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A COMPARATIVE STUDY OF THE ECONOMIC AND ENVIRONMENTAL BENEFITS IN THE USE OF GREEN BUILDING TECHNOLOGY AND TRADITIONAL BUILDING CONSTRUCTION

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Abstract

This study is a comparative study of methods used in the construction sector. More specifically, it examines the economics and environmental benefits in the use of green building technology and traditional building construction. The first section gives a detailed discussion of the concept, technique and system implemented by both methods. Second section highlights on the empirical literature review done on green building benefits. The third section will present the impact on the cost elements of each method includes the rental property income, sales price, operating cost, environment cost, public infrastructure costs, financing costs, building costs, development costs and design costs.

Keywords: Green Building, Traditional Building, Economic Benefits, Environmental Benefits, Sustainable Development

1. Introduction

1.1 Construction Industry

Evolution of building construction is depending on the technology developing by the expertise along the centuries. Material, method, cost, population and environment are the most important factors that lead on revolution of construction industry. New era will drive the demand on new types of high-performance buildings which are supported by rational design method that reflect to cost of implementation. *(J.Straube,2007)*. The awareness of professionals and expertise due to environmental challenges such as global warming, pollution, energy efficiency may lead to develop new approach in construction of building in the world. Therefore, the revolution in construction industry nowadays is more towards green building construction in order to save the earth that exposed to environmental problems.

1.2 Traditional Typical Building Construction

The term 'traditional build' is most often used to describe a structure where the internal load bearing leaf of the walling is of masonry construction and tied with stainless steel ties to an outer leaf of either block or brick. Although the modern methods of construction are taking building practices into the future, traditional brick and block methods still remain one of the most widely used build types in the United Kingdom and Ireland. The traditional typical building is normally used traditional method of construction such as conventional formwork, reinforced concrete structure and using conventional system of mechanical and electrical system.

1.3 Green Building

Definition: According to the Associated General Contractors of America, green building is a sustainably designed, high performance buildings which is balanced through their sitting, orientation, design, construction, and operation are highly energy efficient, have lower operating costs, are better for the environment in broad and specific terms, and promote whole health for their users and occupants with measurable results.

1.4 Green Building Index

The Green Building Index (GBI) in Malaysia is an environmental rating system for buildings developed by Malaysian Institute of Architect and the Association of Consulting Engineers Malaysia (ACEM). The Green Building Index is a comprehensive rating system for evaluating the environmental design and performance of buildings based on the six (6) main criteria's of energy efficiency, indoor environment quality, sustainable site planning and management, materials and resources, water efficiency, and innovation. The development of green building index system are to define green buildings by establishing a common language and standard of measurement, promote integrated of whole building designed, recognized and reward environmental leadership, transform the built environment in order to reduce its environmental impact, and ensure new buildings remain relevant in the future and existing buildings are refurbished and upgraded properly to remain relevant.

1.5 Impact on Cost Implementation

Implementation of green building may lead an impact to the cost. The assessment of cost implementation is based on the whole life cycle (WLC) technique and life cycle assessment (LCA). The whole life cycle cost of a project usually consists of capital costs, operational costs, maintenance costs and disposal costs. (*Cheng J. et Al, 2006*). The capital costs will be calculated as a construction costs and the other costs will be calculated as a post-construction costs. In the impact on cost implementation, comparison of capital costs and operation will be demonstrate in term of various green solutions based on sustainable design principal. There is perception of cost increasing especially in capital costs due to technology applied in the green building construction adoption. Furthermore, the increasing of the capital costs will give long term benefits that can be attained if the whole life costs such as the operational costs, maintenance costs and disposal costs are taken into consideration. In the general consensus, the cost varies is depending on the Green Building Index certificate. For Certified, costs will be varied from 1 to 3 percent, Silver from 2 to 6 percent, Gold from 5 to 10 percent and Platinum from 7 percent and above.

1.6 Comparison between Traditional Building and Green Building

The comparison of typical traditional and green building will be demonstrated to examine the technology adoption and cost impact implementation. In capital costs comparison, the analysis will involved substructure, superstructure, internal finishes, fitting and furnishings, building services, external works and services, and preliminaries and contingencies. The entire element that contributes to the design of the building will have a comparative in term of method and economic impact.

