

Construction Performance Optimization toward Green Building Premium Cost Based on Greenship Rating Tools Assessment with Value Engineering Method

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Abstract. Green building concept becomes important in current building life cycle to mitigate environment issues. The purpose of this paper is to optimize building construction performance towards green building premium cost, achieving green building rating tools with optimizing life cycle cost. Therefore, this study helps building stakeholder determining building fixture to achieve green building certification target. Empirically the paper collects data of green building in the Indonesian construction industry such as green building fixture, initial cost, operational and maintenance cost, and certification score achievement. After that, using value engineering method optimized green building fixture based on building function and cost aspects. Findings indicate that construction performance optimization affected green building achievement with increasing energy and water efficiency factors and life cycle cost effectively especially chosen green building fixture.

1. Introduction

Building facility has been a human need for some activities platform such as social, economic, and environment. In the other hand, building construction has both positive and negative impacts that there are not only on construction phase but also on operational, maintenance, and demolition phase. The negative impacts of conventional building are high energy consumption which up to 40% of total global energy production, consuming 12% of the total clean water supply in the world, and spending 30% of the world resources for building construction phase. In addition, indirect negative impact of building operational and maintenance is greenhouse gas emissions production that up to 40% of total emission in the world. In 2030, this emission was predicted 30% come from countries in Asia. Therefore, these conditions should be prevented to decrease greenhouse gas emissions with some concrete steps such as sustainable environmentally development concept [1].

Building concept that concerned on sustainability environment in several countries is known as green building concept. Green building concept is the concept with friendly environment buildings that accommodated the interests of environmental, social, and economic integration aspects of buildings according to standards that it has been determined from the building life cycle plan. Some proponents of green building concepts walk with the owners needs of their building, rating tools and knowledge, government aid, and government regulations [2]. The Green Building Concept in Indonesia has been formulated in several laws and provisions such as Greenship. It was published by Green Building Council Indonesia (GBCI). Some of Government regulations that supporting green



building such as Presidential Regulation Number 38/ 2015 on public-private partnership on energy conservation infrastructure, Ministry of Labor Regulation Number 80/ 2015 on national competence in energy management for industry and buildings, and Ministry of Public Works and Housing Regulation Number 02/ PRT/ M/ 2015 about green buildings[3].

The main problem of conventional buildings as the previous discussion is the greenhouse gas emissions that harm directly. The main cause of the greenhouse gas emissions is come from energy production and consumption, so that the necessary action for energy efficiency and conservation. Based on Energy Conservation Partnership Program and JICA Study (2010), construction of commercial buildings in Indonesia is still in poor pursuing energy efficiency. The largest energy is used on office buildings, malls, hotels, and hospitals (Figure 1). It is strengthened further by the low number of green building in Indonesia when compared with countries which they have implemented the concept of Green Building [4]. Based on Green Building Council Indonesia record, there are only eighteen green buildings in Indonesia (Table 1). The main reasons of the low interesting in green building implementation based on Green Building Market Report South East Asia (2014) were higher cost of application green building materials, additional time and cost for research material, training, documentation, and design stage. (Figure 2).

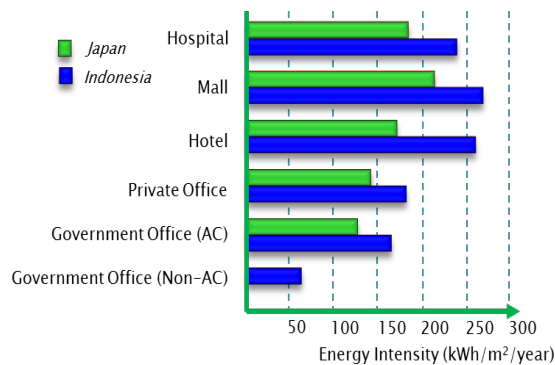


Figure 1. Building Energy Performance Compilation between Indonesia and Japan [5]

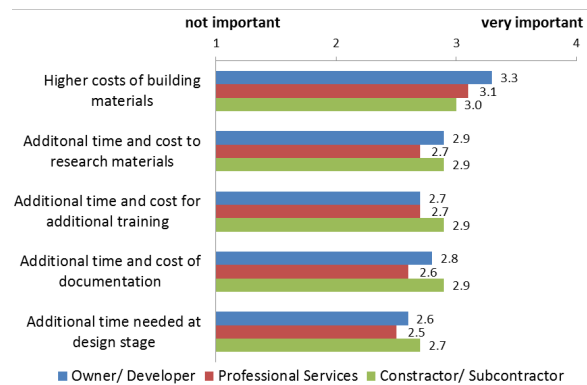


Figure 2. Reason of Low Interest on Green Concept in Indonesia [6]

