1.0000	10	s67	0.9463	0.9382	0.9914	0.9768	0.9768	0.9999	16
b33	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1	s68	0.8358	0.7919	0.9475	1.0000	0.9818	0.9818	14
b34	0.9667	0.9597	0.9928	0.9999	0.9987	0.9989	16	Avg.	0.9518	0.9238	0.9712	0.9934	0.9901	0.9966	
b35	0.9958	0.9944	0.9986	1.0000	1.0000	1.0000	10	S.D.	0.0492	0.0930	0.0878	0.0113	0.0125	0.0075	

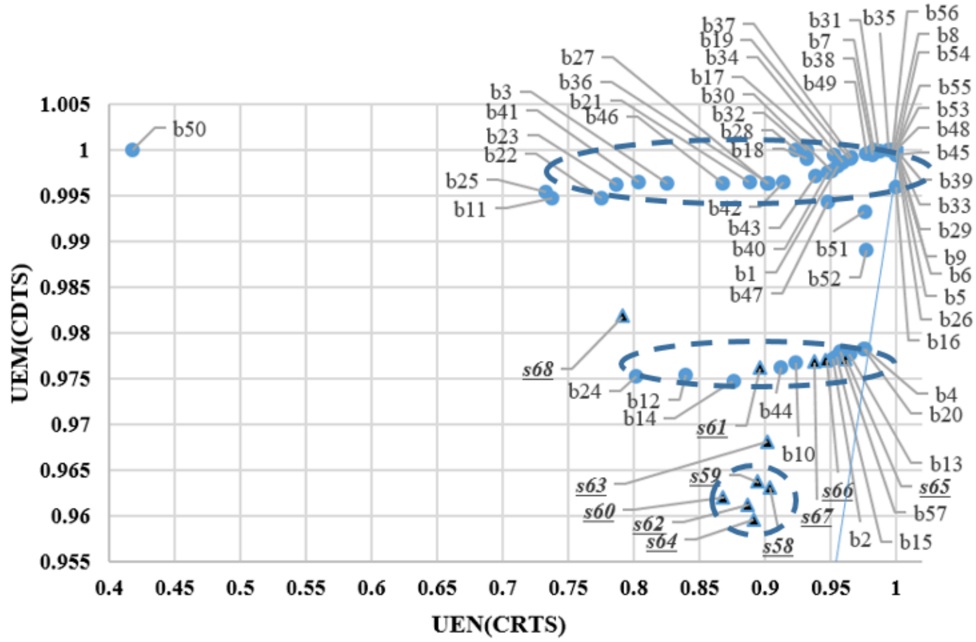

Figure 2: Visual description on two unified efficiency scores, CRTS and CDTS

Figure 2 visually describes the electricity products plotted by unified efficiency measures under managerial disposability (UEM) on the vertical axis and unified efficiency measures under natural disposability (UEN) on the horizontal axis. The plotted dot is a symbol for a product generated with bituminous coal, while a triangle symbolizes a product with sub-bituminous coal. The 68 products are roughly classified into three groups encircled with dotted line vertically as depicted in Figure 2.

As shown in Table 3 and Figure 2, this study found (1) the value of UEM are mostly larger than that of UEN, (2) the standard deviations of UEM are smaller than those of UEN, and (3) the group in the upper part of the graph encircled with dotted line, composed of products with bituminous, however, the group in the lowest part of the graph consists of products with sub-bituminous. It is also found that the competition of US electricity market is high and well homogenized under managerial disposability compared with natural disposability.

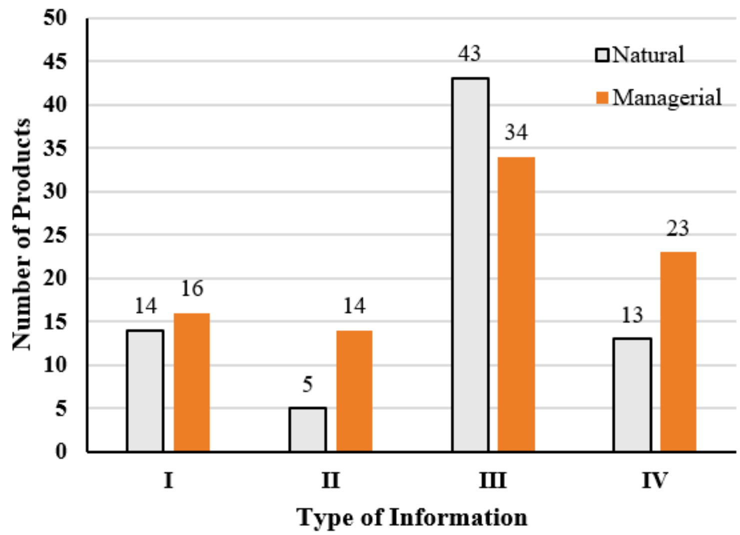

Figure 3: Type of Information and disposability

Figure 3 depicts the possible type of information in green positioning strategy under natural and managerial disposability in the US coal electricity market. In terms of under natural disposability, 13 of 68 products/marketers can use Type IV, whereas, 23 of 68 products under managerial disposability can use Type IV. This means that a limited number of DMUs/products has appropriate size of capacity under natural disposability. The comparison the situation between both natural and managerial disposability provides us with an important strategic implication that which type of disposability is better for a DMU/product to select in green positioning strategy.

Table 4: Type of coal and information

Type of Information	Bituminous		Sub-bituminous	
	N	M	N	M
I	24.6%	28.1%	0.0%	0.0%
II	8.8%	21.1%	0.0%	18.2%
III	56.1%	43.9%	100.0%	81.8%
IV	22.8%	35.1%	0.0%	27.3%

Table 4 summarizes the type of information by coal type under natural and managerial disposability. For example, a green positioning for a product generated by Sub-bituminous under natural disposability is not able to use Type I, II, IV but Type III.

Discussion

In discussing green positioning, it is important for marketers to recognize the current situation of electricity market and their productivity evaluated with unified efficiency measures. The comparison between two green positioning strategies under natural and managerial disposability is also important because marketers should recognize their advantages and weaknesses among competitors and they should develop effective strategy under a competitive market.

The US electricity products generated by coal were examined in terms of green-imaged positioning proposed in this study. The results of paired t-test between UEN and UEM imply that (1) the competitiveness of productivity is higher under managerial disposability than that under natural disposability, (2) a product differentiation by an efficient company under managerial disposability is considered to need more efforts to sustain current position than that under natural disposability.

This study finds that electricity products generated by coal-fired power plant operated with sub-bituminous have limited type of information (only Type III) to use in green positioning strategy under natural disposability. It is recommended that the sub-bituminous electricity should be phased out under natural disposability because it will benefit both the competition of coal electricity market and the future sustainable economic growth.