2. Literature Review

Green Building (GB) have an enormous impact on the environment, human health, productivity and the economy. Turcotte et.al (2006) described the concept of GB encompasses ways of designing, constructing and maintaining buildings to decrease energy and water usage and costs, improve the efficiency and longevity of building systems, and decrease the burdens that buildings impose on the environment and public health. Based on his study over 20 cities in the United States have saved money an gained other important benefits by setting up GB programs and incentive. For instance, the city of San Diego's, green municipal building used 65% less energy than a conventional building yielding a savings of $70,000 in utility costs.

Richard (2010) in his study stated that green buildings offer a tremendously reduced environmental footprint compared to traditional building where offer a 30 percent energy saving, 35 percent carbon saving, 30-50 percent water saving and a 50-90 percent waste saving.

A 2003 study by the California Sustainable Building Task Force shows that an initial green design investment of just two percent will produce savings greater than 10 times the initial investment, based on a very conservative 20-year building lifespan. For example, $40,000 in green design in a $2 million dollar project will be repaid in just two years. Over 20 years, the savings will amount to $400,000.

Gregory (2003) described energy is a substantial and widely recognized cost of building operations that can be reduced through energy efficiency and related measures that are part of green building design. The average annual cost of energy in Massachusetts buildings is approximately $2.00/ft^2. On average, green buildings use 30% less energy than conventional buildings—a reduction, for a 100,000 ft^2 state office building, worth $60,000 per year, with a 20-year present value of expected energy savings at a 5% real discount rate worth about three quarters of a million Dollars. Green building energy savings primarily come from reduced electricity purchases and secondarily from reduced peak energy demand. On average, green buildings are 28% more efficient than conventional buildings and generate 2% of their power on-site from photovoltaics (PV). The

financialbenefits of 30% reduced consumption at an electricity price of $0.08/kWh are about $0.30/ft^2/yr, with a 20-year NPV of over $5/ft^2, equal to or more than the average additional cost associated with building green.

A study of 31 green buildings from the City of Seattle found that absenteeism was reduced by 40 percent among workers. Another study, sponsored in part by commercial real estate giant Cushman & Wakefield, reported 30 percent fewer sick days among one company's employees, and discovered a 10 percent increase in net revenue per employee in another company, after each office moved to LEED-certified buildings. Companies in green offices also have an edge in attracting and retaining great employees.

According to a study from Geof, et al.(2003) titled "Managing the Cost of Green Building," higher construction costs can be avoided by the inclusion of green design from the outset of the project. The investment of an additional 3% of project costs in the design phase can reduce construction costs by 10%.

There has been one widely cited early study by Greg Kats (2003) which had a sample of 33 green building projects that suggested present value benefits of $37 to $55 U.S. dollars per square foot as a result of productivity gains from less sick time and greater worker productivity. These resulted primarily from better ventilation, lighting and general environment.

In a fairly recent study in Australia a law firm tracked the before and after sick days after a move to a 5 green star rated building, a high rating in Australia, and found sick days reduced by 39% overall to .28 days per month. That change alone cut the average monthly cost of sick leave significantly. Other productivity gains were said to have "gone through the roof." But this is one case study, and we need to know if we can generalize from such indicators (Dunckley 2009).

According to the US Environmental Protection Agency, health and well being are supported by the indoor air quality inherent in green buildings. Poor indoor air resulting from insufficient air circulation, poor lighting, mold, temperature variances, carpeting, furniture materials, pesticides, toxic adhesives, paints, and other pollutants contribute to respiratory problems, allergies, nausea, headaches, and skin rashes. The Heschong Mahone Group, found that green building that emphasizes ventilation and non-toxic, low emitting materials create healthier and more comfortable living and working environments.

