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Research paper

Using PLS-SEM to analyze the criteria for the optimum cost of green MICE projects in Indonesia based on value engineering and lifecycle cost analysis

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Abstract: Starting in May 2021, green building is mandatory for new buildings in Indonesia. Greenship is a green building certification system in Indonesia issued by the Green Building Council Indonesia (GBCI) which is a member of the World GBC for the conservation and efficiency of resources (energy, water, land, materials, and nature). Greenship will be implemented in MICE which is a building for Meetings, Incentives, Conventions, and Exhibitions that has a strong economic attractiveness in Indonesia, which has a population of 270 million. Using the SEM-PLS it was quickly concluded that energy is the most influential factor in achieving platinum ratings from GBCI. With the value engineering (VE) method and life cycle cost analysis (LCC), it is needed an additional 4,689% cost for the platinum grade green costs through energy optimization will get a payback period of 3 years and 10 months. The novelty of this research, since the design, it is necessary to take steps to measure energy efficiency and other resources with a selection of materials/machines and working methods of the green concept to know the amount of additional initial costs that do not much burden investment costs compared with some future benefits of green MICE.

Keywords: greenship, lifecycle cost analysis, SEM-PLS, MICE, value engineering

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1. Introduction

MICE stand for Meeting, Incentive, Convention and Exhibition which is a building used for Meeting, Incentive, Convention and Exhibition activities that have a strong economic attractiveness [1], especially in countries with large populations such as China, India, Indonesia, and America. used to introduce products, services, technology, and meetings from that country by bringing among businesspeople or businesspeople with customers, both local and international [2]. Tourists who have the intention for business (business visitors) have higher spending than tourists for recreation (leisure visitors), especially in Indonesia where the tourism industry has become the second largest source of gross foreign exchange income for the country so that all elements for increasing tourism industry income will be a concern for the Indonesian government [3]. Moreover, currently in Indonesia there are no buildings for MICE activities that are green certified and integrated for facilities that support MICE activities such as hotels, restaurants, malls, parking, shuttle buses and others.

The regulation of Minister of Public Works and Public Housing of Republic Indonesia no. 21 of 2021 concerning green buildings, it is mandatory for new buildings to be designed with green building standards. Green buildings have become a demand for building users, especially building users on an international scale [4]. The green building concept has several advantages related to the economy, social and environment that make the building have a sustainable concept of resource conservation (energy, water, land and nature), resource efficiency (energy, water, land and material) and resource sharing (public facilities on transport and working) [5]. The green building concept also brings safety and health to its users so that their work productivity will increase [6]. In Poland there is an increase in profits of 26% per year for green buildings that follow green building standards [7].

There are several categories, prerequisites and criteria that must be followed to meet the green building standards to get the certification issued by the Green Building Council Indonesia in the assessment of buildings used for MICE activities [8].To find out the criteria or influencing factors in achieving the platinum rating quickly simultaneously [9], the Smart-PLS SEM will be used as a tool to process it [10].

By knowing what criteria or factors influence the achievement of green building certification, it can be seen how much it costs to design a conventional building into a green building [11]. Based on previous research, it was found that the cost of making a green building varied but the lowest was 7% [12].

Knowledge of the benefits of green buildings can assist stakeholders in realizing their commitment to following government regulations in realizing green buildings that can make the survival of the environment and existing resources longer and more sustainable through value engineering methods and lifecycle cost analysis in the optimization cost of design, construction, operation and maintenance of green buildings that can extend their useful life so that it becomes more feasible in this MICE business [13].

2. Structural Equation Modelling (SEM) SMART-PLS (Partial Least Square)

Structural equation modelling (SEM) combines two approaches to model testing, namely factor analysis and multiple regression analysis. Regression analysis deals with the relationship between criterion variables and predictor variables, whereas factor analysis attempts to find a set of latent variables (i.e., factors). it explains the general variance that exists among a set of observed variables. Factor analysis is most often applied to determine the structure of the underlying factor scores in a set of questionnaire items. therefore, sem-pls (partial least square) is very suitable for this research. in this way, the current study examines the measurement model (validity and reliability) and the structural model (tests the relationship between variables).

