A COMPREHENSIVE COST BENEFIT ANALYSIS OF GREEN BUILDING

[1]NUSHRAT SHABRIN, [2]SAAD BIN ABUL KASHEM

University Malaysia Sarawak, Swinburne University of Technology Sarawak
E-mail: [1]15030091@siswa.unimas.my, [2]skashem@swinburne.edu.my

Abstract- Nowadays green building has high impact in society. Now designers understand that fresh air, improved indoor environment, and water savings is also important. Green building is well-known because of its environmental benefit, In this report economic and social benefit of green building has been discussed. Aspects of green building around the world have been discussed. Strength, weaknesses, opportunity and threat (SWOT) analysis, Life-cycle cost calculation for green building was done on a projected green building. In economic analysis, the total monetary cost and non-monetary cost are counted together as one in order to know the residual accrues to the government. The findings of this study are similar to those in other countries, in most of which the excess cost of the green building was estimated at 0–10%.

Keywords- Green Building; Indoor Environment; Cost-Benefit Analysis; Monetary Cost; Sustainable; Economic Analysis.

I. INTRODUCTION

Nowadays, everyone is looking for a solution to reduce the environment pollution, from home to office. According to U.S. CO2 emissions, every building is producing 40% of CO2 in the environment.

The green office building is a way to reduce this CO2 emission to the environment as well as increase the property value as well. This green building practice is a big step to save the world.

And through this practice employees will get involved and will conscious about the environment pollution, and every day. In offices office equipment like light, heat and air condition and other electrical equipment like PCs, photocopiers, and printers typically account for more than 20% of the energy used in most offices and in some cases up to 70 %.

(Green office guide, 2016) The main of green building is to efficient use of resources (energy, water, and materials) and improve environment and human health, they can achieved through buildings design, structure, building's lifecycle, operation, maintenance.

To assess the viability of green building project, a new green building has been proposed and its cost benefit is also analyzed here. The purpose of this project is to give a neutral, evidence-based judgment of the costs and benefits of this project, without regard to its political complications.

At first glance, the extra work and other resources needed to build green may seem like an onerous cost, but closer consideration discloses this insight to be deceptive. It has been considering that energy improvements are part of an overall process. Often it has been found that the added costs are balanced by long-term savings. Like a good investment, the original costs will return over time.

Figure 1. The proposed project location

II. LITERATURE REVIEW

Green building is a building whose construction and lifetime of operation reassure the healthiest possible environment. The green building tools are contrived from local eco-sources that offer a healthy environment assembled on the traditional and architectural heritage. Through their lifecycle, the green buildings reduce the injurious impact on the ecology, decrease the use of resources (energy and water); and provide the healthier indoor environment. (Samer, 2013).Building materials and components are re-using or recycling, because they are ecologically friendly materials. For the past thirty years, the green building movement has been continuously developing. In 1970's, during the energy crisis, the idea of green building developed and peoples try to establish in their real life to get the advantage. To decrease the dependence on nonrenewable energy, peoples start using solar panel. User and investor were in doubt of the efficiency of solar panel, is it really reduce the negative impact on the environment, and lower energy bills. Now Eco building does not only use a solar panel to make the building more efficient, but also, they use harnessing sunlight, Building materials, and a good location. Green building design also an emphasis on less water use recycling. According to Green Building Index, a building is considered green when it emphasizes on the competent use of resources

energy, water, and materials and also reduce the bad impact on the environment. (Malaysia Productivity Corporation, 2014). National Green Technology Policy (NGTP), also focuses on the elevation of application of renewable energy and energy efficiency. (M S Suhaida et al., 2013). Most of the people don't want to invest in green building, but now a day's scenario is changing. According to Nielsen global survey on corporate social responsibility, majority of people said they will pay additional money for products and services those create positive impact on society and environment. Another positive news is that, according to a global survey of construction firms in between 2013 and 2015 63% construction firms working on new green commercial projects and among them 50% have plans for green restoration work(Syazwan et al. 2009, Syphers et al. 2003). McGraw-Hill arranged a survey concerning architects, engineers, contractors and building owner's involvement, habits and perceptions about green buildings. He found that on average anticipated operating costs decrease between 8% and 9%, ROI expected to improve 6.6%; increase in building values expected around 7.5%; Rents expected to rise by 3%, Occupancy expected to increase by 3.5%. Another analysis from international and Australian data the Green Building Council of Australia stated that increased the productivity of occupant from 1 to 25%, higher relative investment returns, less staff agitate, higher market value for the asset, free promotion (free promotion means that media, environment concern people, government will talk about the green building. Without any cost on promotion, the owner can get publicity).