According to a U.S. Green Building Council report titled, "Building Momentum: National Trends and Prospects for High-Performance Green Buildings," an estimated 40% of schools in the United States have poor environmental conditions that compromise the health and learning of students. According to a Paladino & Company study titled "Washington High Performance School Buildings: Report to Legislature," green schools result in a 15% reduction in student absenteeism. Improvements in test scores have also been shown in green schools. According to a study called "Greening America's Schools Costs and Benefits," a review of 30 green schools across the country concluded that "based on a very substantial data set on productivity and test performance of healthier, more comfortable study and learning environments, a 3-5% improvement in learning ability and test scores in green schools appears reasonable and conservative."

Based on the past study, green building provide various benefits that conventional buildings do not. These benefits include economics, energy and water savings, reduced waste, improved indoor environmental quality, greater employee comfort/productivity, reduced employee health costs and lower operations and maintenance costs. This paper will focus on two of these benefits: 1) Economic benefits and 2) Environmental benefits.

3. Discussion

3.1 A Residential Building Cost Impact

In a residential building, the green design will involved more on electrical and mechanical appliances system. Therefore, in residential building, most of the cost impact is related to the electrical and mechanical system that will contribute to energy used and water supply system. Based on the case study for a residential building, green technology for energy saving will contribute to higher saving of operational costs. 70 percent operational costs will be decreasing due to application of solar powered for hot water supply. It is because these appliances will generate natural energy harvesting from sunlight compared to hydroelectric. The intelligent system for lighting and heating will reduce the energy used because it will automatically off if the system is not in used. This system may increase the operational cost saving up to 45 percent.

In the water supply system, water harvesting method and distribution method to the users is part of the values in green building design. A few methods can be implemented in green building design such as rain water harvesting and grey water recycling. In implementing grey water recycling, it may increase the operational cost saving up to 14 percent. By using water recycling, it is generally meet the requirement of 80 liters per person per day as in regulation f water supply design. Furthermore, it will benefit the end users in low water charges for metered customers because the recycling system will be installed individually at home.

Besides that, for the distribution system the appliances used for fitting may also give an economic impact to the green building. In this review, the fitting system that has been implemented as part as a green design are efficient taps, efficient shower head and dual flow flush water closet. In using the efficient water taps fittings, it may increase the operational costs saving up to 3 percent. For kitchen taps, the calculations assume that the taps are used at a rate of 0.44 per person per day and have a fixed used factor of 10.36. Therefore, this system is fitted that limits the tap about 50 percent of full flow. In using efficient shower head system as sanitary fittings appliances, it may save of operational costs about 4 percent of total operational cost by using normal shower heads. This shower head system is specified by flow rate of water. This efficient showering leads to energy savings. By using this system it may reduced about 5 liter per minute from 12 liter per minute in standard shower heads system. Therefore, this system will provide operational costs saving up to RM1, 210 per year.

Dual low flush water closets is designed to allow different flush volumes, the lesser flush should not be more that two third of the total volume of the flush. By using this system in a green design building, it may reduce the operational costs up to 9 percent. From the water calculator assumes, the ratio of use for the different volumes will be shared between 33 percent for full flush and 67 percent for half flush. Therefore, the water saving in this system may up to 67 percent per flush in one time.

In a green residential design building, the cost impact is due to operational costs of the mechanical and electrical system of the building. It is because the limited space and stories of the building may limited the contribution of green building classification on the structural system used. With that, the operational cost saving of a residential green design building is contributing by adopting the mechanical and electrical fittings and appliances.

3.2 An Office Building Cost Impact

The construction of high-rise structure in the world is become major type of construction due to constraints of land and drastic development in urban area. On the other hand, each of the construction of high-rise building should be follow the need of future generation about environmental awareness. Therefore, the implementation of green design should be used in order to achieve the need of the earth. Based on the study that has been done, Table 4.2 shows the cost impact on the green office building with 7100 square meter is increasing about 10 percent in capital cost.

The element for cost impact of this building is separated into few different elements which are substructure, superstructure, internal finishes, fitting and furnishings, building services, external work and services, and preliminaries and contingency. The highest element that contributes to cost is superstructure because it is the main element to construct the building either typical design building or green design building. But, there are a few benefits of the decreasing of cost impact on green design building which are on the building services element, internal finishes and fitting and furnishes. This is because the system that adopting has different method on installation and operation that lead in reducing the capital cost. In water installation as an example, there is zero cost in green building design because they use grey water recycling or rainwater harvesting as a water resources for the building. This implementation is absolutely reduced the cost up to 100 percent compare to typical design building.

