

Green Building Construction Guidelines Using Game Theory

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Abstract—The study of decision possibility of building owner and constructor using game theory showed that in case of one-time playing game, both of players would choose to construct normal building because of its prominent strategy as it provided more result than green building construction, so there was no co-operation between both players

The results found that

Case 1: Fiscal policy was not required to interfere. Building owner would construct green building or repaired to be a green building when supplement income from green building and discount of maintenance were more than result that supplement expense from green building construction. Constructor would construct green building when supplement income construction was more than supplement material cost.

Case 2: government section enforced a measure to interfere building owner when supplement expense from green building construction was higher than sum amount of supplement rental cost and maintenance discount

Case 3: The government section enforced a fiscal measure to interfere constructor when supplement cost from construction was higher than constructor supplement income.

This game relied on cooperation from both sides. It would be the highest result. If both did not co-operate and only focused own self benefit, they could not construct a green building. Owner and constructor chose normal building to be a main strategy because there was more benefit. If we wanted to then to choose green building construction, we should add returns to owner and constructor more than supplement and material cost from green building construction. To analyze game model found that when we processed under freedom market ideal, it will not bring green building construction. The government is responsible for using tools for marketing to construct green building following it needed. Tools which will be useful are economic tool including tax, social tool including education and technical tools including law, regulations and examination which always being improved.

Index Terms—green building, decision-making process, game theory

I. INTRODUCTION

What is the Green Building? Why the Green Building? Why the businessmen, the project owners and the occupants are interested in and prioritize it? Green Building is not just a building with green trees around the area or the building painted with green, but it should be

the ones that reflect the heat, the material used for rooftop should be sunlight rays highly reflective.

According to the purpose of the Green Building, it should be environment-friendly, reduce energy usage and enhance occupants' health and living quality when using it. Therefore, it is found that currently the project owners, the building owners, public and private organizations are paying more attention to management in terms of environment and energy reduction in order to develop the country sustainably. Therefore, the engineer and architectures need to adapt according to trend of customers' demand regarding Green Building such as applying technology with the building and always learn more in relation to design and construction of the Green Building. The Green Building does not always require high technology. Some of the technology used are automatic system, applying treatment on project waste water and reusing it within the project, recycling solid wastes from the project by differentiating types of wastes, arranging differentiating areas for users and it should focus on sustainable development, reducing natural resources usage and production and reducing transportation of material and raw material. However, it depends on the construction budget of each building and it does not need to consider every single criterion in order to consider if the building is a Green Building or not [1] (World Green Building Council, 2017).

Currently, the world is paying attention to Green Building and each country has developed its own standard to be used to evaluate Green Building. For example, in the U.S., they have United States Green Building Council-USGBC which develops Leadership in Energy and Environmental design (LEED), in England, they have Green Building standard using an evaluating system called Building Research Establishment Environmental Assessment (BREEAM), in Japan, they use Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), in Australia, they use Green Star, In Canada, they use Building Environment Performance (BEPAC) and in Thailand, we use Thai's Rating of Energy and Environmental Sustainability as an evaluating standard of sustainability of energy and environment. Even with many evaluating standards globally, LEED is the most popular one used as basis regarding Green Building standard adaption in each country. Thailand also developed its standard from LEED by adapting or adding some standards in compliance with

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the environment, geography and weather. Some countries, are using LEED as the standard of their countries without adapting such as India which is called LEED-India [2] (United States Green Building Council, 2012).

The reason LEED is popular and succeed more than any other standard is because it differentiate types of buildings which is in compliance with new buildings such as LEED-NC (New Construction) which is used for new construction such as home, office, government organization, hotel and factory. LEED for Home is used for homes or residential building, LEED for School is used for schools, LEED for Retail is used for shops, LEED for Healthcare is used for health centers or hospitals, LEED-CI (Commercial Interior) is used for buildings which need interior change, LEED for Neighborhood Development is use to develop the community in the same area to build a unite and sustainable community, LEED-CS (Core and Shell) is used to certify the body and the structure of the building and LEED-EB &OM (Existing building & Operation and Maintenance) is used with the buildings which are open for a period of time. [3] (Jerry Yudelson, 2008)