Table 1. Number of Green Building in Some Countries [7-10]

Country Name	Year	Number of Green Building
US	1998-2012	13,000
Hongkong	2005-2014	1,500
Singapore	2005-2014	509
Germany	2009-2016	490
Malaysia	2009-2013	61
South Korea	2008-2012	53
Israel	2005-2013	45
Indonesia	2009-2015	18

This research was carried out to solve two major problems; there are optimum cycle cost of green building in Indonesia and performance optimization key factors on green building construction premium cost to achieve green building operation and maintenance goals. Therefore, this research was observed green building from design recognition data up to operational and the maintenance phase data as an assessment on final assessment for new and existing building. Observations were constrained by building function as office buildings in Jakarta with Value Engineering Method.

2. Green Building Construction

Building life cycle generally consists of design and material production phase, transport and construction phase, and operation and maintenance phase. Greenhouse gases and other building emissions is not only produced in the operation and maintenance phase, but also prior to this, such as in the design and material production phase, and the material transport and construction phase, which are considered to minimize the negative effect for environment [11]. Green building that minimized the negative impact of building construction has been one of the ways to get the sustainable infrastructure because it decided building operational and maintenance in the beginning of building design. Beside that, Green building concept knowledge that makes simply in monitoring, controlling, and improving of building cycle stage especially in building construction phase, could accelerate design process. After planning phase was finished, the preliminary assessment valued building plan based on green building rating tools to control construction phase sustainability [12].

3. Greenship

According to Greenship workflow, green building development has been started from initiation stage. Therefore, understanding green building concept is already required for all of the green building initiator. Green building assessment will be decided on the green building expert court to bring design recognition (DR) certification. In construction phase, building will be built according to design recognition that it needs fully integrated part of building stakeholder such as owner, consultant, and contractor. Each phase of the work will be supervised by a professional on greenship association. At the end of the construction, Green Building Council will make the final assessment based on expert court decision to determine building achievement on green building rating tools to enter operational and maintenance phase. This phase certification is named as Final Assessment (FA) certification for New Building (NB). Green building monitoring walks on the operation and maintenance phase by the building management and evaluate by green building council team yearly [13]. The final result of green building council team monitoring will be used as evidence for building certification on operational and maintenance phase that named Final Assessment (FA) certification for Existing Building (EB). Green building assessment process flow based on Greenship Assessment Tool can be drawn as Figure 3.