Table 1: A Residential Building Cost Impact

	CAPITAL COSTS		SAVING OF OPERATIONAL COSTS
GREEN SOLUTION	**GBP**	**RM**	**PERCENT**
Solar powered hot water supply	2134	10329	70%
Intelligent lighting system	1120	5421	35% - 45%
Intelligent heating system	978	4734	10% -20%
Grey water recycling	1324	6408	14%
Efficient taps	50-100	200 – 500	3%
Efficient shower heads	50-75	200 – 300	4%
Dual low flush WCs	200-300	800 – 1300	9%

Table 2: An Office Building Cost Impact

Element	Typical Design Building			Green Design Building		
	Cost RM	RM/m2	% of total	Cost RM	RM/m2	% of total
Substructure	1531376	215.67	3.55	3607736	508.15	7.56
Superstructure	17710044	2492.60	41.10	20918964	2947.56	43.85
Internal finishes	4123680	580.80	9.57	3429624	484.00	7.19
Fitting and furnishings	713900	100.53	1.66	713900	100.53	1.50
Building services:						
sanitary appliances	202312	28.51	0.47	287980	40.56	0.60
disposal installations	197472	27.83	0.46	844096	118.87	1.77
water installations	327668	46.17	0.76	**	0.00	0.00
space heating & air treatment	3922336	552.44	9.10	2007632	282.75	4.21
electrical installations	2478564	349.11	5.75	3126640	440.39	6.55
gas installations	86636	12.20	0.20	86636	12.20	0.18
lift installations	706640	99.51	1.64	193600	27.25	0.41
protective installations	60984	8.57	0.14	**	0.00	0.00
communication installations	521752	73.47	1.21	521752	73.47	1.09
special installations	613228	86.39	1.42	891528	125.55	1.87
builder's work	329120	46.37	0.76	329120	46.37	0.69
External works and services	3253448	458.25	7.55	3603864	507.57	7.55
Preliminaries/contingency/OHP	6316200	889.59	14.66	7139000	1005.51	14.97
Total	43095360	6069.75	100.00	47702072	6718.60	100.00

In a comparison on the cost impact based on per square feet, the increasing of the total cost is about 10 percent with zero percent for water installation and space heating and air treatment. The implementation of green design for office building may decreased the operational cost of the building especially on the electrical charges. This is because there is some of the building is fully ventilated by using natural system like Suruhanjaya Tenaga Building at Putrajaya Malaysia with Platinum Certified in green building classification. Therefore, the technology and system that has been planned for the building will give the big impact to the cost because it will increase the requirement of the green building index. In an overall view of this comparison, for the office building construction the green design building will increase the capital cost and generate long-term benefits to the respective owner of the building.

3.3 Cost Comparison on Typical Design Building and Green Design Building

In construction industry, the cost impact will be generating from preliminary stage, construction stage and post-construction stage. In comparison of this case study, it may involve on construction phase and also post-construction phase. In construction phase, the cost analysis is based on the operational cost of the building that involved structural work, mechanical work, and electrical work. The comparison is also made into two different demographic areas which are United Kingdom case study and also Malaysian case study. On the other hand, the cost comparison is also analysis between the typical design building and green design building in order to determine the economic and environmental impact on both building system.