II. THE THAILAND CASE

In the future, evaluation standard in terms of sustainability of energy and environment of Thai's Green Buildings, a corporation by Association of Siamese Architects under Royal Patronage and Engineering Institute of Thailand under Royal Patronage, will be used by designers and constructors as it might turn into regulation or be a part of Design Codes as both institutes are encouraging it. The projects which need to acquire Green Building of which were certified in compliance with international standard of other countries such as LEED or BREEAM, will also need to be certified as Green Building in Thailand in order to ensure that such building were considered suitable regarding design and construction which are in compliance with the environment. Geography, weather and society condition of Thailand. Currently, many new projects focus on Green Building status from the process of design to the process of construction as it will benefit building users, owners and occupants including the environment, plants and animals in the project and the adjacent areas. Design and construction of Green Building is the kind of design that consider about the environment and natural resources. It uses low energy. The minimum energy used in the building should be the same level as similar buildings. It should be compared with the old designed and constructed building in order to see ratio of energy usage. Moreover, it should consider air contamination in order to make sure that the occupants get fresh air, unpolluted and not release any toxic to destroy the condition of the building users and occupants

The reason the project owners are more interested in Green Building is because it benefits a lot. For example, the building occupants or users have been life quality as the internal environment condition is filled with fresh air and unpolluted and toxic gas, such as Carbon Monoxide

in various parts of the building which are used by a lot of users such as meeting room, is checked. In addition to gas measure, fresh air is brought into the building occasionally. Smoking in the entrance or near the windows is prohibited or separated smoking rooms will be provided with different pressure control. Material used in the building does not consist of volatile matter or have strong smell due to material selection and toxic-producing room separation such as room with copy machines and cleaning equipment storage. All this things enhance building occupants or users' quality of life. They will get sick less, reducing sick leaves and work efficiently. This benefits both the organization and the staff.

Green Building will benefit the building owners in 3 aspects; 1. Reduce cost in terms of maintenance, 2. Earning more rentals and 3. Selling the building at higher price. Even though it might need a little bit more expense regarding construction, it still benefit construction business and related labors.

TABLE I. BENEFIT CONSTRUCTION BUSINESS

Subject	U.S.	Thailand
1. Additional income of Green Building owners	4-17%	42.9%
2. Additional expense for construction	3.10%	17.6%
3. Benefit regarding less energy used	1,128 Million USD	59%
4. Additional cost regarding material and labours	N/A	N/A

Thai Green Building Institute has adopted standard to evaluate sustainability of Thai energy and environment for construction and new project development which is a CSR regarding environment. It can be concluded partly that it is related to CSR. TREES (Thai's Rating of Energy and Environmental Sustainability) can be divided into 8 groups as follows;

There is prohibition for Thai's Rating of Energy and Environmental Sustainability. The building should meet following qualifications;

1. A legal building
2. A permanent building with no intention to move to another place
3. Have a suitable space, the border must be clear in order to perform activities of the projects. If such project is a group of buildings such as industrial estate or university which is without clear border, the area must be suitably allocated during the evaluation.
4. Minimum internal space of 100 m2. If the building is too small, it will effect fundamental intention of this evaluation.
5. At least a building user to let the building be designed for users according to the intention of the standard

6. Minimum internal space must not be less than 5% of the land of the project in order to avoid inequality regarding project development on a huge land.

7. This Green Building evaluation standard is not designed directly for homes or living places with less than 2 floors.

To evaluate the value of the ecosystem of the business whether most business value do not focus on relation between completeness and change of ecosystem and how the business performance relies on and affects the ecosystem of business. Therefore, value of the environment cannot be evaluated [4] (Pinyada, 2012). Corporate Ecosystem Valuation (CEV) and Ecosystem Services Review (ESR) will help to connect relation between ecosystem and business performance by evaluating reliance and effect of the organization towards the ecosystem and it is related to the change of ecosystem which affect business performance.