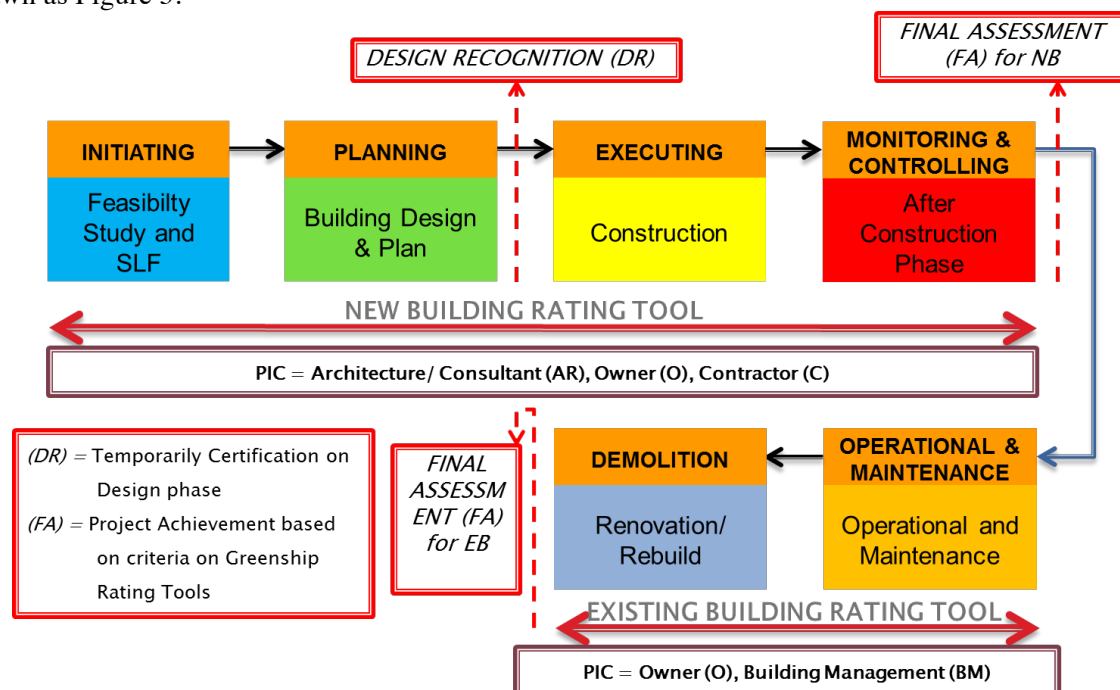


Figure 3. Flow Process on Green Building Assessment on Greenship Rating Tools [7]

4. Research Methodology

This research was conducted by observation of green building design innovations that it already has obtained Final Assessment Certificate. After that, value engineering method process was begun with information and function analysis phase. Value Engineering (VE) is an effort with systematic and organized system function, production, and service to reach essential function of life cycle cost [14]. The essential function is the optimization result of consistent performance, reliability, quality, and safety implied [15, 16]. This study begins with data collection from green building in Indonesia to benchmark achievement of aspects that was valued with green ship (green building rating tools in Indonesia). After that, creative phase began the new model that was illustrated by Function Analysis System Technique (FAST) diagram. It will be evaluated to get the result in the workshop step, analyzed the project models understand what the required functions was needed.

Generate ideas on all the possible ways accomplished the required functions. Synthesize ideas and concepts that were selected, were feasible for development into specific value improvements. Selected the 'best' alternative improved the building performance; it was continued with life cycle cost analysis. Life cycle cost analysis is a part of value engineering process, it will value for money in the owner of physical assets during all of building life cycle [17]. The best results are achieved by the optimum total costs of asset ownership.

5. Result and Discussion

This research is developed by four phase, there are information phase, function analysis phase, creative phase, and evaluation phase. In the first phase, building benchmark was based on data collection of two green office buildings in Indonesia, there are Indonesian Ministry of Public Works Building and BCA Tower. According to data survey, Both Green Building of Public Works and Housing and Green Building of BCA Tower, have premium costs for green building fixture application. Cost components of green building fixtures come from structure and architecture works and mechanical and electrical works. Initial cost breakdown structure of green building can see on Table 2.

Table 2. An Example of Green Building Initial Cost Modelling

Nu.	Building Component	Price	Unit
A INITIAL COST for GREEN FEATURE			IDR
1	Structure & Architecture	10,119,889,115.07	IDR
	- Windows & Frame Works	862,752,000.00	IDR
	Glass Volume (Facades)	15,136.00	m ²
	Conventional Glass (Clear Glass)	785,000.00	IDR/ m ²
	Green Glass (Blue Green)	842,000.00	IDR/ m ²
	- Sun Shading	4,597,560,000.00	IDR
	Sun Shading Volume	7,568.00	m ²
	Sun Shading Prices	607,500.00	IDR/ m ²
	- Insulation	85,057,474.60	IDR
	- Ceiling	443,525,119.21	IDR
	- Floor + Finishing	944,782,238.75	IDR
	- Façade Work (Wall Envelope Structure)	3,186,212,282.51	IDR
2	Mechanical & Electrical installations	6,687,828,935.64	IDR
	- HVAC	2,405,008,390.80	IDR
	- Electrical System	516,554,224.27	IDR
	- Lighting System	121,291,072.28	IDR
	- Security System	42,224,017.67	IDR
	- Fire Alarm System	179,673,488.75	IDR
	- Internal Feature Work	2,887,012,337.45	IDR
	- Water Supply System	536,065,404.44	IDR

Green building fixtures may not only give affect in initial costs of building but also in operational and maintenance costs of building. Therefore, green building operational and maintenance cost data breakdown can see on Table 3. There are benefits from green building operational, although there are some increasing maintenance costs. Benefits of green building in operational phase come from energy efficiency and water conservation. In addition, green building energy efficiency makes impact to reduce carbon emission (Table 4). This research was limited with some assumptions such as inflation, discounted rate, and salvage value (Table 5).