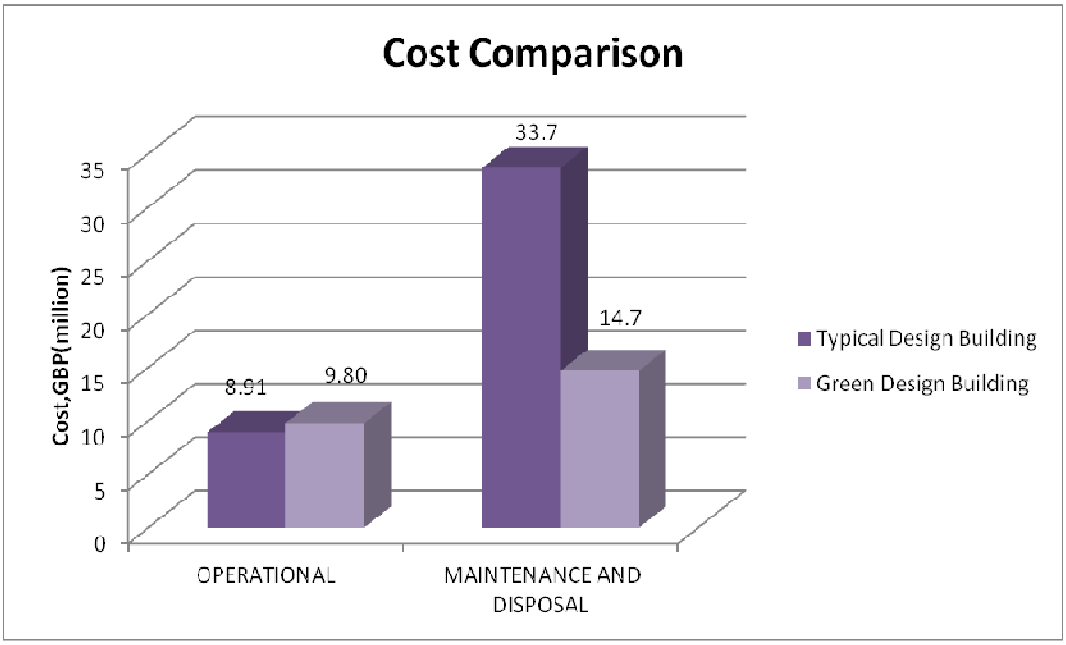

Figure 3.3: Cost Comparison of Typical Building and Green Building in UK

Figure 4.1 shows the cost comparison between typical design building and green design building in term of operational costs and maintenance and disposal costs. In operational costs, the cost is increasing about 0.89 million GBP due to the system implemented in the construction of the building. The increasing of 9 percent of the operational cost because the green technology may lead the production costs of the appliances and fittings. Some of the system need to be imported from other country and this process may lead the increasing of the cost. Constraint with the sources of the product and limited manufacturer and supplier, the cost of the product will be high because the contractor will not have much opportunity to choose the product based on the price and quality of the product.

It is different for the maintenance and disposal cost of the both design. Based on the review, the maintenance and disposal cost of the green design building much lower than typical design building. The maintenance cost of the green building is decreasing about 56 percent compared to typical design building. The decreasing cost is due to long term benefits that contribute by the technology of the system that need low maintenance. Well-designed building may also help to reduce the amount of waste generated by the occupants.