Corporate Ecosystem Valuation (CEV) is to evaluate value of change of the ecosystem and value of the service of the ecosystem in order to improve decision of the business sectors in terms of risk management and develop business opportunities which are about to occur regarding service of the ecosystem. The Corporate Ecosystem Valuation will help the business organization to be able to evaluate level of responsibilities and performance in terms of environment in order to evaluate value of business performance more concretely which will further lead to business performance improvement and profit increase sustainably to the organization and related ecosystem.

[5] Pushkar, S; Becker, R; Katz, A. T, (2005) Ecosystem Services Review (ESR) is the process of considering benefit the ecosystem service including material needed for business performance. It can be separated into 4 types as follows;

1. Provisioning Services which are production material services such as food, forest, plant and animals.

2. Regulating Services which are phenomenal control and natural process of the ecosystem such as climate control, waste filtration, bank and shore prevention and flood prevention.

3. Cultural Services which are abstract benefit related to social and cultural values such as festival, tourism, aesthetic and entertainment.

4. Supporting Services which are natural process that supports other existing services such as nutrients of the primary production, photosynthesis and habitats of young animals. The Green Building can be evaluated by using following methods;

A. Cost Approach to Value

Main principle of the Cost Approach to Value is that value of an object = replacing by another comparable object. It can be done by estimating cost of the building construction to be replaced by the present price, deducting the depreciation (if any) and adding the market price of the land and you will get the value of such property. In order to construct or improve the Green Building to meet the appropriate standards, it requires additional cost to demolish the old system and to add the

new one. The price of the market is something to be considered.

B. Market Comparison Approach

Market Comparison Approach is the best and the clearest method. The value of our property will be equal to the price of the comparable property that other people can sell. The analysis guideline is to start by seeking for the comparable property that is sold or asking to see if there is any similar or different characteristic. After enough data is acquired, the next thing to do is to verify in order to select to true comparable property to analyse by stipulating comparing conditions of both the evaluated property and the comparable property such as quality of the building, size of the land-building and them conclude for the appropriate value by analysing and comparing.

In case of the Green Building, we need initially consider how much the sale price or the rental price of the Green Building is higher than other ordinary ones, how the difference or the Premium if this Green Building is comparing to the improvement cost. Is it worth in terms of finance, fame and others?

4.3 The process to transfer income into value that is present value = total net income to be earned in the future until the end. The property is value because it brings income. The property that would make a lot of money is more likely to have higher value (better location-quality). The process is to estimate the income of the property from every sources by directly considering market comparison and actual income of the estimated property and deducting the chance of not benefiting or bad debt according to the fact, comparison or market trend. Then you will have actual income. After that, deduct by expenses such as administration, tax, insurance, management and maintenance. Then you will have net income. After that, apply the formula $V = I / R$ whereas V is the value of the property, I is the net income and R and the benefit rate.

In terms of Green Building Valuation, it can be done by considering how the market rental price, benefit rate, possession rate and administration expense affect added value of the Green Building. If the result is good, how is the ordinary building different to the Green Building? If they are significantly different, it means the value of the Green Building is as invested.

What need to be carefully considered about is the benefit in terms of business fame or Goodwill of the Green Building other than the increased income according to the development or improvement of this Green Building. Being Market Niche with rich and good look renters to enhance the look and as there are limited number of Green Buildings, low supply, the rent price should be high accordingly.

Thai example

The Bangkok Residence Project is the project which was designed, constructed and quality controlled to be Green Building according to the Thai's Rating of Energy and Environmental Sustainability – New Construction (TREES-NC) of Thai Green Building Institute (TGBI) with characteristic according to the building valuation as follows;

Section 1: Building Management.

The building is prepared to be Green Building (BM P1) and to present to the society (BM 1) by making manual and arrange training in terms of usage and maintenance (BM 2) including valuating while designing, constructing and once finishing (BM 3)

Section 2: Site & Landscape

- Located on developed area
- Support and reduce energy usage by reducing personal car usage
- Green environment with open area for 20% of the whole area
- Drainage water system was designed in compliance with water flow on the surface in order to reduce flood problem

The project is located on the heart of Bangkok, Research Center Alley, which is development on developed land (SL1). It can avoid inappropriate land for the building (SL P1), reduce effect to natural area (SL P2) according to regulations of TREES-NC. In addition, it also reduce personal car usage (SL 2) as it is within 500 meters away from bus stop and there is also bicycle park with not less than 5% of the building users and bath room of not less than 0.05% of the permanent staff within 80 meters away from the entrance.