Table 3. An Example of Green Building Maintenance and Operational Cost Modelling

B. OPERATIONAL AND MAINTENANCE COST			
Building Power			
1	Energy Consumption Intensity	250 kWh/m ² /yr	
2	Power needs	5,676,000.00 kWh/ year	
		473,000.00 kWh/ month	
3	Energy saving average	54% per year	
	(Based conventional building)	3,065,040.00 kWh/ year	
4	Power Prices	1,200 IDR/ kWh	
5	Power Cost (PLN) - Conventional	6,811,200,000.00	IDR/ year
Water			
1	Water consumption intensity	50 liter/prs.dy	
2	Water Needs	34,050.00 m ³ / year	
		2,837.50 m ³ / month	
3	Water saving average	35% per year	
	(Based conventional building)	11,917.50 m ³ / year	
4	Water price	12,000 IDR/ m ³	
5	Water Cost (PLN) - Conventional	408,600,000.00	IDR/ year
	Maintenance/ Renewal	603,613,154.44	IDR/ year
1	Air conditioner	44,794,802.87	IDR/ year
2	Wall painting	24,634,123.52	IDR/ year
3	Cleaning service and indoor quality test	333,623,697.27	IDR/ year
4	Building structure maintenance	22,400,754.84	IDR/ year
5	Lift	18,115,101.45	IDR/ year
6	Electical	81,434,121.35	IDR/ year
7	Plumbing	30,851,339.01	IDR/ year
8	Safety	31,877,481.37	IDR/ year
9	Sanitair	15,881,732.78	IDR/ year