Conclusions

This study discussed the importance of green positioning strategy in a fully liberalized electricity market. This study proposed conceptual framework of green-imaged positioning using unified efficiency measure under natural and managerial disposability. Our approach is partly based on and newly extended from the research by Sueyoshi and Goto (2016). This study also discusses four types of information based on VRTS, CRTS, SEN, VDTS, CDTS, and SEM measured by DEA model to create a distinct product impression in consumers' mind by identifying and communicating its uniqueness. In order to develop effective positioning strategy, marketers can identify their strength of electricity products and competitors' situation by the proposed approach in this study, and their availability type of information under natural and managerial disposability in the market. This study has examined the US coal electricity market by the proposed approach. It is possible for us to consider various applications including an idea of frontier shift (or future frontier without replicating the current target frontiers), a desirable congestion to be identified for new technology, an undesirable congestion to be avoided caused by capacity limitation, and so on in the proposed green positioning strategy. For future research, it is also possible for us to expand our green-imaged positioning approach to pricing strategy including other production factors such as other natural resources and costs.

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Between Land and Sea:An Approach for Resilient Waterfront Development along the San Francisco Bay

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Abstract
The waterfront along the San Francisco Bay is facing a growing threat from sea-level rise. By the end of the century, a projected sea-level rise of 140cm may affect an estimated 270,000 people in the Bay Area and 331 sq. kilometers of current urban development valued at $62 billion. To further complicate matters, it is estimated that 2.1 million people and 660,000 homes are expected to arrive by 2040, adding to the 7 million current Bay Area residents. In addition to urban development, sea-level rise will also affect the ecology of the San Francisco Bay, threatening to submerge the majority of existing tidal wetlands by mid-century.
To combat sea-level rise, many are calling for bigger and better levees, while still others claim that urban development in the areas at risk of inundation should be removed to allow for tidal wetlands to migrate to higher elevations as sea levels rise. I propose that both may be accomplished by a managed retreat of existing development, enabling wetland migration, while introducing a resilient new typology of development built on levees and piers that is designed to co-exist with a tidal ecosystem.
I have chosen three waterfront sites around the San Francisco Bay that contain urban development at risk of inundation from sea-level rise. I will demonstrate a design strategy that utilizes techniques in site analysis to collaborate with the unique characteristics of each area to create a new set of relationships between urban life and ecology, ultimately redefining the coastal boundary.

Keywords:Resilience, Sea-Level Rise, Wetlands, Urban Design, Ecology, Sustainability, Managed Retreat, Waterfront

Introduction

I will begin by framing the issues associated with sea-level rise in the San Francisco Bay Area by presenting research on the implications for people, property, and the ecosystem. I will present my plan for a combined managed retreat and resilient redevelopment to address issues of sea-level rise, wetland ecology, and population increase. This will include a description of my site analysis, design methodology, and proposed development strategies. I will conclude with a reflection on the design process and outcomes.

The Impact of Sea-level Rise on The Bay Area

Two state-sponsored studies of sea-level rise impact on the Bay Area were used extensively in preparing my research: the San Francisco Bay Conservation and Development Commission's (BCDC) "Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline" (2011), and the Pacific Institute's "The Impact of Sea Level Rise on the California Coast" (2009). These reports represent a robust analysis of projected implications for urban development and bay ecology due to rising sea levels. They constitute a wealth of data quantifying

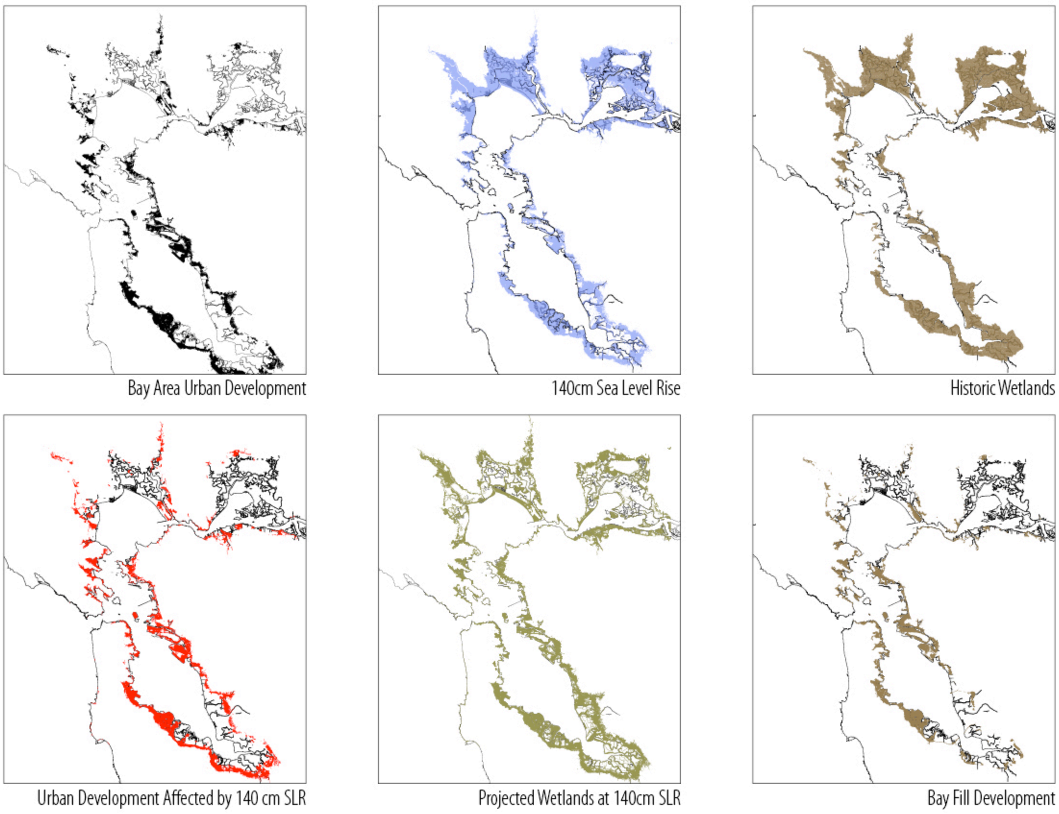

Figure 1 Mapping Analysis of the San Francisco Bay Area

sea-level rise impacts and serve as advisory information for potential adaptive strategies.