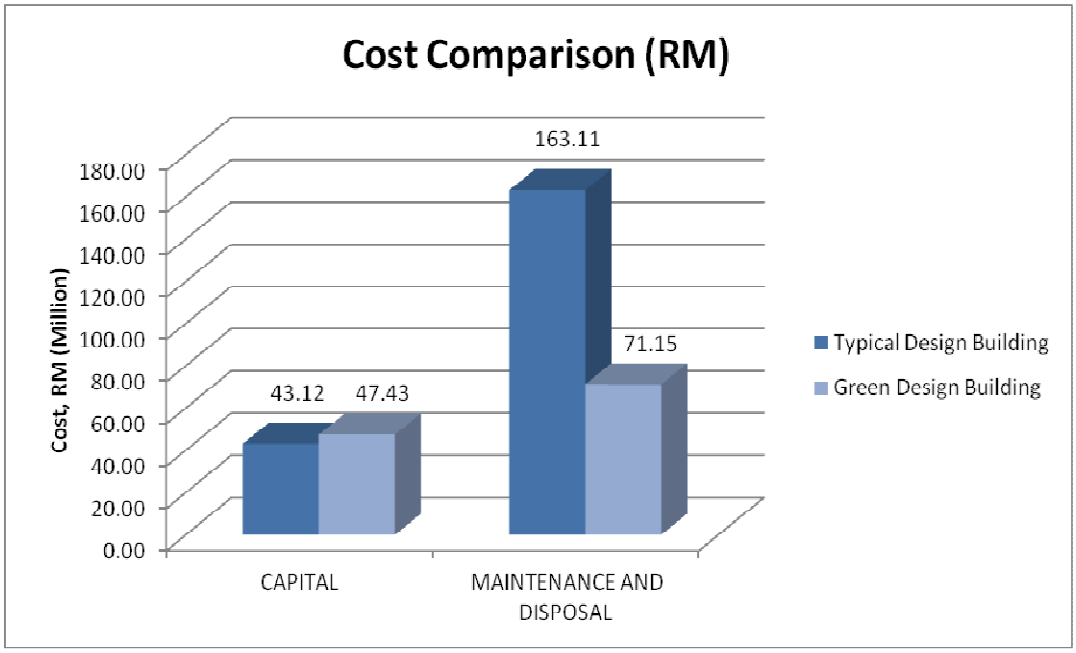

Figure 3.4: Cost Comparison of Typical Building and Green Building in Malaysia

In Malaysia case study review, the behavior of the cost comparison is same as United Kingdom case study. The analysis of the costs is for the commercial building which is high-rise structure. Based on the review, the comparison of the cost is for building that is about 7100 square feet. Therefore in capital cost of the building construction, the typical design building is lower than green design building about 4.31 million Ringgit Malaysia. Figure 4.2 shows the cost comparison of both building system. The increasing of the capital costs in green design building due to the different method of implementation. In green design building, the product cost will reflect the technology and installation of the system and may lead the cost increasing during the construction of the building.

In the maintenance and disposal cost of both method, the cost will be decreasing almost 60 percent of the total cost is the implementation of green design building occur. In Malaysia, the traditional method of construction may increase the disposal cost because of the method used such as traditional formwork may lead to increase the site waste. In green design practice, the formwork system is using steel formwork that may recycle at different part of the building and also for long-term usage. In this case, the decreasing of disposal cost of the site wastage may up to 100 percent in formwork system that is implemented in the building construction. Therefore, the justification of the cost impact in typical design building and green design building is depending on the system implemented during the design and construction of the building until the maintenance and disposal stage of the cycle.

3.4 Economic Impact Over The Building Life Cycle

Life Cycle Assessment (LCA) is the component in sustainable development because it may lead the building lifetime assessment. In building life cycle, the consideration is based on few elements which are building operation, design, installation, commissioning, and decommissioning phase. Therefore, in this overall study, the element has been breakdown to several elements which are property rental income, sales prices, operating cost, an environmental cost, public infrastructure cost, financing cost, building cost, development cost and design cost.

Table 4.3: Economic Impact and Rationalization

	Element	Economic Impact	Rationale
↓	Property Rental Income	Positive	Less turnover, some tenants pay more for green space
	Sales Price	Positive	High NOI, reduced risk
	Operating Cost	Positive	Reduced in long-term
	Environmental Cost	Positive	Government incentive, reduced emissions rebate
	Public Infrastructure Cost	Positive	Government incentive, reduced DCC's
↑	Financing Cost	Negative	Reduced environmental risk vs increased long-term cash flow risk
	Building Cost	Negative	Higher initial cost
	Development Cost	Negative	Higher environmental standard, site treatment
	Design Cost	Negative	Premium for green design, increased consulting costs

Table 4.3 above shows the economic impact and rationalization of the impact. In overall view of the impact, it shows that the cost will increased in designing and construction of the building that is implemented green design. On the other hand, the post operation cost and external cost will be decreasing and give positive economic impact. Furthermore, the table is also show the reason of the economic impact for each element that is contributed in green design building. Each reason is based on the analysis that has been made by the researcher. Most of the rationalization of each element is related to impact to the final users of the green building and also to the financial provider of the project. This rationalization may lead as information to public in order to increase awareness about environment in order to keep the environment in green for the sake of future generation.