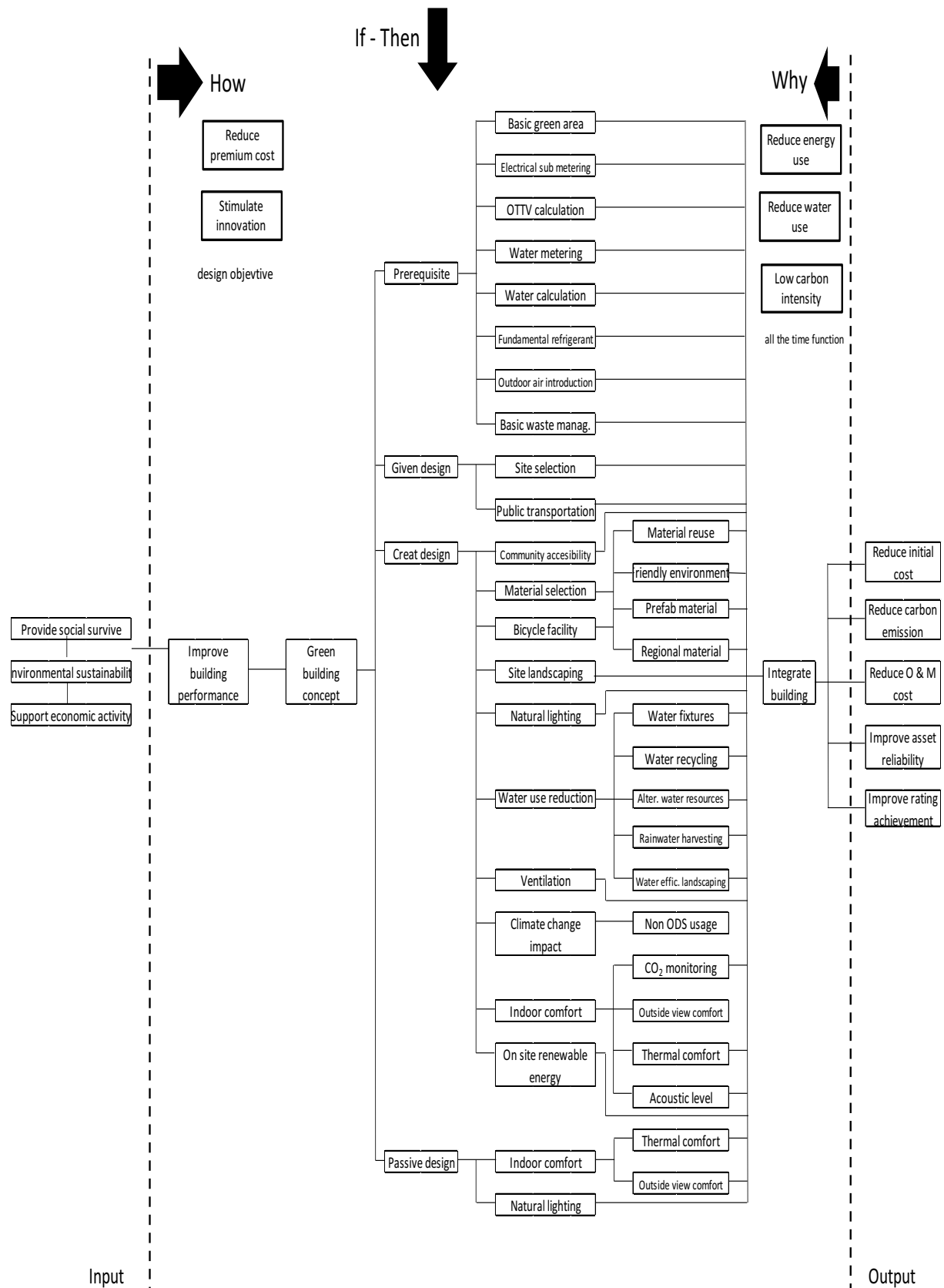
Table 4. Carbon Emission Data

C Carbon Emission Reduction		
1	CO ₂ conversion	0.891 KgCO ₂ / kWh
2	Carbon emission reduction	2,731 Ton/ year

Table 5. Assumption in Analysis

Assumption		Source
1	Current year	2014-2015 BI Rate
2	Inflation (Average)	6.81% BI Rate
3	Discount rate (Average)	12.75% BI Rate
4	Salvage Value	25.00% Trixy, 2012

In function analysis phase, this research used Function Analysis System Technique (FAST) Diagram to analyze green building construction component which could optimize building construction cost by stimulate innovation. Based on the literature, there are four main design elements which influence green building construction such as prerequisite design, given design, created design, and passive design (Figure 4). For prerequisite design, the owner has to construct prerequisite elements before getting rating point from rating criteria. In the other hand, given design was the building element that was given by the area development such as road network, bank, terminal, post office, fire department office, library, government office, medical facilities, etc.

**Figure 4.** Function Analysis System Technique Diagram

Creating building design in rating tools, ways to get the green building criteria point depend on the owner needs. In generally, creating design is decided by how many points that the building owner wants to get certification achievement. From three design factors which influences green building concept achievement, have affect to green building passive design. The example of green building passive design used efficiency on ventilation energy which can value the indoor comfort such as CO₂ monitoring and outdoor air introduction controlling. Based on this condition, using efficiency energy on ventilation system would get credit point from energy efficiency and conservation criteria. In the other hand, increasing indoor comfort by using this ventilation would make building get extra point indirect from indoor health and comfort criteria. The output of green building design that influence construction phase, is design integration of reduce initial cost, carbon emission, operational and maintenance cost, improve asset reliability, and rating achievement.

In creative phase, this research was collecting results of green building operational and maintenance. The green building managements were focus on water conservation and energy efficiency and conservation optimization. Energy saving analysis is shown in Table 6 and Table 7. Both of them describe the average calculation of annual energy efficiency. The efficiency of energy is compared to average office building standard in Indonesia and design recognition phase. Indonesia Ministry of Public Works gets platinum achievement certificate from Green Building Council Indonesia in 2012. Energy efficiency in Indonesian Ministry of Public Works reach up to 53% if it is compared to conventional office buildings energy standard value and 19% if it is compared to its design recognition. Similarly, the efficiency value in 2013 and 2014 are presented in Table 6. BCA Tower is existing building which it was retrofitted to reach Platinum rating achievement. Energy efficiency value is 18% in 2010 if it is compared to average office building standard. All of the building value by the year could be seen on Table 7. BCA Tower can't be compared with the design because it was existing green building without energy target value in the beginning.