The first outside measurement model is concerned with measuring convergent validity with individual item reliability (> 0.700), aggregated reliability (> 0.700), and mean extracted variance (ave > 0.500). in addition, in this model discriminatory reliability is measured in terms of cross-loading, and the variable correlation was evaluated [14]. The inner structure of the two models relates to the coefficient of determination (r^2), goodness of fit of the model, and hypothesis testing [15].

2.1. Indicators

There are Eligibility provisions and six categories of assessment to get the Greenship New Building certification from GBCI. Each category consists of several criteria containing Prerequisites, Credit Points and Bonus Points. The six categories are as follows Appropriate Site Development (Table 1), the Energy Efficiency and Conservation (Table 2), the Water Conservation (Table 3), the Material Resources and Cycle (Table 4), the Indoor Health and Comfort (Table 5) and the Building and Environmental Management (Table 6).

Table 1. Appropriate Site Development

Factor	Indicator	Point
Basic Green Area	E.1.1	Prerequisite
Site Selection	E.1.2.	2
Community Accessibility	E.1.3.	2
Public Transportation	E.1.4.	2
Bicycle Facility	E.1.5.	2
Site Landscaping	E.1.6	3
Microclimate	E.1.7	3
Stormwater Management	E.1.8	3
Total Category		17

Table 2. Energy Efficiency and Conservation

Factor	Indicator	Point
Electrical Sub Metering	E.2.1.	Prerequisite
OTTV Calculation	E.2.2.	Prerequisite
Energy Efficiency Measures	E.2.3.	20
Natural Lighting	E.2.4	4
Ventilation	E.2.5	1
Climate Change Impact	E.2.6	1
On Site Renewable Energy	E.2.7	5 (Bonus)
Total Category		26

Table 3. Water Conservation

Factor	Indicator	Points
Water Metering	E.3.1.	Prerequisite
Water Calculation	E.3.2	Prerequisite
Water Use Reduction	E.3.3.	8
Water Fixtures	E.3.4.	3
Water Recycling	E.3.5	3
Alternative Water Resources	E.3.6	2
Rainwater Harvesting	E.3.7	3
Water Efficiency Landscaping	E.3.8	2
Total Category		21

Table 4. Material Resources and Cycle

Factor	Indicator	Points
Fundamental Refrigerant	E.4.1	Prerequisite
Building and Material Reuse	E.4.2	2
Environmentally Friendly Material	E.4.3	3
Non ODS Usage	E.4.4	2
Certified Wood	E.4.5	2
Prefab Material	E.4.6	3
Regional Material	E.4.7	2
Total Category		14

Table 5. Indoor Health and Comfort

Factor	Indicator	Points
Outdoor Air Introduction	E.5.1	Prerequisite
CO2 Monitoring	E.5.2	1
Environmental Tobacco Smoke Control	E.5.3	2
Chemical Pollutant	E.5.4	3
Outside View	E.5.5	1
Visual Comfort	E.5.6	1
Thermal Comfort	E.5.7	1
Acoustic Level	E.5.8	1
Total category		10

Table 6. Building and Environmental Management

Factor	Indicator	Points
Basic Waste Management	E.6.1	Prerequisite
GP as a Member of Project Team	E.6.2	1
Pollution of Construction Activity	E.6.3	2
Advanced Waste Management	E.6.4	2
Proper Commissioning	E.6.5	3
Green Building Submission Data	E. 6.6	2
Fit Out Agreement	E.6.7	1
Occupant Survey	E.6.8	1
Total category		13

In obtaining the Greenship New Building certification, there are two (2) stages of assessment:

a. Design Recognition Stage (DR), with a maximum score of 77 points.

If the building is still in the planning stage, the project team will receive a provisional award for the project at the final design and planning stage based on the Greenship assessment tool.

b. Final Assessment Stage (FA), with a maximum score of 101 points.

In the final stage, the overall performance of the building is assessed thoroughly both from the design and construction aspects based on the Greenship assessment tool.

Every new building with an area of over 50,000 M2 will have two stages of assessment, at the time of design and when the building is completed which will be carried out by a professional Greenship.

The rating from Design Recognition (DR) and Final Assessment (FA) in Table 7.