3.5 Environmental Impact Benefit Rates

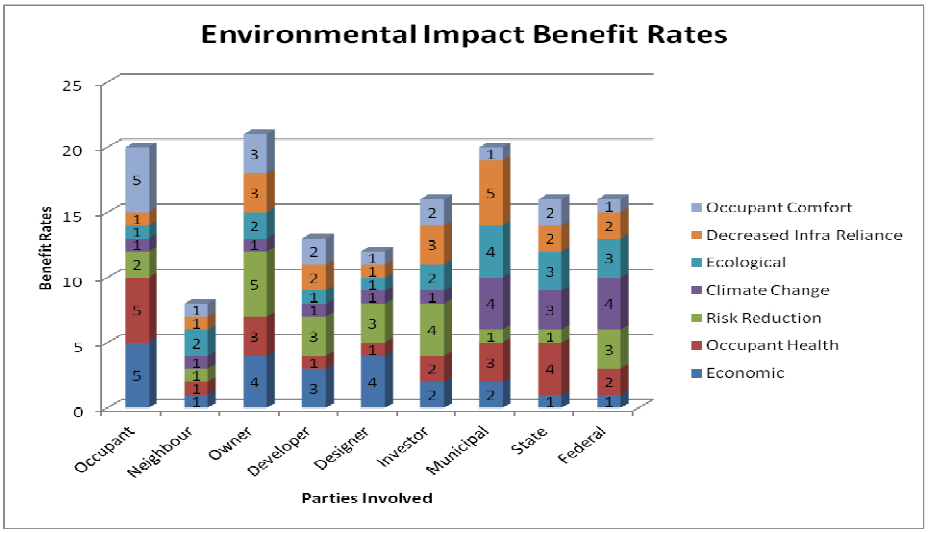

Figure 4.3: Environmental Impact Benefits Rate

In green design building, the environmental impact should be the main concerns as part of benefits due to the design consideration. Figure 4.3 shows the environmental impact benefit rates is scale from 1 to 5 in several impacts which are economic, occupant health, risk reduction, climate change, ecological impact, decreased in infrastructure reliance, and occupant comfort. A green building's architecture can significantly reduce the impact of development and maintenance of a building on its surrounding environment. This is done by protecting existing natural spaces, as green buildings tend not to be constructed on environmentally sensitive areas. Measures are taken to limit ecological impacts, enhancing existing ecology through the restoration of plant life, reducing water use, reducing material use, and using low impact materials in concert with efficient

design and the elimination of unnecessary materials, and reducing emissions to air by decreasing energy use and using appropriate refrigerants.

By adopting the green design, it may increase the benefit rates among the parties that reflect to the development. Based on the review in this research study, the maximum benefits is to the occupant in term of economic, occupant health, and occupant health. This is reflecting the important of keeps the environment in green in order to ensure the living things can have a better life. The lowest benefit rates is to the neighbor because the system in a green building design is mostly implemented to the occupant of the building and have a low impact to the surrounding people that staying out of the building. On the other hand, the benefit rate is different in term of impact to surrounding environment which are ecological and climate change. The highest benefit rates are rates to municipal government, state government and federal government due to the areas is under the entire parties involved. Therefore, the benefits rates given are from 3 to 5.

In term of risk reduction benefit rates, the benefit is rated based on the parties that responsible as a founder and financial provider of the project development. Then, based on the above figure, highest benefit rate are rated to owner, investor, federal government, designer and developer. The reduction of risk due to green building design is because of the technology use in the building system have low maintenance for long-term usage. High technology that is adopted in the system may increase the lifetime of the building and low the risk to the parties that responsible on funding and operating the building. Other than that, the environmental impact benefit rates due to decreased of infrastructure reliance has been rated to the municipal as the highest because the responsibility of the infrastructure at each area is under municipal government. In an overall view of green design building, the environmental impact benefit rates will be increasing because of the surrounding factors will influenced the rating.