In Malaysia GBI (Green Building Index) is the green building rating organization. The main aim of GBI is to encourage sustainability and help to raise awareness among green building users and producers (Developers, Architects, Engineers, Planners, Designers, Contractors and the Public) about environmental issues and responsibilities to the next generations. (Green Building Index, 2015).GBI certification is based on six key criteria, namely energy efficiency, indoor environment quality, sustainable site planning and management, materials and resources, water efficiency, and innovation. The total points for all criteria are 100 and to achieve the points, building company will comply with necessary possessions so that the building will likely be greener environment-friendly.

Table 1 GBI Scoring for Non-Residential

Criteria	Scoring	Rating Award
Energy Efficiency	35	GBI platinum
Indoor environmental quality	21	Gold
Sustainable site planning and management	16	Silver
Material and resources	11	Certified
Water efficiency	10	
Innovation	7	
Total	100	

To be a Green building, it must be energy efficient. The energy used by buildings is mostly generated by burning fossil fuels. Then it generates greenhouse gasses and it creates an impact on climate. One building can be defined as a Green building when it consumes less energy and produces fewer greenhouse gasses. Table 2 shows the energy consumption and CO2 emission of different types of buildings per meter square area.

Table 2 Energy consumption of different types of building

	Gas/oil consumption(kWh/m²)	Emissions(kgC02 /m²)
Naturally ventilated smaller office	79	32.2
Naturally ventilated ,open plan office	79	43.1
Air-conditioned, standard office	97	85.0
Air conditioned headquarters	107	143.4

Green building design should be different from normal building. The building should be avoidance of the sun but have to locate like this that sunlight can come into the building and able to use as a substitute of light at day time. The building can use active or passive architecture for cools the building. To make use of the sunlight as a light source the building design can allow the car park at the basement. Another beneficial and cost efficient way of energy saving is using the sensor .The sensor can easily detect the presence and movement ,if no one inside the room the light will switch off automatically. Water efficiency is another aspects of green building, rainwater using technology is one of the best way to use water efficiently. They are paying more attention to energy efficiency.

III. COST BENEFIT ANALYSIS

Cost-benefit analysis (CBA) is the examination of a decision in terms of its consequences or costs and benefits (Stephanie Riegg Cellini, James Edwin Kee (2010)).To identify the total benefits with the cost of a single program or a policy to society CBA is one of the best measurement scale. To identify the economic benefit of making any given investments, and select and rank the project from numerous investment options, cost benefit analysis is the best way. The analysis done is not to solve all such conflicts, or eliminate the uncertainty and hence the demand for sound judgment, but to provide a deep body of data gathered in a disciplined manner that can help decision-makers confronted with difficult investment or insurance determinations. (Puget Sound Regional Council, 2009). When performing the analysis, the most crucial part is to transform estimations of benefits over costs into today's money value. Other than that, calculating net present value (NPV) is a relatively easy way to examine a stream of current and future benefits and costs .That represents the present value of an investment's future financial

benefits minus any initial investment. (United State Green Building Council, 2003). In order to provide a consistent measure of costs and benefits, future costs and benefits are discounted to produce Present Values (PV). These Present Values are then used in the NPV calculation.

IV. PROJECT BENEFIT

In this section, the potential benefits of the project will be discussed. The project benefits will be divided into five aspects; namely social and community, environmental, government, economic and others. Figure 4 shows the flow chart of the aspects. The details of the aspects are given after the flowchart.

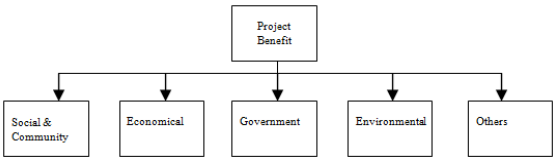

Figure 2 Categories of Project Benefits

4.1 Economical Aspect

This project's main intention is to promote the healthy and green environment to the surrounding. In term of the economic aspect, it will reduce much of the money spent as a lot of saving will be done especially for the lighting and water supply in the building. The lighting is generated by the energy from solar that had been stored and the water supplies are from the rainwater. Besides that, the wages earned by the employees from the green building for the construction and maintenance can be spent on local business; especially on their groceries. The local bank might as well invest in some of the project conducted by the green building, and they might develop some of the recreational areas all around the green building as it suitable to build such places in that area. This will increase the state in term of the economical aspects. The government may give some subsidized to whoever who want to buy the house, as this will increase the people's interest in buying the houses.