A vulnerability assessment by BCDC uses two sea-level rise projections: a 16-inch (40cm) sea-level rise by mid-century and a 55-inch (140cm) rise in sea level by the end of the century. Their study puts 281 square miles of Bay shoreline at risk of flooding from 40cm of sea-level rise, and 333 square miles at risk from a 140cm sea-level rise. A 140cm rise in sea levels would place an estimated 270,000 people around the Bay Area at risk, constituting over half of the projected population affected in the entire state. The Pacific Institute further elaborates on these metrics by describing how communities of color and low-income populations will be disproportionately affected, while critical infrastructure and "vast areas of wetlands and other ecosystems" will be at increased risk of inundation.[1]

The report by BCDC also places significant portions of the bay ecosystem in peril with rising sea levels. A sea-level rise scenario of 40cm is "sufficient to impact 90 to 95 percent of the existing tidal marshes."[2] With decreased sediment flowing from the Delta, it is uncertain whether tidal wetlands would be able to migrate with rising sea levels. Static coastal management structures further complicate the future existence of tidal wetlands, creating a barrier for upland migration with the potential consequence of submersion.

The Case for Preserving San Francisco Bay Tidelands

A "2013 National Climate Assessment on Coastal Impacts, Adaptation, and Vulnerabilities" states that a functioning coastal ecosystem is essential to all of the economically important sectors by "providing an environment that sustains natural habitats and resources for use by communities."[3] The interdependence of cities and their surrounding ecosystem often goes unnoticed in this age of inter-global trade and regionally connected infrastructure. The field of ecology has demonstrated that however detached people may feel from their surroundings, the intricate web of life connects human action with the natural environment, which in turn supports our very existence.

As the largest estuary along the Pacific shore of North American, the San Francisco Bay is an important and unique ecosystem. The defining characteristic of the Bay is the tidal wetlands, habitat for millions of migrating birds yearly. The tidal wetlands also provide flood protection and improve water quality through natural filtration of pollutants and shoreline stabilization, while also serving a vital role as a source of carbon sequestration.

Over 80 percent of the tidal wetlands in the San Francisco and San Pablo Bay have been filled or modified since the late 1800s.[4] The sea-level rise projections for the mid and end of the century, in combination with proposed levees for coastal armament, will all but wipe out the remaining tidelands. On the other hand, if given the opportunity, tidal wetlands may be able to migrate with rising sea levels, returning to their historic location and expanding inland. To accomplish an inland migration with the rising tides, wetlands build soil by trapping mineral sediment carried by tidal waters and accumulation of plant matter. Under moderate projections of sea-level rise,

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1 Heberger and Herrera, et. al. 2009
2 San Francisco Bay Conservation and Development Comission (BCDC) 2011: 80
3 Burkett and Davidson 2013: 7
4 BCDC 2011: 79

simulations show that coastal marshes would likely survive if there were adequate upland area with which to migrate.[5]

Sea-Level Rise Mitigation Strategies

Many people regard sea-level rise as a far off threat, since it appears to be advancing slowly. The Bay Area lacks the type of storms recently seen in New York and New Orleans that have caused massive damage; further adding to a public perception that sea-level rise is not a pressing issue. However, a comprehensive plan to address the complexity of rising tides in the Bay Area will need to be implemented before major problems occur if the desire is to do more than put a bandage on the current outdated infrastructure. This will require an orchestrated effort between Federal, State, and local governments around the San Francisco Bay, including the participation and support of residents and various stakeholders. The decisions that are made, including non-action, will have a rippling effect on the future trajectory of the Bay Area for generations to come.

A report by the coastal zone management subgroup of the IPCC divided available sea-level rise response options into three groups, with the following definitions:[6]

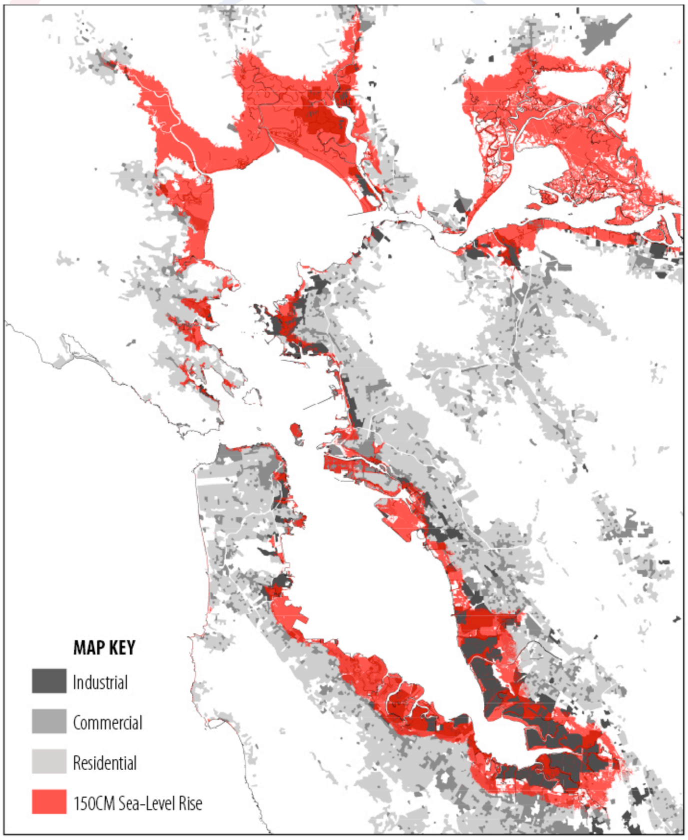

Figure 2 Composite Map Illustrating Impact of 150cm Sea-Level Rise on Land Use

[5] Burkett and Davidson 2013: 57
[6] IPCC 1990: 8

"Retreat - abandon structures in currently developed areas, resettle the inhabitants, and require that any new development be set back specific distances from the shore, as appropriate".

"Accommodate - continue to occupy vulnerable areas, but accept the greater degree of flooding (e.g convert farms to fish ponds)".

"Protect - defend vulnerable areas, especially population centers, economic activities, and natural resources".

The question of "retreat," "accommodate," or "protect," is at the core of the sea-level rise debate. However, this separation of words into categories both mirrors and perpetuates the entrenchment of advocacy groups into a singular view of the issue. By contrast, a mitigation strategy may incorporate all three sea-level rise options, or variations of each. Giving a word or phrase the title of an entire strategy serves to polarize groups and box in options. This is key to the debate of "levee vs. wetlands."

Fight or flight is one way the debate has narrowed into a strategy of protection of property or protection of the environment. This pits property owners versus environmentalists. While an emotional topic for both parties, much of the debate will hinge on economic forces that will likely come from many places. If larger levees are to be built or city boundaries pulled back to accommodate rising tides, this will require massive funding that local government would be unable to afford, requiring help from federal and state agencies.