Table 7. Rating Design Recognition (DR) and Final Assessment (FA)

Rating	Percentage	Score Minimum DR	Score Minimum FA
Platinum	73%	56	74
Gold	57%	43	58
Silver	46%	35	46
Bronze	35%	27	35

Indicators related to engineering were made starting from E1 to E6, related to Construction fields related to structural work (ES), architecture work (EA), mechanical work (EM), electrical work (EE), and other work (EO), while in Operations fields are related to energy (OE), maintenance (OM), worker/employees (Ow), and others (OO). For 8 phases of value engineering, indicators will be named from VE1 up to VE 8, so that the structural model is as shown in Figure 1.

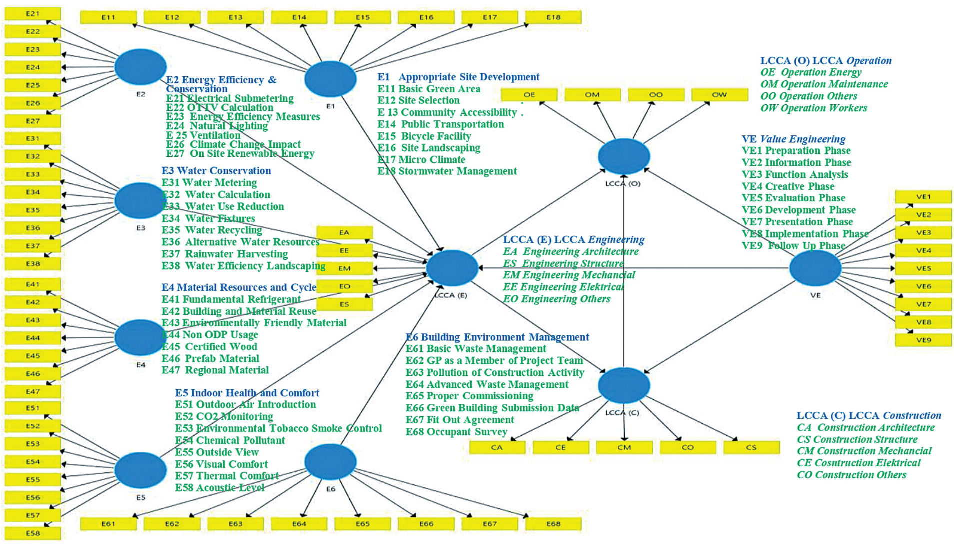

Fig. 1. Structural Model Green Building, Value Engineering, Lifecycle Cost analysis

2.2. Outer Loading Analysis

In phase I, with the calculation of the Smart PLS program. The Smart-PLS results from the Calculate PLS command where the PLS Algorithm produces a Path Coefficient with an Outer Loading value > 0.5 is still acceptable and will be removed from the diagram that has an outer loading value < 0.5. All indicators whose outer loading value is > 0.5 based on the outer loading validity are stated that all indicators have convergent validity as Average Variance Extracted (AVE) as shown in Table 8.

Table 8. Average Variance Extracted

Factor	Average Variance Extracted (AVE)	Factor	Average Variance Extracted (AVE)
E12	0.628	E56	0.774
E15	0.593	E58	0.711
E16	0.637	E62	0.748
E17	0.645	E63	0.732
E18	0.643	E64	0.529
E22	0.566	E66	0.720
E23	0.795	E68	0.575
E24	0.512	EE	0.821
E27	0.819	ES	0.788
E33	0.762	VE1	0.870
E34	0.647	VE2	0.871
E37	0.747	VE3	0.815
E42	0.789	VE4	0.830
E44	0.844	VE5	0.844
E46	0.503	VE6	0.937
E52	0.784	VE7	0.920
E53	0.587	VE8	0.897
E54	0.553	VE9	0.775

The next step is to conduct an analysis of Construct Reliability. Construct Reliability is measuring the reliability of the latent variable construct. The value that is considered reliable must be above 0.70. Construct reliability is the same as Cronbach alpha as shown in Table 9.