4.1.1. Increased Productivity

Most modest businesses realize the relationship between work environment and productivity, and directly it creates an impact on company's profit. This topic has now established that link between office environments and productivity is very strong (Haynes, 2007).Haynes give emphasis on the behavioral and physical elements of office. Like 1) physical layout 2 .Environmental condition (artificial lighting, ventilation system, natural lighting,); and 3) comfort level. Inside a Green building, all these facilities are present, these subsequently decrease the sick leave and increase the productivity and profit as well.

Green building is with all the green facilities like integrating passive wall, roof, and floor design, proper building orientation and window veneering insulation system that help the building to maintain the cooling system naturally . According to Miller, et al. (2009), essential natural lighting, the lack of organic composites, good ventilation and suitable temperature inside the building makes worker happier. As a result increased employee retention and less sick leave

4.1.2. Costs of Green Building

Analysis recommends that many green projects can attain a perfect design within their old building budget or with a very extra small fund. Gregory Kats Green building expert work on 33 LEED certified building, finally he said that investment in a green building projects should be start from the design phase, otherwise it may rise the construction cost. If investor invest 3% additional cost in the design phase then at construction stage cost can be reduce by 10% (Green Building Costs, 2016).

4.1.3. Payback Period for Green Buildings

The initial cost of green building is sometimes higher than the conventional building, but the saving is created in green building by low consumption of energy, water, and health cost, gives a quick return of the investment and makes an effect in revenue. "The Costs and Financial Benefits of Green Buildings," reported by the Massachusetts Technology Collaborative for the State of California Sustainable Building Taskforce presenting a definitive cost-benefit analysis of green building based on a review of LEED-certified buildings, states that 2% nominal increase in green building design would save 20% of total construction costs over the life of the building which is more than ten times the initial investment.(The Business Case for Green Building, 2016).

4.1.4. Operating Costs

Green building is popular and well known because of its cost savings quality. It saves money through reduced energy use, water use and lower maintenance cost of the building itself. In Malaysia GBI (Green Building Index) certified buildings are enjoying Tax exemption and stamp duty exemption. In green building its energy saving quality help to surpass design and construction cost within a normal payback period.

Normal payback period: The payback period is calculated by counting the number of years it will take to recover the cash invested in a project. Let's assume that a company invests $400,000 in more efficient equipment. The cash savings from the new equipment is expected to be $100,000 per year for 10 years. The payback period is 4 years ($400,000 divided by $100,000 per year).

4.1.5. Improved Internal Building Conditions

In China Gou et al (2013) conducted a study, they found that the inhabitants of the green building are more satisfied with the air quality and thermal

comfort of their workplace than the lighting conditions. Nowadays employers are giving importance on satisfying workers by creating comfort.

4.1.6. Scaling Up from Green Buildings

It is possible to contribute to climate change mitigation, low energy use, good quality of life, and new job opportunity and so on by making a more green building.

4.1.7. Higher Building Value

A study by Halim (2012) state that, in Malaysia green building office rental rates is around RM0.50 – RM2.25 per square feet and operating cost saving is around RM0.164 per square feet (Halim et al., 2012). In Australia and United states, studies found the same result. Chong, (2010) in his studies mentioned that, evolving green buildings help their owners to earn higher rents, higher values and higher occupancy rates than non-green buildings. In Malaysia, buyers are prepared to pay at least 5% more for green buildings, because of their environmental friendliness, quality, comfort and natural lighting. In the United States average costs of green buildings and non-green are not that different (Bertrand).

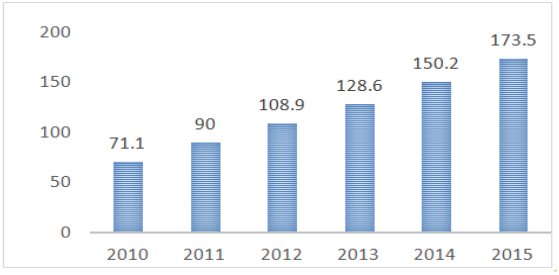

Figure 3 Building Value in the USA

4.1.8. Cost Savings

In green building costing people always take into account its design and construction cost, if they take into account its maintenance, replacement, and repair cost. Assimilated building design, operation, and maintenance complement, life cycle evaluation gives the owner continuous cost saving. In a study, Singapore reveals that green buildings save approximately 10 percent in operating cost and green office buildings market value increase by about 2 percent. Uma (2011) stated that they surveyed twenty-three sample buildings like retail, office, and hotel. Then they found that their average savings were about seventeen per cent of the total building's energy consumption .Tax exemption is another savings. LEED Gold certified building, Education Headquarters Building (California) save taxpayers $500,000 yearly in energy costs alone