The project has developed its plan to be sustainable (SL 3) with open ecological area regarding the 2nd option that is 20% of the area including rooftop garden area. The open ecological area should have at least 40% green area.

Section 3: Water conservation

Reduce water usage with water saving sanitary ware both for the staff and customers

Section 4: Energy & Atmosphere

- The efficiency in terms of energy reduction is 30% better than the standard building
- Aerated concrete wall reduce heat 5 times better
- Using LED light bulb for the whole building reduces electricity usage 30% better
- Using VRV for air conditioning system is more efficient and contain no refrigerant that harm the atmosphere, reduce occurrence of Legionella

The project has quality assurance (EA P1) according to the regulation. It has plan for testing and system adapting by the third party. The project has low energy usage (EA P2) with the energy efficiency (EA1) according to the 1st option which is whole building simulation. It saves 30% more than the standard building. Besides, its refrigerant does not harm the atmosphere (EA4)

Section 5: Material & Resources

- 10-20% of material used is local or domestic with green label which has low effect to the environment.

The project uses local or domestic material (MR5) for 10-20% and it has low effect to the environment (MR6).

Section 6: Indoor Environmental Quality

- Install air import system in control the quality of the air in the building
- Control air pollution from outside the building
- Smoke-free building, arrange smoking zone outside the building

- Control the light in the building by separating the circuit every 250 meters

The project meets the standard in terms of air condition in the building (IE P1) and light control (IE P2) and it also reduce affect from pollution (IE 1) by

- Not install air tube at the area with heat or air pollution
- Control copy machine room, chemical contaminating room
- Control pollution sources from outside the building
- Smoke-free building

The project control the light in the building by separating the circuit every 250 meters (IE 3), is able to use natural light inside the building (IE 4) and has comfortable condition 80% (IE 5)

Section 7: Environmental Protection

- Manage construction waste, reduce waste which affect the environment
- Use non-environmental effect chemical to extinguish the fire
- Use not more than 15% light reflective mirrors

The project meets the standard in terms of pollution from construction (EP P1) and waste management (EP P2) by separating construction waste. Besides, it used low effect chemical to extinguish the fire, it use not more than 15% light reflective mirrors (EP 3) and as it does not used air condition system with cooling tower, it meets the standard in terms of deacease control regarding the building (EP 4) and it installed electronic measure to the water drainage system which reflects intention to use (EP 5)

Section 8: Green Innovation. The project pays attention to be developed into Green Building by hiring TREES-A as consultant.

Related research

[6] Nattapong Khetkratok (2013) studied energy and environment management of Bannasarn building 2, Bannasarn center and educational media, Suranaree University of Technology. Such building has inappropriate energy management and does not save energy. The purpose of this research is to study Bannasarn Building 2 by considering energy saving, worthiness and compliance to the Green Building standard of Office of Pollution, Natural and environmental resources in 7 sections; management in order to be Green Building, plan and architecture, water usage, energy, environment in the building and innovation in acknowledge such management information which will lead to suggestions for improvement.

[7] Wasurat Chainuwat (2016) studied motivations and barriers of green building development in Thailand collecting data by expert interview and 101 questionnaires from people who used to design green building including project owners, inspectors, consultants of green building and experienced experts of green building certified by Green Building Institute of Thailand. It was found that important motivation to construct green building in Thailand in present day was creating a good image to organization and developing building to users

having a good quality. The barrier of green building development was from project developers. Most of developers concerned cost which was very low and did not focus on it. They did not aim for public utilities much while they used the building. Questionnaire answerers said that if they had a support from the government for example to deduct tax, to increase in floor area ratio would be a motivation to project developers. Creating right understandings will create awareness in value and importance of green building in Thailand. The research which compares cost, building life cycle cost showed public utility cost which was lower.