2.3. Inner Loading Analysis

The next step is to find the coefficient of T Statistics as a research hypothesis testing. Where the Smart-PLS result or output from the PLS calculation command produces T Statistics. The result of the statistical T value is above 1.96, so it can be concluded that there is a significant effect as shown in Table 10. And if what is displayed is the P Value

Table 9. Convergent Validity – Cronbach Alpha

Factor	Convergent Validity-Cronbach Alpha	Factor	Convergent Validity-Cronbach Alpha
E12	0.859	E54	0.790
E15	0.769	E62	0.887
E18	0.709	E63	0.799
E23	0.881	E64	0.703
E27	0.874	VE1	0.871
E33	0.863	VE2	0.871
E34	0.824	VE3	0.819
E37	0.764	VE4	0.828
E42	0.838	VE5	0.844
E44	0.823	VE6	0.937
E46	0.738	VE7	0.920
E52	0.809	VE8	0.896
E53	0.759	VE9	0.774

Table 10. T Statistics Value

Factor	T Statistic Value	Factor	T Statistic Value
E12	13.077	E54	8.897
E15	10.251	E62	24.079
E18	8.651	E63	10.744
E23	29.350	E64	6.342
E27	5.908	VE1	22.493
E33	27.645	VE2	19.295
E34	5.213	VE3	16.839
E37	9.623	VE4	14.709
E42	15.065	VE5	16.788
E44	11.535	VE6	69.494
E46	3.401	VE7	40.634
E52	28.697	VE8	33.830
E53	8.497	VE9	9.026
E54	8.897	E54	0.000

of the loading factor and path coefficient. For the results of P Value < 0.05, all indicators forming the construct are declared valid so that they can be used to test hypotheses at the structural measurement stage as shown in Table 11.

Table 11. P Value

Factor	P Value	Factor	P Value
E12	13.077	E54	0.000
E15	10.251	E62	0.000
E18	8.651	E63	0.000
E23	29.350	E64	0.000
E27	5.908	VE1	0.000
E33	27.645	VE2	0.000
E34	5.213	VE3	0.000
E37	9.623	VE4	0.000
E42	15.065	VE5	0.000
E44	11.535	VE6	0.000
E46	3.401	VE7	0.000
E52	28.697	VE8	0.000
E53	8.497	VE9	0.000

The value of R Square which is the goodness-fit-model test, the results of the research. The R Square value of the joint effect on LCCA (E) is 0.718 with an adjusted R Square value of 0.691, it can be explained that all independent variables simultaneously affect LCCA (E) of 0.691 or 69.1%. Because adjusted R Square 69.1% > 50%, the influence of all independent variables on LCCA (E) is strong.

The results of the analysis for the Platinum rating of the Green Building which is a model of the relationship or influence factor, it is concluded that the most influential factor is Energy Efficiency Measures (0.895) whose model is as follows:

$$\begin{aligned}\mathrm{LCCA(E)} = {} & 0.859E12 + 0.769E15 + 0.689E18 + 0.895E23 + 0.884E27 + 0.810E33 \\ & + 0.637E34 + 0.764E37 + 0.838E42 + 0.823E44 + 0.538E46 + 0.809E52 \\ & + 0.759E53 + 0.790E54 + 0.887E62 + 0.799E63 + 0.673E64 + 0.871VE1 \\ & + 0.871VE2 + 0.819VE3 + 0.828VE4 + 0.844VE5 + 0.937VE6 \\ & + 0.920VE7 + 0.896VE8 + 0.774VE9\end{aligned}$$

Based on the answers from 80 respondents, it was found that 17 of the influential factors out of 46 Greenship factors as shown in Table 12 and all phases in value engineering as shown in Table 13 affect life cycle cost analysis (Engineering) in achieving platinum rating.

Table 12. 17 Influential Factors

Variable	Factor Greenship (GBCI)	Points
E12	Site Selection	2
E15	Bicycle Facility	2
E18	Stormwater Management	3
E 23	Energy Efficiency Measures	20
E 27	On Site Renewable Energy	5
E 33	Water Use Reduction	8
E 34	Water Fixtures	3
E37	Rainwater Harvesting	3
E42	Building and Material Reuse	2
E44	Non ODP Usage	2
E 46	Prefab Material	3
E52	CO2 Monitoring	1
E53	Environmental Tobacco Smoke Control	2
E54	Chemical Pollutant	3
E62	GP as a Member of Project Team	1
E63	Pollution of Construction Activity	2
E64	Advanced Waste Management	2
	Total Platinum	64