3.6 Environmental and Cost Trend of Construction System

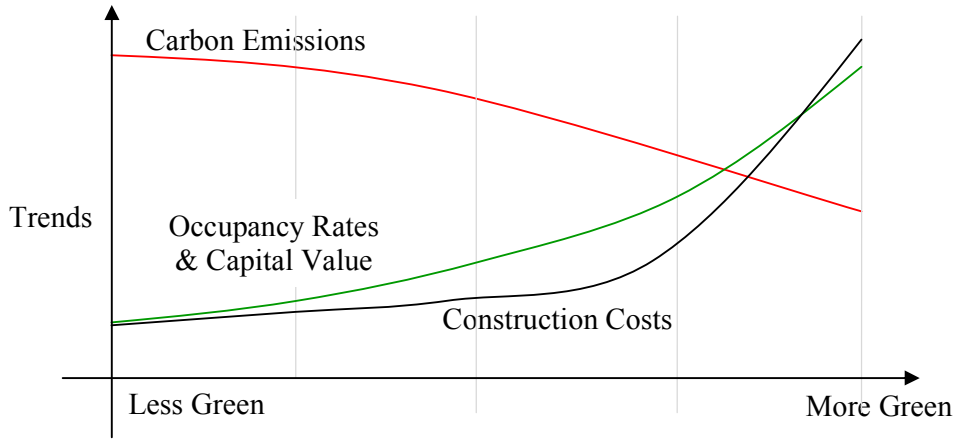

Figure 4.4: Trends of Environmental and Cost Impact due to Green Design Building

In a Green Building Index classification, the main element that contribute to the point is the greenest impact to the environment that contribute by the component of the building either in structural system, electrical system or mechanical system that is adopted in the building. Figure 4.4 shows the trends between carbon emissions, occupancy rates and capital value, and cost construction of implementation of green design building. This trend is developed to produce the relationship of environmental and economic impact in typical design building or green design building.

In a carbon emission trend, the emission will be decreasing if the element of green building that installed in the building is increased compare to typical design building method. The carbon emission at site is due to waste disposal and refurbishment process. In typical design building which is less green, some of construction site will used burning method to dispose the waste at site and therefore it will increase the carbon emission at site. On the other hand, in green design building the construction system will automatically reduce the waste at site. Besides that, the disposal method for the waste that produce from site will be dispose by using technology like incinerator method that will reduce the carbon emission to the surrounding environment.

The occupancy rates and capital value of the building is increasing due to green design building compared to typical design building. The occupancy rates will be depending on the building comfort rate. In green design building, it will provide the most comfortable occupancy due to the green technology such as inverter system for air-conditioner system and refrigerator. This system will increase the occupancy because it will save the energy expenses and finally reduce the electrical charge for the whole household. On the other

hand, it is also will increase the capital value of the house due to the technology need higher cost to install and applied.

The construction cost trend will be affected due to different method of execution work. In green building construction, the construction cost will be increasing because the influence of the design and technology implemented in the building system. There are few factors that influence the increasing of construction costs of green building which are demographic location, bidding climate and culture, local and regional design standards, intent and value of the project, timing and implementation, size of the buildings, and synergies. These factors have given different implication to the construction costs especially for green design building.

4. Conclusion

A comparative of economic impact on traditional building construction and green building construction study will increase the view among parties involved in the industry. This review will absolutely give the best impact to all entire respective agencies to enhance and enforce the requirement of green building or traditional building in construction industry. Furthermore, this review is already highlight the important and benefits in construction of green building in order to save our environment that is in danger situation due to few issues. In an overall perspective on economic impact between traditional or typical design building and green design building, the increasing of cost will be varies about 10 to 15 percent especially in capital cost. It is different in operational costs where the economic impacts in green design building reduce the operational costs because the lifetime of the technology installed in the building system leads to have low maintenance and disposal costs.

Moreover, the environmental benefits is also distinguish in this review study in order to ensure that the reflection with the economic impact. On that occasion, the environmental impact will be give tremendous impact to economic because the elements of both factors are reflected each other. The environmental benefits will reflect the overall capital costs and operational costs of the building. The final user is really concern about the building impact especially on the maintenance of the building. Many sustainable design features can be defeated and diminished by poor construction. Therefore, to reduce this problem sustainable development may give full commitment due to development planning will save the environment for the sake of future generation. We believe that by engaging with the users and operators during the design process, it may lead to develop better design and a better understanding by the users about the function of sustainable features. In the shell nut, to realize the implementation of green building practices, awareness among the parties involved such as developer, designer, contractor, government and users should be nailed immediately.

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