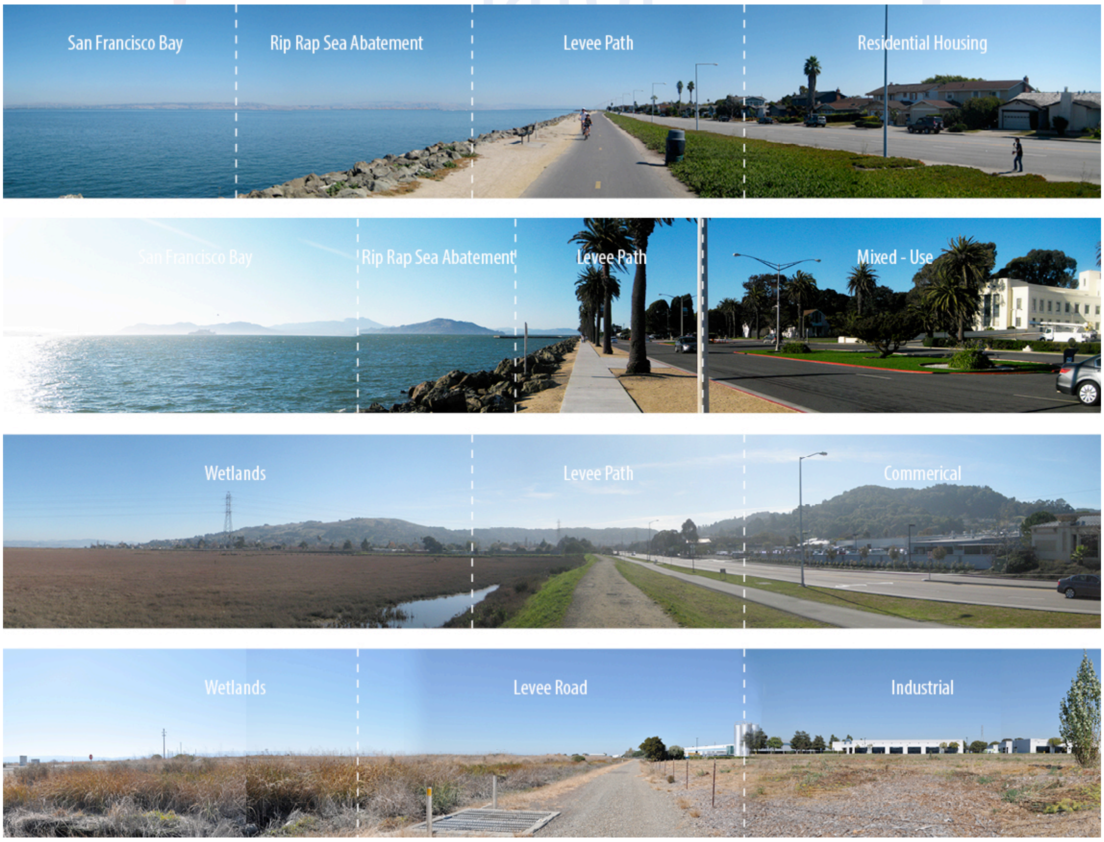

Figure 3 Waterfront Typology Study of the San Francisco Bay

The question of protection versus relocation is ultimately a question of economics. Will it be worth building sea abatement structures if high-risk areas continue to be vulnerable to rising sea levels? Are the remaining tidal wetlands in the San Francisco Bay an economic asset that outweighs the cost of a managed retreat? Currently, land that is protected by a levee, but below sea level is not considered at risk of flooding by insurance assessment.[7] This is almost sure to change in the future as cost outweighs the benefit of selling insurance in areas of high risk. What then will be their fate?

When talking about a managed retreat strategy, eminent domain is the elephant in the room. This phrase conjures up a myriad of responses relating to the people that will be displaced, the logistics of how it will be accomplished, and the money that it will cost. A BCDC report states that with a sea-level rise of 140cm, 98 percent more people will be at risk. According to the report, by the middle of the century, and likely earlier, "residents, businesses and entire industries that currently thrive on the shoreline are subject to flooding."[8] Approximately 103 square miles of residential development will be subject to 100 percent chance of flooding by mid-century, with over 128 square miles vulnerable to flooding by the end of the century. The total assessed economic value of Bay Area shoreline development at risk of flooding from 140cm sea-level rise is estimated at $62 billion, accounting for two-thirds of vulnerable property in California.