Table 13. All Phases Value Engineering

Variable	Factor Value Engineering
VE 1	Preparation Phase
VE 2	Information Phase
VE 3	Function Analysis Phase
VE 4	Creative Phase
VE 5	Evaluation Phase
VE 6	Development Phase
VE 7	Presentation Phase
VE 8	Implementation Phase
VE 9	Follow-Up Phase

3. Research result

There are 17 factors or indicators that influence the MICE building to get a green building certificate from Greenship for platinum rating, and it takes an additional cost as a green building cost of IDR 379,036,191,458 = 7.494% with details as shown in Table 14 and the breakdown cost as in table 15 so that the initial cost from IDR 5,057,670,000,000 to IDR 5,436,706,191,458.

Table 14. Total Additional Green Costs

Work Description	Initial Cost IDR	Worth to Green Building IDR
Preliminaries	536,964,000,000	536,964,000,000
Project Site Preparation & Vacuuming System	46,000,000,000	46,000,000,000
Basement Foundation & Piling Works	575,470,000,000	575,470,000,000
Structural Works	1,338,265,000,000	1,338,265,000,000
Architectural Works & Finishes	800,208,000,000	907,953,638,400
MEP Services	1,546,565,000,000	1,817,855,553,058
External & Infrastructure Works	178,043,000,000	178,043,000,000
Other Packages	36,155,000,000	36,155,000,000
Total Investment	5,057,670,000,000	5,436,706,191,458
Total Additional Cost		7.494%

4. Value Engineering

To achieve the optimum cost of investment costs to build MICE buildings based on Greenship, it is necessary to analyze based on value engineering and life cycle costs to attract MICE building owners to the benefits that will be obtained and the costs incurred [16].

Based on Pareto law where there is work that exceeds 20%, value engineering can be done. Based on Table 14 the initial costs from the breakdown of the largest costs are mechanical and electrical work of 30.6% and the most influential factor E 23 = Energy Efficiency Measures = 20 points so that the focus is on internal energy earned a platinum rating of Greenship as green costs.

Mechanical and electrical work will be described in more detail, including any work that involves other work that can cause changes in the cost of mechanical and electrical work, such as building envelope work that will affect the air conditioning capacity to be used in the building, where there is an increase in costs on the improvement of the building envelope but the air conditioning capacity will decrease so that there will be savings in the initial investment cost or operational costs [17].

Table 15. Cost Breakdown Of Additional Cost Before Value Engineering

Work Descriptions	Initial Cost IDR	Worth to Green Building (IDR)
Preliminaries	536,964,000,000	536,964,000,000
Project Site Preparation & Vacuuming System	46,000,000,000	46,000,000,000
Basement Foundation & Piling Works	575,470,000,000	575,470,000,000
Structural Works	1,338,265,000,000	1,338,265,000,000
Architectural Works & Finishes	800,208,000,000	800,208,000,000
Additional Cost for Glass replacement on Building Envelope		107,745,638,400
MEP Services	1,546,565,000,000	1,546,565,000,000
Additional cost on Chiller		60,522,553,058
Additional cost on BMS		154,224,000,000
Additional Cost on PV		56,544,000,000
External & Infrastructure Works	178,043,000,000	178,043,000,000
Other Packages	36,155,000,000	36,155,000,000
Total Investment	5,057,670,000,000	5,436,706,191,458

The increase in the building envelope will affect the overall thermal transfer value not only reducing the capacity of the air conditioning system to be used but also reducing carbon dioxide.

From the value engineering stage, this research uses the Function Analysis System Technique (FAST) Diagram in analyzing energy optimization.

Energy optimization is carried out on:

a) the air conditioning system that will be used because the energy cost of a building is the highest from the air conditioning machine,
b) the Air Conditioning load which will be evaluated from the load of the glass envelope building as Overall Thermal Transfer Value (OTTV),
c) other energy besides Air Conditioner which requires energy management,
d) alternative energy sources as renewable energy.

All is called FAST diagram before value engineering as shown in Figure 2.