4.1.9. Branding and Prestige

Green Building Council of South Africa stated that green building is a divergent product which is technologically and environmentally advanced and socially liable. Kato et al (2009) mentioned his study that, In Australia building managers are happy because they are getting a competitive advantage and become a leader in the industry if the building is Green Star-rated. According to Kuiken (2009) relaxed depreciation, higher rent, lower occupancy allowance all are price premium for green buildings. Demand for green buildings is increasing in both the Netherlands and Sweden because of its operating costs (Malaysian green building index, 2016). Finally, it can be said that all the positive qualities of green buildings can create a good impact on the brand of the organization.

4.2 Social and Community Aspect

In term of social and community, the local can get more job opportunities as the green building has been launched. Lots of jobs will be offer as there are many departments involves in the building that caters from managerial to the lowest rank of the employment. The current employees will be trained to be more efficient and be able to use the system that had been implemented in the new building. (Lots of job will be offer because green building is a new journey, lots of unopen door is here in this industry new generation can make research and explore about this industry.

4.3 Government Aspect

The job opportunities that had been offered by the green building will increase the number of employees of in the state. The government can earn more tax revenue from the employees and corporate. The government can also generate money from the project that is going to build all over the green building.

4.4 Environmental Aspect

In terms of the environmental aspect, the building is reducing heat gain. This is because the building are east-west oriented and the majority of the windows are facing north and south region. The building is also designed to optimize the daylight utilization. The atrium will allow passive solar shading. The lighting design and control system are depending on the daylight and occupancy. Meanwhile for the water supply, the green building promotes the water harvesting system. The renewable energy in the building is based on the photovoltaic system.

4.5 Others Aspect

The other benefits of the green building are the research and develop team will always find a way to make the improvement for the building. In the future, a lot or organization will choose to have this kind of building because of it has a lot of benefits and may cut a lot of cost in term of maintaining the building. In addition, researchers will focus on the greenhouse effect as this will cause harm to the environment in the long term.

V. PROJECT COST

The cost of this green building is approximately RM 3 million; it's an 8 storied building, Project scale: 40,000 m^2. The project is targeted to fully obtain its return on investment in the year of 2021. This section is divided into two parts namely monetary cost, and Non-Monetary Cost. Monetary cost refers to any cost

that is directly incurred upon implementation and throughout the life of the project, and Non-Monetary Cost includes costs that are likely to be absorbed through the project. This section will discuss the analysis of all cost-estimating materials for the green building project in order to evaluate its cost and schedule risk inherent in the current estimate.

5.1 Monetary cost

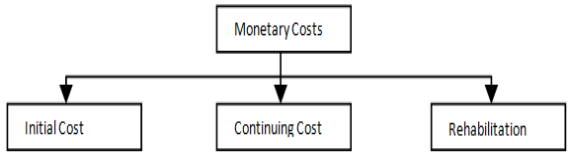

Figure 4 Sections of Monetary Costs

The Monetary Cost are divided into three parts namely Initial Cost, Continuing Cost and Rehabilitation Costs. Initial cost is consist of planning or project design, land acquisition, infrastructure construction, project-related staff cost, equipment, and vehicles purchases and facilities erection. For the Continuing Cost, it covers the operation cost of the green building such as maintenance, labor, equipment, utilities and contract services such as outside contract for research, advertising and cleaning. For Rehabilitation Costs, it covers from infrastructure repairs and future improvement cost beyond the routine maintenance. These future improvements of the green building may cover the installation of advanced technology, as well as improvise the parking lots and etc.

Table 3 Monetary Cost

MONETARY COST	ESTIMATE BUDGET (RM000', 2015)
Initial Cost	
Planning and project design	25
Land acquisition (RM4 300/per acre)	800
Infrastructure construction	150
Project-related staff cost	75
Property, Plant, and Equipment	133
Others	15
Continuing Cost	
Maintenance cost	150
Labor cost	50
Installation cost	100
Research, Development, and Training	100
Energy Bill	90
Cleaning contract	35
Water Bill	25
Rehabilitation Cost	
Infrastructure repairs	12
Downtime cost	10
Future improvement cost;	
Additional parking lots	95
Installation of advanced technology	130
Others	5
TOTAL MONETARY COSTS IN YEAR 2020	2 000 000

5.2 Non-Monetary Cost

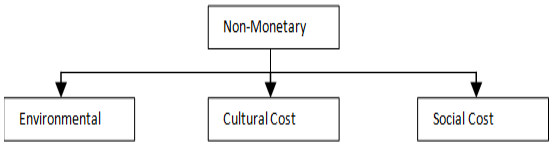

Figure 5 Section of Non-Monetary Costs

For this Non-Monetary section as shown in Figure 7, the project will affect environmental, cultural and also social. These costs are also known as opportunity cost as government sacrifices the resources such as land and people; in order to build the green building.