Table 6. Analysis of Energy Consumption Intensity in Indonesian Ministry of Public Works

Year	Energy Consumption Intensity			Energy Efficiency	
	(kWh/m ² .tahun)			Toward ASEAN Office Building	Toward Green Building Design
	ASEAN	Design	Actual		
2012	240	140	112.88	53%	19%
2013	240	140	118.08	51%	16%
2014	240	140	111.20	54%	21%

Table 7. Analysis of Energy Consumption Intensity in BCA Tower

Year	Energy Consumption Intensity		Energy Efficiency
	(kWh/m ² .tahun)		Toward ASEAN Office Building
	ASEAN	Actual	
2010	240	196.45	18%
2011	240	161.29	33%
2012	240	158.30	34%
2013	240	136.16	43%

Both of green building which was benchmarking in this research is focused in energy and water efficiency for cost saving. Based on Indonesian standard, water usage target is 50 liters per user per day, but with green building design target is expected to achieve maximum 18.5 liters of water usage per user per day. The data collected in Table 8 and Table 9 show the values of efficiency that there was achieved by two green building in Indonesia. In the Year 2012, The Indonesian Ministry of Public Works Building saves water reach up to 35% compared to Indonesian standard but still beyond expectations green design target is -76%. However, the BCA tower building there is only reference

value data efficiency because the building is the existing building (not planned from the beginning as a green building).

Table 8. Analysis of Water Consumption Intensity in Indonesian Ministry of Public Works

Year	Water Consumption Intensity			Water Efficiency	
	liter/person.day			Toward SNI	Toward Green
	SNI	Design	Actual	Office Building	Building Design
2012	50	18.5	32.50	35%	-76%
2013	50	18.5	36.50	27%	-97%
2014	50	18.5	27.80	44%	-50%

Table 9. Analysis of Water Consumption Intensity in BCA Tower

Year	Water Consumption Intensity		Water Efficiency
	liter/person.day		Toward SNI
	SNI	Actual	Office Building
2010	50	8.63	83%
2011	50	36.72	27%
2012	50	49.67	1%
2013	50	53.59	-7%

Based on information phase, function analysis phase, and creative phase, is created an evaluation to get the optimum of construction performance of green building. Evaluation phase is synthesizing ideas and concepts and select those that are feasible for development into specific value improvements. According to green building observation, operational cost could be reduced by energy efficiency and water efficiency. Green building futures is modelled from initial investment looked like on Table 2 and the energy efficiency and water efficiency results for operational phase can see on Table 10. Actual Ministry of Public Works (MoPW) application for green building futures make 54% energy efficiency and 35% because there are some different system of operational. Design of MoPW begins with 44% energy efficiency and 63% water efficiency. For energy design application is good, but in water efficiency is not achieved. Therefore, this research is evaluation the cause of water efficiency problem in MoPW such as increasing building tenants and water system leakage that is not treated immediately. Green Building BCA Tower is an existing building which got retrofitting system. At the operational phase, BCA Tower can reach 35% energy efficiency and 81% water efficiency. The last system that was threatend in this research was renewable energy which never used in Indonesia.

Table 10. Optional of Green Building Efficiency Results for Energy and Water Used

Design Name	Optional	Energy Efficiency	Water Efficiency
Actual MoPW	1	54%	35%
Design MoPW	2	44%	63%
Comb. of Opt. 1 & 2	3	54%	63%
Actual BCA Tower	4	35%	81%
Comb. Opt. 3 & 4	5	54%	90%
Comb. Ops. 5 + Ren. E	6	100%	90%

This case study was formatted for combination of green building fixtures to develop the optimum green building model based on construction result until operational and maintenance phase. Indonesia Passive design in Ministry of Public Works, concerns on indoor comfort, water usage reduction, and

natural lighting system. Indoor comfort can be accommodated with structure and architecture design such as window fixture, roof insulation, ceiling, and facade work. Beside that, there is mechanical and electrical contribution such as HVAC, electrical, lighting, and security/ alarm/ sensor system. Water usage reduction is worked by water supply system to detect the water demand. Natural lighting can be controlled by sun shading, beside that it can reduce UV radiation.

For building maintenance, there are some fixtures will get maintenance and reduce operational cost. Maintenance cost elements were HVAC system, structural maintenance, mechanical and electrical system, sanitaria, and safety. In building operational, this research only considered water and energy cost. Based on deep interview, operational and maintenance aspects of green building can be optimized by enforcing smoke-free laws, commitment of top management to carry out a performance audit program building, energy/ water/ guidance of building usage campaign, convenience building used survey, pest control, installing safety equipment in the building, energy/ water metering calibration, and using automatic features/ sensor in public areas.