[7] FEMA 2014
[8] BCDC 2011: 2

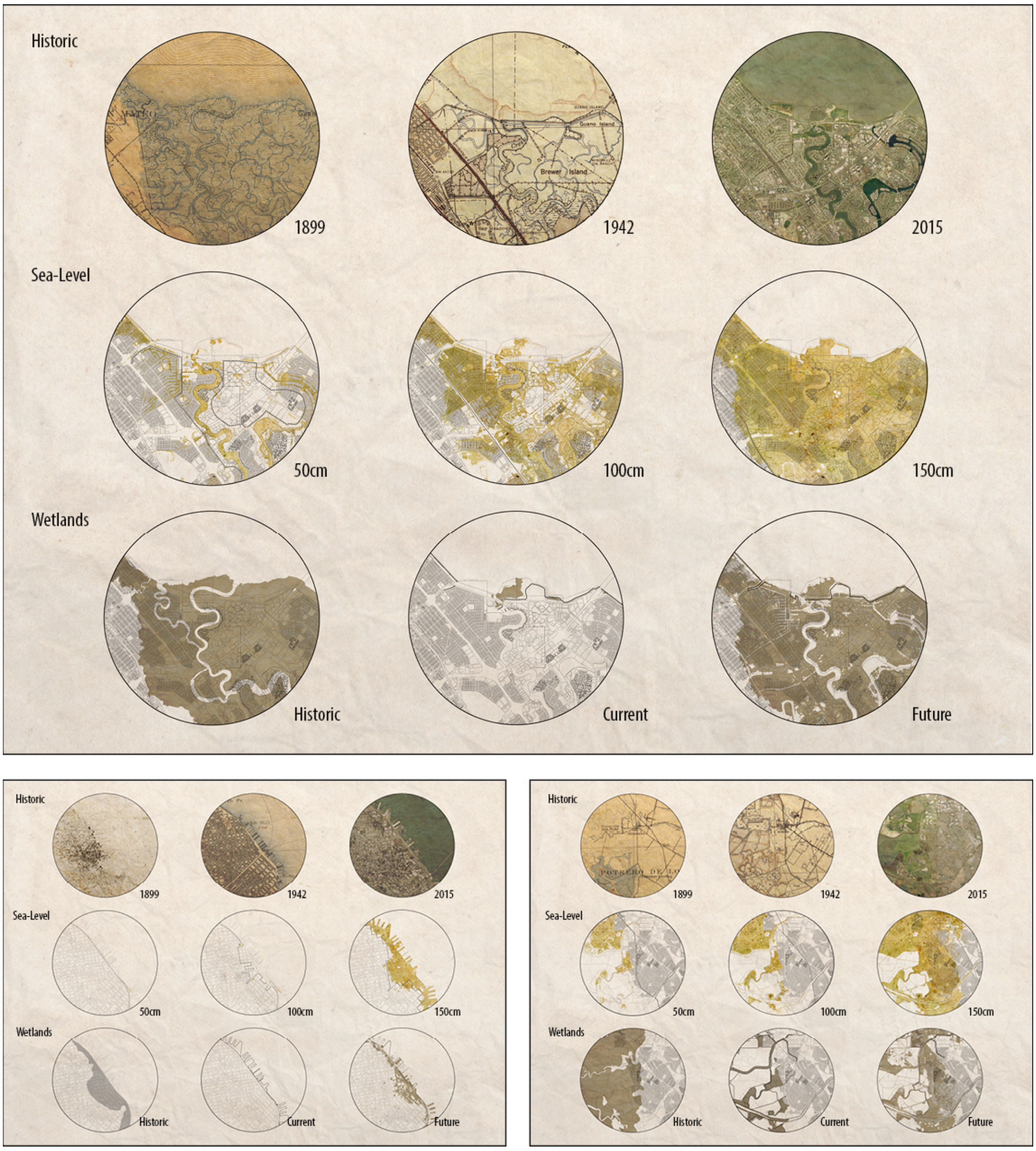

Figure 4 Site Analysis (counterclockwise from top) San Mateo, San Francisco, Union City

Ultimately, economic cost will play a driving force in determining managed retreat viability. By simply removing current urban development and replacing it with tidal wetlands, there are no immediate earnings to offset what will be staggering costs. These costs include the relocation of public infrastructure, compensation for private property, removal and disposal of current urban development; in effect, undoing the short sighted "progress" since the mid-twentieth century.

Examining the issues of sea-level rise on Bay Area development, it becomes apparent that conventional solutions will not solve the problems that we face. Neither the building of more levees nor a managed retreat alone offers a viable plan to address the issue of sea-level rise. I propose that it is time that we consider other options that combine protection and relocation with design? By reframing sea-level rise as an "opportunity" rather than as a "problem," we have a chance to redesign the Bay Area

Figure 5 Suitability Analysis – Historical Waterway Buffer (San Mateo)

waterfront to be a model of sustainability for the 21st century. Through the incorporation of resilient and adaptable design strategies, we can aim for a new development that is environmentally, economically, and socially sustainable.

Site Analysis

Site analysis involved an examination of the past and present built and natural environment and future sea-level rise scenarios. Analysis began by examining the historic context of each site. Starting first with mapping, geo-referenced historical maps were overlaid with maps of the present built and natural environment. These composite maps were used for the purpose of investigating historical ecology and urban morphology, to better understand the pre-development conditions and site transformations. Research of site history through photographs and text supplemented a mapping analysis. For this purpose, two books were especially valuable in understanding the historical transformations around the Bay Area: *Imperial San Francisco: Urban Power, Earthly Ruin* by Gray Brechin and *Down by the Bay: San Francisco's History Between the Tides* by Matthew Booker.

My work utilizes historical ecology as a framework to better understand the native ecosystem around the San Francisco Bay, thereby informing an approach for a managed retreat, wetland restoration, and re-development strategy in response to sea-level rise. In my research, I have combined a variety of historical records, including a numerous books written on the history of San Francisco Bay and historic maps from the David Rumsey collection. Many of these maps show accurate depictions of not only the built environment, but also the natural landscape.

The San Francisco Estuary Institute defines historical ecology as:

> Synthesizing diverse historical records to learn how habitats were distributed and ecological functions were maintained within the native California landscape. Understanding how streams, wetlands, and woodlands were organized along physical gradients helps scientists and managers develop new strategies for more integrated and functional landscape management.[9]

The 1852 U.S. Coastal Survey and the 1899 and 1942 USGS maps served as my primary historic map references. Geo-referencing these maps in ArcGIS allowed for the overlay of current layers of infrastructure for further analysis, therefore enabling a comparison between historic conditions and those of the present built and natural environment. A look at historic maps of the 19th and 20th century around the San Francisco Bay, in combination with archived accounts and detailed descriptions, paints a vivid portrait of the native landscape along the Bay. This knowledge was used in understanding not only what the coastline looked like in the past, but also how it can be restored in the future.

By overlaying sea-level rise maps onto historic maps, it was evident that the San Francisco Bay water is once again reclaiming the land that had been filled for development. Visualizing the superimposition of historic creeks and sloughs with projected inundation areas from rising sea levels speaks to the dormant nature of the native landscape that exists beneath our cities. This realization led to my use of historical ecology as a driving force in the design process. In this way, the native landscape and existing development act as collaborators in the design of a managed retreat, wetland restoration, and adaptive re-development.

Site Selection

For my study, I choose three sites located along the urbanized waterfront of the San Francisco Bay Area. Each of these sites was chosen as representative of unique urban and ecological characteristics to serve as a model for similar areas around the Bay Area. To locate these sites, I began through a data-driven mapping process. I quantified and compared 84 sample sites that contained urban development at risk of sea-level rise, development built on bay fill, and historic or current wetlands. An addition to the original query explored the amount the potential area of wetland migration with sea-level rise and the quantity that overlapped with current urban development.

The three sites that were chosen include:

- San Francisco – Downtown (San Francisco County)
- East San Mateo – Peninsula (San Mateo County)
- Union City – East Bay (Alameda County)

[9] San Francisco Estuary Institute "Historical Ecology."