III. MODEL AND METHODOLOGICAL CONSIDERATIONS

Game theory was adapted widely to analyze competition behavior and it described why rivals chose different tactics. It was a reasonable tool to considerate economic result and competitor interaction [8] (Nagarajan and Sasic, 2008). Moreover, game theory was a mathematic theory showing reaction to decided situation which was used for model. Strategic game assumed that players chose a strategy making themselves to gain the highest result, so players would select the prominent strategy without no consideration to other players choice. For a game which had 2 players and 2 choices, each player would have 2 choices to decide to chose or not. Both of players might decide to choose same strategy or combination. It would be benefit of selecting strategy correctly.

We assumed that there was a result table from green building (Table I). It set each player having results as below [9] (Wen, Q. & Fang, H., 2012)

TABLE II. PREVIOUS RESULTS FROM GAME THEORY'S GREEN BUILDING CONSTRUCTION

Constructors		
Strategy	Green building	Normal building
Green building	$(U_1 + U_2 - A_1 - A_2 - A_3 + A_4, A_1 + A_2 - C_1 - C_2)$	$(U_1 - A_1 - A_2 - A_3, A_1 + A_2 - C_1)$
Normal building	$(U_1 + U_2 - A_1 - A_3 + A_4, A_1 - C_1 - C_2)$	$(U_1 - A_1 - A_3, A_1 - C_1)$

Building owners

Set U_1 as a normal income of owner

Set U_2 as a supplement income of green building comparing with normal building

Set A_1 as a cost for normal building construction/ income of constructor

Set A_2 as a supplement cost for green building construction/ supplement income of constructor

Set A_3 as a maintenance of normal building cost

Set A_4 as a discount of maintenance of green building cost/ energy saving value

Set C_1 as a cost of normal building construction material

Set C_2 as a supplement cost of green building construction material

It could be explained that case 1. (high left table) owners wanted green building, constructors chose green

building to construct. The result was that green building which owners got result of $U_1 + U_2 - A_1 - A_2 - A_3 + A_4$. And constructors got result of $A_1 + A_2 - C_1 - C_2$. When $U_2 > A_2 > C_2$ would make owner and constructor got the highest benefit. Case 2 (high right table) owner wanted green building but constructors chose normal building to construct. The result was that normal building which owners got result of $U_1 - A_1 - A_2 - A_3$ and constructors got result $A_1 + A_2 - C_1$.

Case 3. (low left table) owner wanted normal building but constructors chose green building to construct. The result was that green building which owners got result of $U_1 + U_2 - A_1 - A_3 + A_4$ and constructors got result of $A_1 - C_1 - C_2$

Case 4. (low right table) owner and constructors chose normal building to construct. The result was that normal building which owners got result of $U_1 - A_1 - A_3$ and constructors got result of $A_1 - C_1$

IV. RESULT

The study of decision possibility of building owner and constructor using game theory showed that in case of one-time playing game, both of players would choose to construct normal building because normal building construction strategy was a prominent strategy. The reason was it provided more result than green building construction, so there was no co-operation between both players [10] (Safari, H. & Soufi, M., 2014)

Following Table I, game model showed that under freedom market, both players chose normal building because owner did not want to pay additional payment for green building construction (A_2). It was same as constructor who did not want to increase material cost (C_2).

Case 1: Fiscal policy was not required to interfere.

The result was net return of normal building owner (N_1) = $U_1 - A_1 - A_3$

The result was net return of green building owner (N_2) = $U_1 + U_2 - A_1 - A_2 - A_3 + A_4$

Owner would choose to construct green building when $N_2 > N_1$

$$U_1 + U_2 - A_1 - A_2 - A_3 + A_4 > U_1 - A_1 - A_3$$

$$U_2 - A_2 + A_4 > 0$$

$$U_2 + A_4 > A_2$$

It meant that building owner would construct green building or repaired to be a green building when supplement income from green building and discount of maintenance were more result than supplement expense from green building construction.