In relation to energy optimization, an analysis was carried out on the causes of the cooling load capacity, and partial load of the chiller, building management systems, and alternative energy sources to reduce additional costs as shown in Figure 3. with details of additional cost reductions to IDR 237,173,388,379. All is called FAST diagram after value engineering as shown in Table 16.

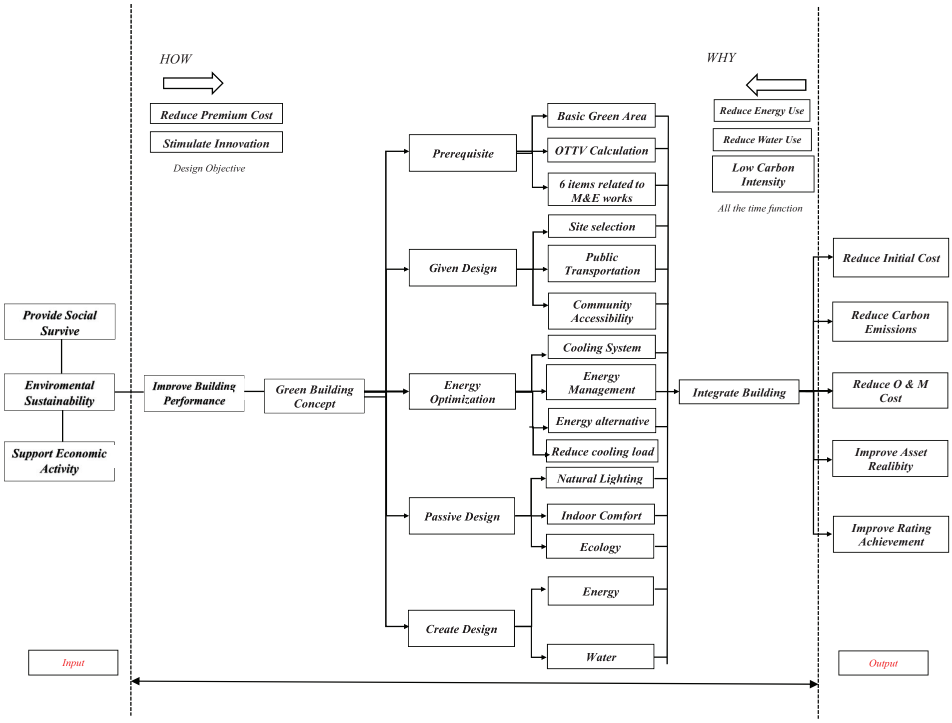

Fig. 2. Function Analysis System Technique Diagram Before Value Engineering

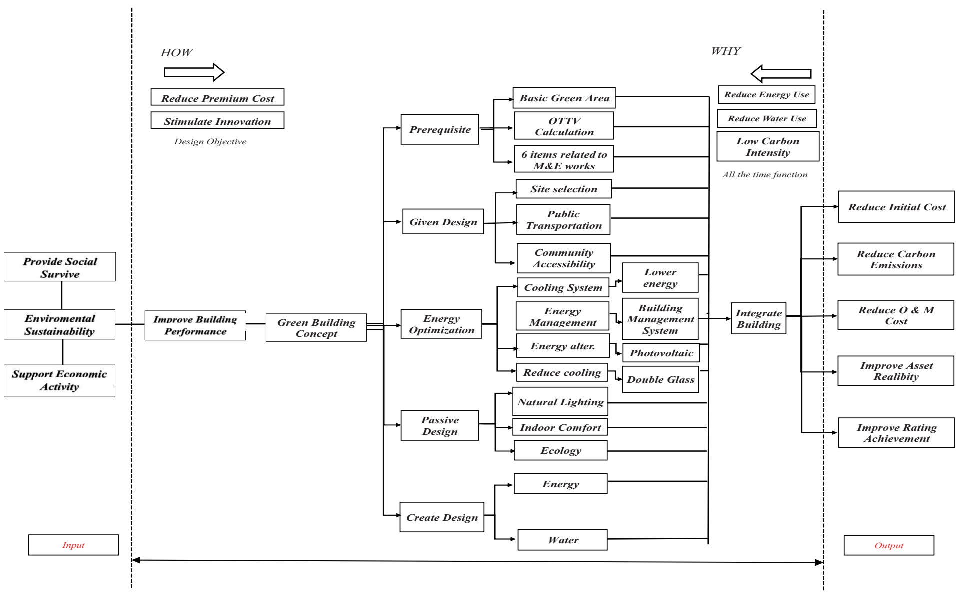

Fig. 3. Function Analysis System Technique Diagram After Value Engineering

Table 16. Cost Breakdown Of Additional Cost After Value Engineering

Work Descriptions	Initial Cost IDR	Worth to Green Building IDR
Preliminaries	536,964,000,000	536,964,000,000
Project Site Preparation & Vacuuming System	46,000,000,000	46,000,000,000
Basement Foundation & Piling Works	575,470,000,000	575,470,000,000
Structural Works	1,338,265,000,000	1,338,265,000,000
Architectural Works & Finishes	800,208,000,000	800,208,000,000
Additional Cost for Glass replacement on Building Envelope		107,745,638,400
MEP Services	1,546,565,000,000	1,546,565,000,000
Additional cost on Chiller		33,073,749,979
Additional cost on BMS		61,200,000,000
Additional Cost on PV		35,154,000,000
External & Infrastructure Works	178,043,000,000	178,043,000,000
Other Packages	36,155,000,000	36,155,000,000
Total Investment	5,057,670,000,000	5,294,843,388,379
Total additional cost		4.689%

4.1. Lifecycle Cost Analysis (LCCA)

This stage is carried out using Life Cycle Cost Analysis (LCCA) which is based on the analysis of the value of money against time based on the estimated rate of interest and the duration of the plan life, with the aim of knowing the long-term benefits of several alternative innovations that have been determined both from the aspects of initial cost prediction (Initial Cost), Energy costs, repair costs (Replacement / Repair Cost), maintenance and operational costs (Maintenance and Operational) and prediction of residual costs (Salvage Cost), then a cumulative analysis of costs is carried out – costs and benefits that may be obtained over the life of the alternative to be selected [18].