Green building development results presented life cycle cost analysis. First of all, Figure 5 describes relation of energy and water efficiency toward building internal rate of return. The bigger option value of energy and water efficiency will increase the internal rate of return. The second, Figure 6 describes the relation NPV of initial cost, efficiency, and salvage value. The highest initial cost for green building fixtures infestation is optional 6 because there is additional cost for renewable energy application. It makes NPV of efficiency and salvage value is higher than the others. The third, Figure 7 describes payback period of green building infestation. Optional 6 has the fastest payback period time of investment on green building (Figure 7). But, the optimum model is optional 4 because with lowest investment cost can get the moderate energy and water efficiency (Figure 8).

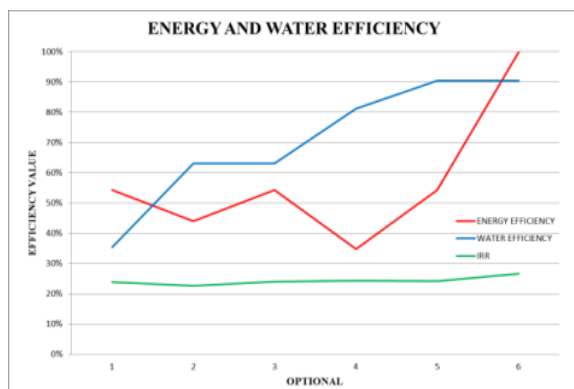


Figure 5. Value of Energy, Water Efficiency, and IRR

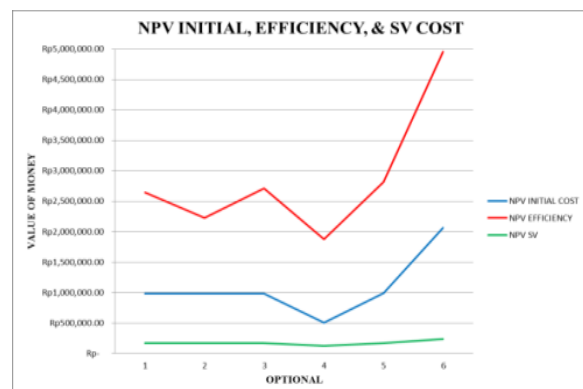


Figure 6. NPV of Initial cost, Efficiency Total, and Salvage Value

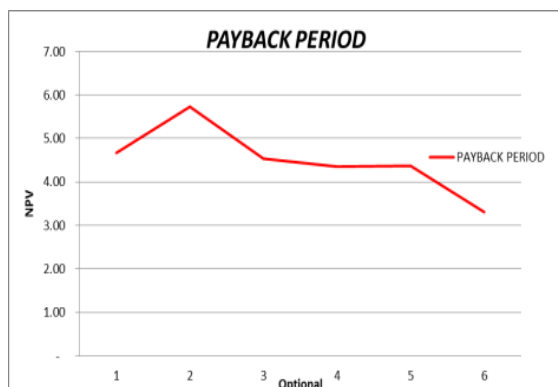


Figure 7. Payback Period of Green Future

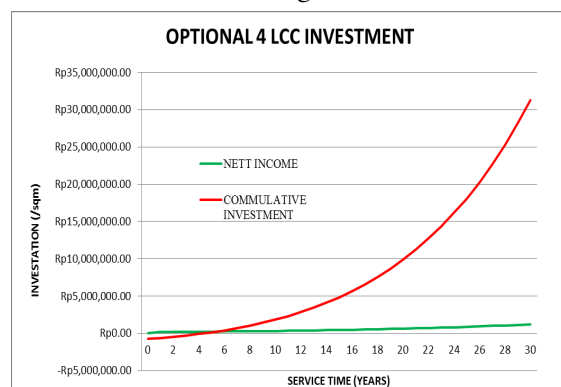


Figure 8. Optimum Cost of Building Life Cycle

6. Conclusion

According to data survey, actual life cycle cost of green building in Indonesia with platinum certificate achievement needs 13.72% additional cost. Based on Y. Lin et al. research, USA building only needs 6.50% additional cost to reach platinum achievement certification. So, green building investment in Indonesia is still in high cost. The optimum optional of green building in Indonesia was optional 4 with 7.34 % for additional cost, optimum energy and water efficiency, and more feasible infestation in Green Building Concept

Performance optimization key factors on green building construction premium cost to achieve green building operation and maintenance goals were building envelope design, kind of material (glasses, shading, and insulation), and construction method. Almost all of the creating design influences the passive design for building operational and maintenance. So, the accuracy of construction has to decide to get the best performance in operational phase. Combination of green fixtures has to measures to get the optimum in energy and water efficiency. All of the building cycle costs components have affect one to the others.

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