5.2.1 Environmental Impact

Green building aim is to reduce the environmental impact of the building on the environment. In order to do so, the amount of natural resources building consumers is reduced, to achieve the objective of the green building. This is also be done to promote the sustainability of the building. First thing, before the building is built, the land needs to be clear, maybe they need to cut the tree. This is the part where it will change the ecosystem of the land area. Thus, a large amount of money will be spent on the environmental cost in order to reduce the environmental impact of the project development.

5.2.2 Cultural Impact

Cultural impact cost may refer to the costs associated with loss of historical value of the proposed area. The local might have their own value, myth, and story on the land where the green building will be built.

In order to preserve the cultural, the green building will be equipped with the gallery or a mini museum, to show the culture of the local people and to ensure that it will always be preserved.

5.2.3 Social Impact

In term of social, the green building will affect the community individual and collective value system, behavior patterns, community structure, lifestyles and the quality of life. This includes the cost of supporting locals' employment, and also their quality of life.

Apart from that, the local quality of life will change as they need to adapt to the changes made in their area.

Table 4 Green Building Project Non-Monetary Cost Budget for the forecast year

NON-MONETARY COST	Estimate Budget (RM000', 2015)
Environmental Cost	
Protection of biodiversity	250
Emission and waste disposal	100
Mitigation of environmental impacts of products and services	45
Environmental cost due to transportation	150
Cultural Cost	
Loss of historical character of the region	55
Product authenticity	50
Imposition on artificially created atmosphere	75
Social Cost	
Supporting locals' employment	155
Crime prevention	20
Locals' quality of life-related costs	100
TOTAL NON-MONETARY COST IN YEAR 2020	1 000

From the cost evaluation above, the total cost associated with the green building is approximately RM 3000,000 in 2015 Ringgit value. In economic analysis, the total monetary cost and non-monetary cost are counted together as one in order to know the residual accrues to the government. This residual is also known as economic profit.

Cost-benefit Analysis:

The life cycle costing (LCC) models is about the primary cost of each substitute, and also discuss about the value of energy savings, revenues, and solar improvements via solar renewable energy credits. Purchase price of the energy features are estimated by different ways like previous greenhouse projects, or data from local manufacture. External variables (inflation rates, energy prices, and discount rates) are also important part of the analysis. Cost-benefit assessment of this project can be done by adopting life-cycle cost (LCC) analysis.

According to the Hydraulic Institute

LCC = Cic + Cin + Ce + Co + Cm + Cs + Cenv + Cd

Whereas

Cic = initial costs, purchase price (pump, system, pipe, auxiliary services) = 25+800+150+75+133+15 = 1198

Cin = installation and commissioning cost (including training) =100+100=200

Ce = energy costs =90+25=115

Co = operation costs =50

Cm = maintenance and repair costs =150+12=162

Cs = downtime costs =10

Cenv = environmental costs = 250+45+150= 445

Cd = decommissioning / disposal costs = 100

From the Table 4 and Table 5, LCC can be calculated as follows:

LCC=1198+200+115 +50+162+10+445+100 =2280

Net Present Value (NPV) is an important factor in the estimation of LCC. The preliminary cost of each system and the energy savings capability both topics is analyzed in NPV calculation. NPV helps to identify the investment and return of money in a certain project. The project also can be assessing through SWOT analysis as shown in Figure 3.

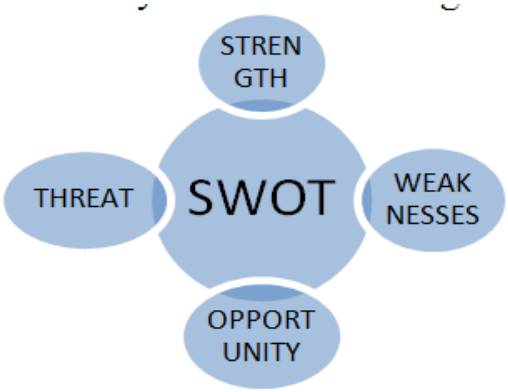

Figure 6 SWOT Analysis

SWOT analysis consists of strength, weaknesses, opportunity and threat. Below are the strength, weaknesses, opportunities and threats for green building.