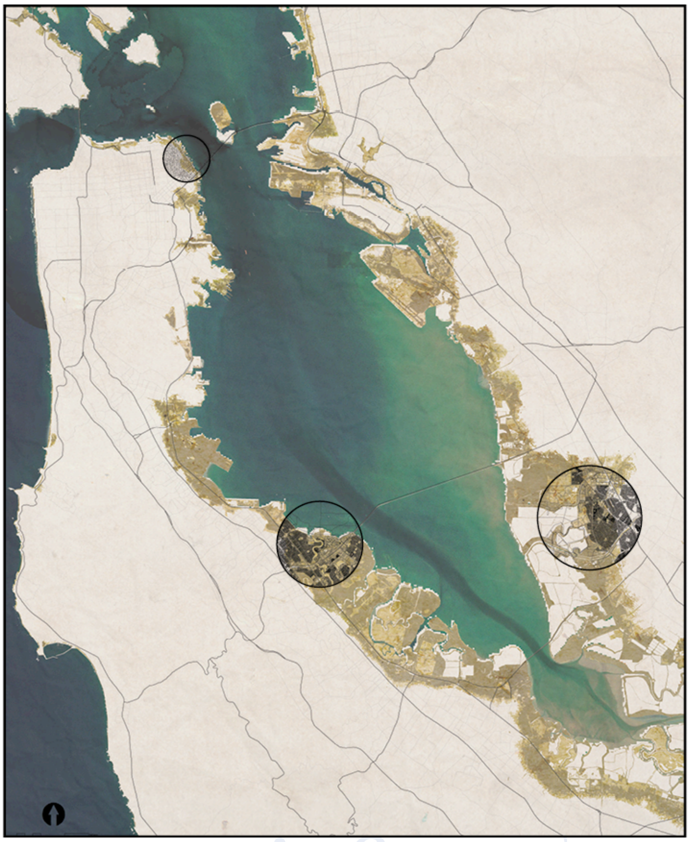

Figure 6 Regional Site Map (counterclockwise from top) San Francisco, San Mateo, Union City

A radial buffer of differing sizes bounds each site. The rationale for the site buffer was to frame particular locations with an area large enough to study the implications of sea-level rise projections 50cm, 100cm, and 150cm, while also containing the current tidal ecosystem and infrastructure. The site boundaries do not indicate where a staged retreat and re-development would stop, but rather imply that it would continue along the coastline in a similar manner to adjacent sites as an interconnected network.

The goal of choosing varying sites was to test the proposed methodology of site analysis, managed retreat, and redevelopment strategy, thereby highlighting the contribution of the unique site characteristics in the design process. The factors of historical ecology, urban morphology, existing infrastructure, building density, and sea-level rise all play an important role in determining the design and urban form of future development. In this way, the site acts as a collaborator in the design process.

Site Development Strategies: Managed Retreat

It is likely that a retreat of the current urban development will be required for the continued survival of the tidal wetlands around the Bay Area if sea levels rise as projected. Much of the current development was built on bay fill in areas of historic marshes. However, the uncertain timeline of sea-level rise creates an added layer of complexity in determining a retreat strategy. The solution is to create a managed retreat strategy that is site specific.

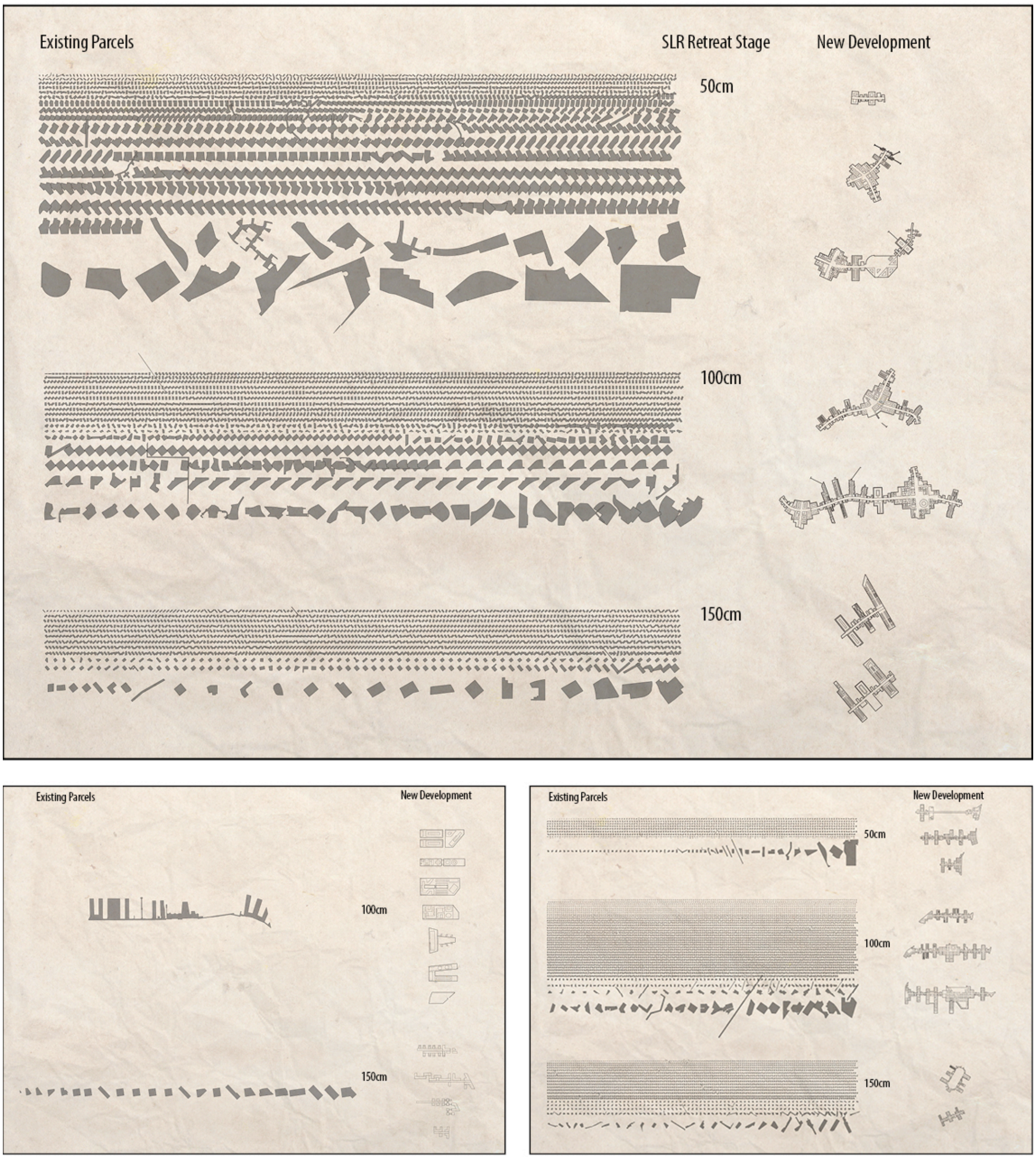

Figure 7 Managed Retreat Plan – Parcel Removal and Replacement with Resilient New Development (counterclockwise from top) San Mateo, San Francisco, Union City

A managed retreat would open land currently occupied by urban development to intertidal action. The land would need to be prepared by removing buildings, roads, levees, and other infrastructure to allow tidal wetlands to migrate with rising Bay tides. The size and location of the land that would be cleared could be careful assessed by the risk of flooding posed at different stages of sea-level rise. I propose using the benchmark sea-level rise stages of 50cm, 100cm, and 150cm.