The result was net return of normal building constructor (N_3) = $A_1 - C_1$

The result was net return of green building constructor (N_4) = $A_1 + A_2 - C_1 - C_2$

Constructor would choose to construct green building when $N_4 > N_3$

$$A_1 + A_2 - C_1 - C_2 > A_1 - C_1$$

$$A_2 - C_2 > 0$$

$$A_2 > C_2$$

It meant that constructor would construct green building when supplement income was more than supplement material cost.

The result was a return to government without green building = 0

The result was a return to government with green building = A4

Case 2: government section enforced a measure to interfere building owner when supplement expense from green building construction was higher than sum total amount of supplement rental cost and maintenance discount

Equation could be written $A2 > U2 + A4$

Solutions

1. To decrease or omit tax to green building owners.
2. To support lessee chose green building by increase a green building rental deduction of income tax
3. If it happened because of non-experienced constructor, the government should control a work permit for green building constructor strictly.

Case 3: The government section enforced a fiscal measure to interfere constructor when supplement cost from construction was higher than constructor supplement income.

Equation could be written $C2 > A2$

Solutions

1. To deduct or omit income tax of green building constructors.
2. Omitting VAT from green building construction material to deduct cost of construction.

This game relied on cooperation from both sides to decide choosing green building. It would be the highest result. If both did not co-operate and had a behaviour which found only own self benefit, they could not construct a green building. Owner chose normal building to be a main strategy because there was more benefit. ($U1 + U2 - A1 - A3 + A4 > U1 + U2 - A1 - A2 - A3 + A4$ and $U1 - A1 - A3 > U1 - A1 - A2 - A3$). The constructor would choose normal building to be main strategy because it was more benefit ($A1 + A2 - C1 > A1 + A2 - C1 - C2$ and $A1 - C1 > A1 - C1 - C2$)

If we wanted to change owner and constructor to decide green building construction, we should add returns to owner (B) more that supplement cost from green building construction (A2). And we should add return to constructor (D) more that material cost from green building construction (C2). It showed in Table II that

TABLE III. A NEW RESULT FROM GREEN BUILDING CONSTRUCTION FROM GAME THEORY

Constructor		
Strategy	Green building	Normal building
Green building	$(U_1 + U_2 + B - A_1 - A_2 - A_3 + A_4, A_1 + A_2 + D - C_1 - C_2)$	$(U_1 + B - A_1 - A_2 - A_3, A_1 + A_2 - C_1)$
Normal building	$(U_1 + U_2 - A_1 - A_3 + A_4, A_1 + D - C_1 - C_2)$	$(U_1 - A_1 - A_3, A_1 - C_1)$
Owner		

To analyse game model found that supplement income from rental amount of green building did not be an

important factor to decide to construct green building. The important thing was a value from supplement expense, trust creating to constructor and supplement result which was more than expense. In this part, the government should take care of it.

To analyse constructor using game model found that supplement income of constructor was not a important factor to decide to construct green building. The main factor was supplement material cost, trust and co-operation from building owner and supplement result from the government which was more than supplement cost. [11] (Patti, A.L., 2006)

We could say that under condition of game decision would consider possibility of other players. Each player would choose green building strategy when return of own self from choosing green building construction had value more that result from normal building construction. There were factors to consider including supplement cost of constructor, supplement expense of owner.

V. EFFECTIVENESS

The study of stimulate to construct green building, the researcher found that to stimulate construction green building included relationship between related people-organization to investment-development to have green building. We could separate into main topics to make them clearer as below.

1. Economic aspect

1.1 To deduct or omit income tax to (B value) related people including green building owner, lessee to create result of players from green building construction having value more than normal building construction. It could be written in equation that $U1 + U2 + B - A1 - A2 - A3 + A4$ which would be more return comparing to normal building ($U1 - A1 - A3$)

1.2 Omitting VAT for material which would be used for green building construction deducted cost of green building construction to constructor or to deduct or omitting income tax to constructor which would be stimulation to him/her to use saving ecology material. It could be written in equation that the return of constructor after the measure to support was $A1 + A2 + D - C1 - C2$. It must be more than return from normal building construction $A1 - C1$. So constructor would decide to construct green building.