Table 5 SWOT analysis for green building

Strength	• Low energy intensity • Renewable (Solar panel), energy efficient • Many reuse option • More motivation of real estate companies and demonstration projects' developers • Carbon storage
Weaknesses	• Emissions to air • Lack of expertise • Bureaucracy • Low investment activity
Opportunities	• New technologies, innovations • Clean technology for building • New regulations • Creation of jobs
Threats	• New regulations • Exposure to climate change • Energy price

The SWOT analysis given is adopted from SWOT analysis for wooden houses (353,528 ha) as its effect on the environment is almost the same with green building effects. As it is so, some modification is done to make it compatible with the proposed project. However, for the purpose of evaluation of CBA for the project, the mentioned model only act as a guideline and some modification need to be done. Through the model, it is important to:

a) Identify and quantify the impact of the project

b) Select the appropriate method to measure each impact

c) Valued the impacts using discounted and net present value.

RECOMMENDATION

From the research results, few recommendations have been made. The objectives stated are limited to a specific number of people as the initial cost of the building is very high and not everyone can afford. The payback period decreases due to low operational cost. More techniques can be implemented to produce an ideal design if the model could be modified and used for more real-world scenarios. Making use of passive design structures keeps the environment clean and safe, hence, it is more stressed to use for existing residents to make use of the technique. More applications can be added by making use of renewable resources; Solar panels, wind turbines, could be used to generate electricity for the use of small mechanical components such as fans to be used with passive cooling techniques to achieve better indoor conditions for example solar panels for the generation of electricity, which can prove cost effective for future purposes. Aluminium and timber roofs could be replaced by cheaper materials such as

roof tiles with the high thermal capacity to absorb large amounts of heat. White paint could be applied to reflect a large chunk of the solar heat gain. In order for better implementation, such rules and guidelines could be regulated by government laws for ease on a large urban scale.

CONCLUSION

Green building is a response to a demand for energy and resource efficiency. Nowadays the green building is much more than the energy efficiency. Now designers understand that fresh air, improved indoor environment, and water savings is also important. Buildings are now examined in different aspects like local, natural and their neighbors as well. At first when environmental expert people and the government was trying to convince people that green building is good and beneficial for the environment, then people's interest level is quite low, then expert people start talking about its other beneficial side like it's good for residents also now they are also disclosing that it's profitable as well. One green building can help to improve the environment, health, and bank balance as well.

Green buildings environmental benefit is well recognized. This report is discussing about social and economic benefit of green building. Green building program has matured with time and now discuss about return on investment, risk mitigation, employee productivity and heal as well. Green building projects shifts their emphasis over time like 'planet' to 'people' and 'profit'

The findings of this study are similar to those in other countries, in most of which the excess cost of the green building was estimated at 0–10%. The high rate of return on investment, stems mostly from savings on electricity (about 40% of the entrepreneur's benefits) and increased worker productivity (about 60% of the entrepreneur's benefits); even when ignoring the latter, and limiting the analysis to the physical aspects of the building, green building is still economic (Hadas et al., 2014). As a return on investment is expected within a short time (few years), the promotion of the private green building market and the public sector must revolve around educating the market, training professionals and developing financial solutions. Furthermore, given the right financial solutions, it is possible to enforce the Green Building Standard by law (in the government and the private sector.

Green building also promoting the water efficiency and the use of environment-friendly materials. It also focus on proper construction waste management with storage and collection and re-use of recyclables.Green building maintain Indoor Environmental Quality and can save many billions of dollars per year that is arise from higher absenteeism, lower productivity, and medical costs. Indoor environment is same important as outdoor environment cause people spend their 90% time in indoor. Initial cost of green building is only 2% but financial benefit is 10%.In some sectors benefit of green building is easily measurable like reduced energy bill but benefit of health cannot measured easily.

Finally, it can be said that it is possible to calculate theoretically the relative benefits of green buildings when the direct calculation is not possible due to a limited inventory. In other countries where a large number of green buildings are available, a direct cost-benefit analysis is possible. But in Malaysia the number of green buildings are quite low, that is why direct cost benefit analysis is not possible. Energy efficient building saves money, reduces financial risk from rising energy costs, and is a proven best practice among leading companies.

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