By modeling inundation at different stages of sea-level rise, I identified the urban areas most at risk of flooding. For protection in cases of extreme flooding a levee perpendicular to tidal action would need to be placed at the new urban edge that defines the extent of the staged retreat. The location of this new levee should optimally be made near the edge of the inundation risk area for a given sea-level rise stage, while corresponding to current infrastructure.

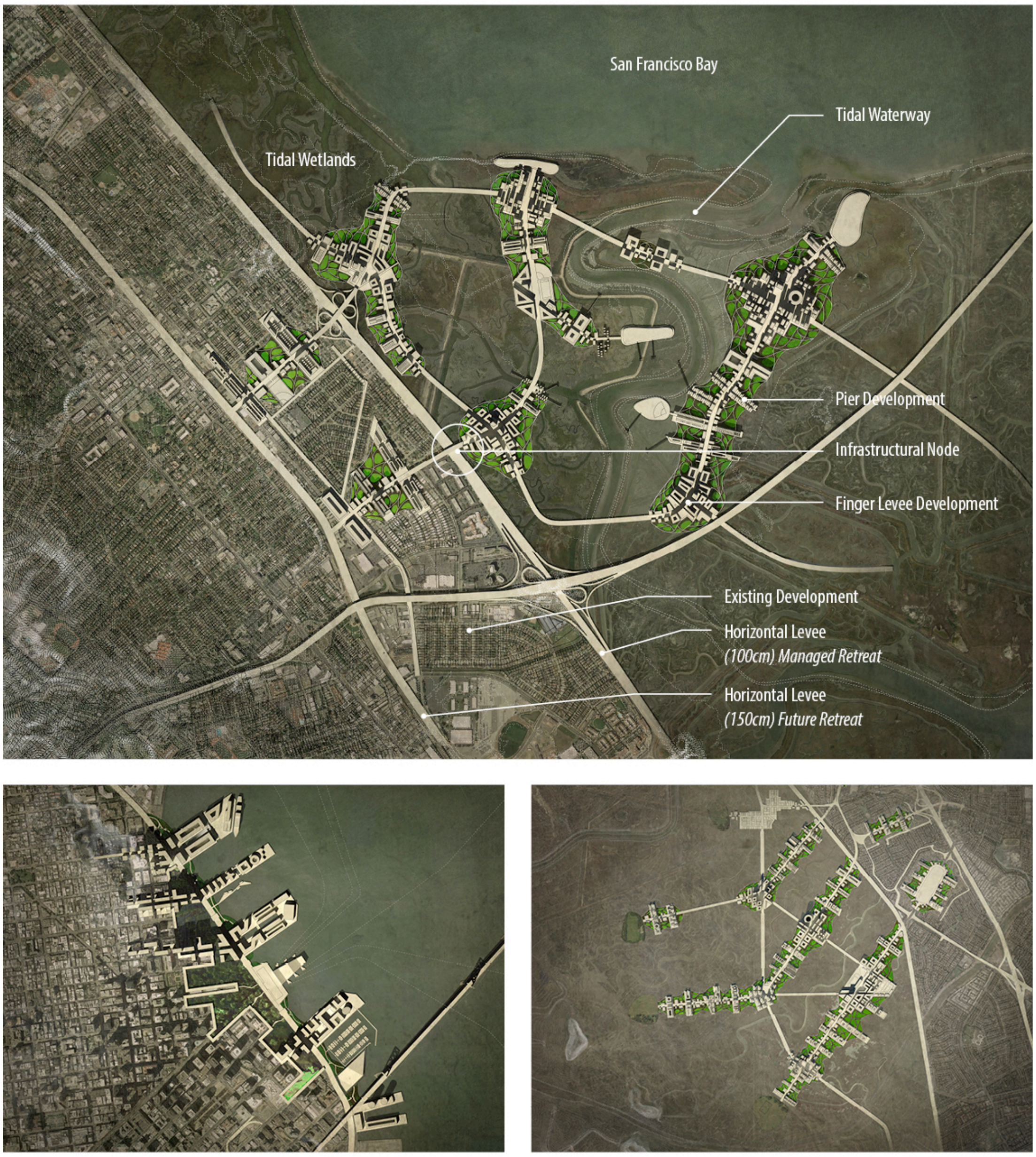

Figure 8 Redevelopment Strategy at 100cm Sea-Level Rise (counterclockwise from top) San Mateo, San Francisco, Union City

Major roadways, including highways, arterial roads, and train track right of ways provide an ideal linear infrastructure location for the new levee. Many of the highways and train tracks along the Bay are at risk of inundation as the sea level rises. Since protective levees will need to be built at higher elevation and run parallel to the coastline, existing linear infrastructure presents an opportunity to have a continuous barrier for extreme flood conditions.

The new levees that run parallel to the coastline are designed to protect development at low risk of inundation with the express purpose of migrating to a new location further inland, corresponding to the edge of the next staged retreat and transportation infrastructure location. The old levee will then be opened to tidal action when existing urban development has been cleared in the interstitial area upland of the old levee.

The managed retreat of urban development allows for the continued migration of tidal wetlands with the rising sea levels and has minimal dependence on human-made sea barriers to protect against flooding. The tidal wetlands, in turn, offer a natural barrier against storm surges, further protecting urban development.

Site Development Strategies: Redevelopment Strategy

By redeveloping in the managed retreat area, a public-private partnership can be used to finance the use of eminent domain, the relocation of infrastructure, building of levees, and the building of new development to house the growing population. This will need to be a new type of development that is built to coexist with rising sea level and the tidal wetlands. The footprint of the new built environment will need to be drastically smaller and significantly denser to allow ample open space for tidal wetlands and housing for an increasing population. My proposal is to build a new resilient form of coastal development on what I call "Finger Levees."

The Finger Levee is the infrastructural backbone for my adaptive redevelopment strategy. In each of the three sites, the Finger Levee development replaces existing development that has been removed after a managed retreat. This involves the use of eminent domain to clear existing development at risk of inundation from sea-level rise and replacing it with new development on levees and piers, while leaving the majority of the land open for tidal action and wetland habitat.

The Finger Levee design aims to create an adaptive and resilient new development that coexists with tidal wetland ecologies in a mutually beneficial relationship. The success of the Finger Levee development starts with the use of historical ecology and urban morphology to determine the most suitable land for development. The natural environment and existing infrastructure act as collaborators in the design process, informing the location and shape of the Finger Levees. The densification of the urban footprint and spacing between Finger Levee developments are important design attributes that allow for a healthy tideland to co-exist adjacent to the urban context. The centralized infrastructure of the Finger Levee, in addition to building development on pier foundations and closed-loop systems, create a resilient and sustainable model for waterfront development along the San Francisco Bay coastline.