1.3 The government, education department and private section cooperated to create understanding to building owner that green building could deduct resource cost, worth to invest in long term and cost would be reduce by energy use deduction and saving maintenance cost.

1.4 the government must support people to recognize the importance of resource saving, effectiveness of energy saving building and benefit from energy saving. To create understanding to people would be a indirect effect to constructor and owner who were interested to adapt themselves to provide people requirement.

2. Technical

2.1 To enforce law to determine a special high building which had area over 10,000 square meter must adjust to be green building

2.2 To design label of material for construction that it was a friendly to environment.

2.3 To decrease public utility to green building

3. To develop examination of green building in the past.

3.1 Applying LED system to control a special hugh building

3.2 To support people who related to examination system of green building

VI. CONCLUSION

Green building construction or to adjust normal building to be green building was a marketing mechanism. There were buyers and sellers. Buyers were building owners and sellers were constructors. If green building construction mentioned before created benefit to both sides, the green building construction would be happened. If there was at least a side who got lower return from

green building construction, green building construction or to adjust could not be happened.

To analyse returns to each section showed that basic Coniston which affected decision might not have a mechanism from government to adjust a decision. If we considered by related people decision, it found that every part denied green building construction. So, the government should enforce a measure to support return to related people.

The measure which government could enforce was tax measure including income tax and VAT. To deduct or omitting to green building owner would make more return to owners. They might decide to create green building. Omitting VAT of construction material made more income of green building constructors than normal building construction. The measure which made understanding to people was a part of ideal support to stimulate green building construction.

APPENDIX A APPENDIX TITLE

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REFERENCES

- [1] World Green Building Council. Building a Better Future Annual Report 2016/17. World Green Building Council is a not-for-profit organisation registered in the United States of America, 2017.
- [2] United States Green Building Council. The Business Case for Green Building: *An International Journal*, 2012; 11(4), 221–222.
- [3] J. Yudelson, *The Green Building Revolution*; 2008.
- [4] P. Athirattanachai, Effects of Self Learning Method on Academic Achievement on Accounting Partnership of Vocational Education Students Level II, Pattani. Princess of Naradhiwas University Journor, 2012.
- [5] S. Pushkar, R. Becker, A. Katz, *A Methodology for Design of Environmentally Optimal Buildings by Variable Grouping*, Building and Environment; 2005.
- [6] N. Khetkratok. *Guideline to building improvement according to Green Building standard: Study case – Bannasarn center and educational media, Suranaree University of Technology*, Master of Engineer, Energy Management Engineer, 2013.

- [7] W. Chainuwat, *Motivations and Obstacle of Green Building Development in Thailand*, 2016.
- [8] M. Nagarajan, G. Sosis, *Game-theoretic Analysis of Cooperation among Supply Chain Agents*: Review and ex; 2008.
- [9] Q. Wen, and H. Fang, "Analysis on the dynamic game model of SMEs group loan," *Advances in Applied Economics and Finance (AAEF)*, vol. 2, no. 4, pp. 437- 441, 2012.
- [10] H. Safari, and M. Soufi, "A game theory approach for solving the knowledge sharing problem in supply chain," *International Journal of Applied Operational Research*, vol. 4, no. 3, pp. 13-24, 2014.
- [11] A. L. Patti, "Economic clusters and the supply chain: A case study," *Supply Chain Management: An International Journal*, vol. 11, no. 3, pp. 266–270, 2008.



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Soponronnarit, S., 2005, "Investigations on Head-rice Yield and Operating Time in the Fluidised-bed Drying Process: Experiment and Simulation", *Journal of Stored Products Research*, Vol. 41, No. 4, pp. 387-400; Poomsa-ad, N., Soponronnarit, S., Prachayawarakorn, S., and Terdyothin, A., 2002, "Effect of Tempering on Subsequent Drying of Paddy using Fluidisation Technique", *Drying Technology*, Vol. 20, No. 1, pp. 195-210; Achariyaviriya, S., Soponronnarit, S., and Terdyothin, A., 2000, "Mathematical Model Development and Simulation of Heat Pump Fruit Dryer", *Drying Technology*, Vol. 18, No. 1&2, pp. 479-491. (Technical Note); Achariyaviriya, S., Soponronnarit, S., and Terdyothin, A., 2000, "Diffusion Models of Papaya and Mango Glace' Drying", *Drying Technology*, Vol. 18, No. 7, pp. 1605-1615. (Technical Note); Ekasilp, W., Soponronnarit S. and Terdyothin, A., 1999, "Sizing of rice Mill's Cogeneration System", *ASEAN Journal on Science & Technology for Development*, Vol. 16, No. 1, June, pp. 39-57.