Life Cycle cost is based on 10% loan interest rate and 6% equity interest rate, with a loan of 80% and 20% equity, the WACC (Weighted average cost of capital) = 9.2%. By estimating the chiller capacity reduction, replacement or repair of glasswork, solar panel work and building management system so the total additional cost after value engineering of IDR 237,173,388,379 so the additional cost can be returned in 3 years and 10 months as a payback period as shown in Table 17.

Table 17. Lifecycle Cost Analysis

		Description		Initial Cost Present Worth (IDR)	After Value Engineering Present Worth (IDR)
A		**Initial Cost**			
	1	Chiller Investment Cost		98,035,794,643	150,541,000,184
	2	Glass Investment Cost		104,953,449,600	212,699,088,000
	3	Chiller Investment Reduction Cost		–	(19,431,455,562)
	4	Solar Panel Investment Cost		37,200,000,000	72,354,000,000
	5	BMS Investment Cost		13,644,150,000	74,844,150,000
	6	Total Investment Costs		253,833,394,243	491,006,782,622
B		**Annualized life cycle cost**			
	7	Ann. Owning & Opening cost			
	a	Initial cost			
		CRF for 20 years @ WACC	0,1175	29,815,175,243	57,673,472,448
	b	Replacement cost		939,075,641	2,169,293,559
				722,841,433	1,669,785,901
	c	Salvage value		(575,762,383)	(884,124,470)
	d	Annual operation		164,448,302,346	72,155,842,042
	8	**Total Annual cost**		**195,349,632,279**	**132,784,269,480**
	9	Annual Difference			62,565,362,799
		CRF = Capital Recovery factor			

5. Conclusions

The use of SEM-PLS based on value engineering methods and Lifecycle Cost Analysis for green MICE in reducing initial costs, reducing carbon emissions, reducing operation & maintenance costs and improving rating improvements is appropriate for use in this study.

Creating a new building based on a green building, especially for MICE, will create several benefits: for the world (reducing CO2 emissions of 12,573,978.82 kg), countries (reducing the use of energy resources of 14,112,208.96 kwh/year) financial (reducing operating costs of IDR 62,565,362,799 /year, increasing profits, and increasing building value as platinum class green building) and productivity (healthy building occupants and users from Indoor Health and comfort in fifth category of Greenship).

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