Development Pattern

The pattern of Finger Levee development is determined by a combination of historical ecology and existing infrastructure for each site. The first step is to map the past ecological conditions of the site. To determine the most suitable land for future development, historic maps were used to identify the most solid land, which was located a sufficient distance from historic and existing sloughs, creeks, and bogs. This involved the creation of a system of buffers around such historic and existing water bodies with a distance that was determined by a safety factor of their ability to flood adjacent land. The area between the buffers made up the proposed buildable land.

The next step in determining the pattern of the Finger Levee development was to create a minimum buffer distance between the pier developments on side of the levee roadways. Buffer distance between Finger Levee developments was determined based

Figure 8 Finger Levee Development Pattern – Wetland Habitat Buffer (Union City)

on criteria for tidal wetland health and research on bird nesting habitat requirements. The Finger Levee roadways were designed to be parallel to tidal action or bridge over tidal input into interstitial wetlands, allowing for an unobstructed connection between wetlands and bay influence. Ample space was given with a development buffer around sloughs to allow wetland growth and sediment accretion.

A minimum of 2000 feet was used as the spacing between Finger Levee developments for bird nesting habitat. This follows research on minimum requirements for a buffer around bird nesting in wetlands. The buffer distance references a study that recorded the distance at which various birds were startled and flew away, thereby creating stress and leaving their nest, resulting in less offspring successfully raised.[10] While each bird type had different requirements for buffer distance, the median distance according to Ruddock and Whitfield was between 500 and 1000 feet.

The last step in laying out the Finger Levee roadways is the connection to existing infrastructure. Similar to an appendage that is being reattached, bone, arteries, and ligaments must be connected to the body. In this case, existing major roadways were identified as a connection "node" to the Finger Levee development, serving as a point of contact for transportation, energy, waste, and water infrastructure between the new and old urban landscapes.

[10] Ruddock and Whitfield 2007

Figure 9 Physical Model – Close-up (left to right) San Francisco, San Mateo, Union City

The Finger Levee operates as a centralized road infrastructure, connecting back to the existing urban fabric. All new infrastructures would be raised with the levee and pier development and protected from inundation and future flooding. Sustainable infrastructural initiatives in the urban design include transit-oriented development (TOD), localized water and waste treatment and reuse facilities, and net-zero energy use with co-generation and other clean energy sources.

As a centralized road network, the Finger Levee acts as a natural TOD, combining efficient and accessible public transit. The design of the Finger Levee roadway is similar to that of a boulevard. A public transportation light rail or BRT runs through the center lane with vehicular lanes on either side. A separated bicycle lane runs throughout the levee roadways, with generous tree-lined sidewalks on either side giving ample space for outdoor seating, landscaping, and public events.

Localizing water and waste treatment facilities to create a sustainable development model for the Bay Area. Recent water and energy shortages in California have demonstrated the need to be more efficient with resources that will only become scarcer in the coming decades. The current drought has shown the unpredictability of water reserves in the arid western United States. Since most of the wastewater treatment facilities around the Bay are located along the waterfront, the majority is at risk of damage from sea-level rise. This will require substantial retrofitting or complete rethinking and redesign.

I propose to create much smaller, localized treatment facilities that use freshwater wetland filtration ponds and utilize waste material co-generation energy plants that double as a tidal wetland sediment source. Water can then be recycled back into circulation through adjacent water purification plants. To create energy independence will require a combination of co-generation from waste, PV panels on rooftops, and wind generation where appropriate.

Material to build the Finger Levee will be sourced from rubble in the staged retreat of the existing development, including asphalt and concrete from roads, parking areas, and building structures. Since the Finger Levee will account for less than 10 percent of the previous urban footprint, the rubble extracted from the use of eminent domain

Figure 10 Physical Model (left to right) San Francisco, San Mateo, Union City

will allow for a height well above sea-level rise projections. I propose that all future development be located at a minimum height of 10-12 feet above present high tide levels.

Pier Development

All buildings in the resilient redevelopment plan will be constructed on piers adjacent to the levee roadway. The rationale for this strategy is two fold; there is not enough rubble from existing development to create the additional levee foundations under buildings as well as roadways and the pier construction typology has less impact than fill on the tidelands environment. Furthermore, water can flow unabated between pier piling to wetlands on either side of pier block development.

I propose that urban blocks be constructed on raised piers attached to the Finger Levee roadway. Continuous pier development would line the sides of the levee roadway, while larger pier blocks can be built perpendicular to the levee road. The pier development that runs parallel to the levee should contain mostly commercial business on the ground level, with office and residential above. The property along the Finger Levee roadway has both visibility and ease of access as a transit-oriented development (TOD). Its relationship with the sidewalk and tideland promenade presents an opportunity for the design of public space that relates consumer-focused business.

The pier development on blocks oriented perpendicular to the Finger Levee roadway would be designed to accommodate the majority of the housing. The tideland habitat buffer shall determine the sizing and spacing of blocks, the density required in each site-specific development, and the space required for freshwater wetlands to recycle wastewater from adjacent buildings.

Conclusion

The task of responding to sea-level rise in the Bay Area can seem a daunting proposal. I suggest that we first being by reframing the issue of sea-level rise as an opportunity to design better cities rather than a problem to be fixed. Perhaps, with this approach we can look beyond the current toolbox of planning, policy, and engineering that has lead to extensive development on bay fill, vulnerable to projected tidal inundation and flooding. Instead, we should be exploring new approaches to design our built environment along the Bay Shore, which strive for a mutually beneficial relationship with the tidal ecosystem, sustainable development practices, and community adaptation.

My design research presents a framework for which to analyze past, present, and future conditions of sites at risk of sea-level rise around the San Francisco Bay for the purpose of creating a managed retreat and redevelopment strategy. This strategy aims to enable a wetland migration with the rising sea level, while introducing a resilient new development and infrastructure that is uniquely defined by the region's ecological characteristics. While I focused on three sites around the Bay, this design proposal is designed as a regional plan for all cities located on the perimeter of the San Francisco Bay.

As a speculative design proposal, my goal is to create a constructive dialog. By envisioning an alternative future and concretizing theory, we can begin to understand the potential implications of policy and design decisions. My work presents a model for an adaptive and resilient response to sea-level rise. However, I believe that an issue this complex will only be solved through interdisciplinary collaboration and community participation.

Acknowledgements

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