He also attend some international conference: Auttawaitkul, Y., Monyakul, V., and Terdyothin, A., 2007, "A New Model of Variable Air Volume Diffuser for Thermal Comfort Based on Fuzzy Logic Control", *The 4th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON 2007)*, May 9-12, Mae Fah Luang University, Chiang Rai, Thailand, pp. 213-216; Laipradit, P., Tiansuwan, J., Terdyothin, A., Kiatsiriroat, T., and Aye, L., 2004, "Simulation of Heat Pump Water Heater using Co₂ as Refrigerant", *The 15th International Symposium on Transport Phenomena (ISTP-15)*, May 9-13, Shangri-La Hotel, Bangkok, Thailand, pp. 197-203; Poomsa-ad, N., Soponronnarit, S., Terdyothin, A., and Prachayawarakorn, S., 2001, "Head Rice Yield after Drying by Fluidization Technique and Tempering", *The 2nd Asian-Oceania Drying Conference*, August 20-22, Buta Feringhi, Pulau Pinang, Malaysia, pp. 717-737; Poomsa-ad, N., Soponronnarit, S., and Terdyothin, A., 2000, "Diffusion Models of Paddy Drying by Fluidization Technique", *CD-ROM The XIV memorial CIGR World Congress 2000*, November 28 - December 1, Tsukuba, Japan, paper No. R6101; Achariyaviriya, S., Soponronnarit, S., and Terdyothin, A., 1999, "Diffusion Model of Papaya Glace Drying," *Proceeding of the First Asian-Australian Drying Conference (ADC'99)* Bali, Indonesia, October 24-27, pp. 196-203; Hirunlabh, J., Wangsupadilong, P., Terdyothin, A., Khedari, J., and Pairintra, P., 1997, "Evaluation of Potential of Dendrothermal Power Plant in Thailand", *Proceeding of Second ASEAN Renewable Energy Conference*, Phuket, Thailand, November 5-9, pp. 861-874.



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Evaluation Project of Energy Conservation in Buildings by Labeling (Plan & Policy Analyst)

High Quality Material and Energy-conserving Machinery Promotion Project (Labeling) Phase 2 (products included were gas burner variable speed drives or VSD, energy-saving glass and glasswool fiberglass) (Project Secretary)

2008: High Quality Material and Energy-conserving Machinery Promotion Project (Labeling) Phase 1 (for gas burners and variable Speed Drives or VSD) (Project secretary)

High-quality Vacuum Cleaner Draft Legislation Project (Co-ordinator)

Hydrogen Development Project for NGV Cars (Project Manager)

Information Technology for Energy Conservation and Alternative Energy Project (or Management of Raw Agricultural Products for conservation) (Computer Technical Officer)

Community Energy Promotion Project (for 7 communities) (Computer Technical Officer)

2007:

Research for Standardization of Car Energy Project (Project coordinator)

Community Energy Promotion Project (for 6 communities) (Plan & Policy Analyst)

Revision of Ministry Ordinance on High Quality Material and Energy-conserving Machinery Promotion Project (covering 11 equipments, such as air-conditioner, refrigerator, water heater, electric fan, rice cooker, gas burner, luminaries, magnetic ballast, electronic ballast, fluorescent bulb)

(Project co-coordinator)

Project for employment of consultant in high-quality and energy-saving instruments

(Project co-coordinator)

Community Energy Promotion Project (for 24 communities as pilot project) (Plan & Policy Analyst)

Building and Improving Provincial Energy Plan Project (Plan & Policy Analyst)