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Green Retrofitting in Hospital Project Based On Value Engineering

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Abstract. The need for hospital capacity is the ratio of the number of beds to the population, World Health Organization recommends 5:1.000 population, while Indonesia's hospital capacity has only reached 1.21:1.000 population. Indonesia still desperately needs new hospitals. To reduce the environmental burden, every hospital must be built and developed with a green concept. Based on research, the lowest green building will experience cost overrun ranging from 4.5% to 7% from conventional design. With the Value Engineering method, then Lifecycle Cost Analysis, the researcher applies the green concept in the case study project, but it is still cost efficient and even lower than the initial Budget Plan. To determine the effect of the two methods on the green hospital project, the researcher analyzed it with SPSS. Return on capital for procurement of HTW waste destroyer = 4.28 Years 4 Years 3 Months for BEP. Without calculating the residual value (residual value), investment as an additional function for HTW waste destruction can be environmentally friendly and profitable in terms of investment.

INTRODUCTION

Referring to the United Nations Environment Program (UNEP, 2009), if Green technology is applied properly it can save energy by 30% - 80%. Furthermore, economic savings due to reduced energy consumption need to be considered. At this point, it's worth highlighting the value of interior and daylight in the hospital building, because, right now, it's one of the best-returning facilities [1].

The architecture, engineering, and construction (AEC) industry are often criticized for its negative impact on the environment, including environmental pollution, waste of energy, and loss of biodiversity [2]. Noting the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity, recognized by some cultures as Mother Earth, and noting the importance for some of the concept of "climate justice", when taking action to address climate change [3].The construction sector is responsible for the use of natural resources and excessive amounts of energy consumption. It is reported that buildings constitute 36% of CO2 emissions [4]. Hospital buildings consume 73 billion kilowatt-hours (Kwh) of electricity each year, contributing to the fact that buildings are responsible for nearly 70% of total electricity use in the United States [5].

One of the major problems hampering the successful completion of most projects in the construction industry is a cost overrun [6]. As for current cost performance, it was concluded that green building projects were generally over budget (4.5%, 7%), which was worse than traditional building projects. [7] Therefore, there were other potential incentive models in green building implementation, such as the Floor-to-Area Ratio (FAR), tax reduction, and expediting the permit process[8].

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As the importance of sustainable design continues to grow, it becomes increasingly vital to develop methodologies capable of aiding designers in assessing if a project is sustainable and cost-effective while still in successful parallel with the owner's goals [9]. With this research, it is hoped that the construction of a hospital can be made more adaptable to the mandatory requirements for the provisions of Green Hospital. With all the modern world variety of ways to organize hospital systems, when designing new hospitals, it is worth considering the general trends: the enlargement of medical buildings, the formation of complexes; emphasis on the intensity of treatment, the use of day hospitals; individualization of design decisions, rejection of stereotypical hospital forms; the formation of an aesthetic space with healing potential; ecological approach and harmony with the environment [10]. Value engineering has been used as a methodology to provide added value and to enhance maximum results for project development in terms of improvement on quality, technology, and innovation [11]. LCCA is a technical and economic optimization method whose main goal is to identify and choose the solution that generates the highest income throughout its service life or, in other words, has the lowest lifecycle cost.[12]. The lifecycle cost analysis using the IRR and NPV approach confirms The Sunda Strait Bridge (SSB) project with additional functions increases the Internal Rate of Return for the whole project by 7.56% that would provide a positive NPV value[13].

There are five main areas to assess: energy efficiency, water efficiency environmental protection, indoor environmental quality, and other green features and innovation[14].

The research question from this research are:

- What are the factors that influence the success of increasing the cost performance of the Green Hospital building project?
- How can an analysis of the implementation of Value Engineering improve the cost performance of the Green Hospital building project?

SPSS Data Analysis (Statistical Products and Solution Services)

There are many software solutions to this issue but one of the most famous is SPSS [15].The SPSS (Statistical Products and Solution Services) data analysis program is used to measure the level of closeness of the relationship between all independent variables / X (independent) aspects of X1= Green Hospital (GH) Project; X2 = Lifecycle Cost Analysis (LCCA) and X3 = Value Engineering (VE) in the to the dependent variable / Y (dependent) Increased Cost Performance.

The data analysis process will use a simulation tool, namely SPSS ver. 21 (Statistical Products and Solution Services) accompanied by interviews and questionnaires, will be found the dominant things from several variables and their sub-factors that affect the cost performance that the author wants to examine.

Effect of Variable X Partially On Y (T-Test)

The results of the SPSS data analysis see (Table 1.):

TABLE 1. T-test

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5,984	2,741		2,183	0.033
Green Hospital	0.106	0.037	0.276	2,869	0.006
Lifecycle Cost	0.112	0.051	0.232	2,193	0.032
Value Engineering	0.141	0.035	0.435	4,018	0.000

Plug the numeric coefficient from column B into the equation:

$$Y = 5.984 + 0.106X1 + 0.112X2 + 0.141X3$$

The t-test is known as the partial test, which is to test how the influence of each independent variable individually on the dependent variable.

Mean and Ranking

The results of the SPSS data analysis see (Table 2.):

TABLE 2. Mean and Ranking Table

Rank	No. Sort	Sub Factor	Mean	Sub Factors
1	2	X1_02	4.68	Competence of project manager
2	6	X1_06	4.67	Policies and regulations
3	14	X2_01	4.48	Initial Cost
4	17	X2_04	4.42	Operational and Maintenance Costs (OM Cost)
5	19	X2_06	4.39	Analysis Period (n)
6	22	X2_09	4.33	Modelling without residual value
7	24	X3_01	4.29	Selection of the right material alternative
8	28	X3_05	4.19	There is a multidisciplinary VE Team
9	32	X3_09	4.17	Input information and communication as well as possible
10	34	X3_11	4.16	Primary function

Based on the ranking of research and questionnaires that have been conducted, that every cost planning, work methods and material specification must be checked again whether it meets the previous green concept, then the performance by a team led by a project manager who is competent in realizing the green concept.

Government policies such as tax free, permit relief, etc. Government regulations, such as not issuing permits if the building does not have a Green concept or is prohibited from standing, building regulations are not Green concept etc.
These are all coercion and the government's strategy so that everything goes towards building a Green concept, in order to ease the burden on the environment and make the quality of life better.

METHOD OF RESEARCH

Applying this Green concept, the writer tries to validate the hypothesis to the hospital project as the object of research is the construction project of the Hospital, by applying the Green Hospital concept using the Value Engineering and Lifecycle Cost Analysis (LCCA) method to achieve cost performance. The building project should thus be considered in terms of its entire life cycle. In this relation, the BLCC approach (Building Lifecycle Costs) plays an important role as it focuses on cost optimization throughout the entire life cycle [16].

Value Engineering

Value Engineering is an engineering technology theory, the basic idea is the minimum cost in exchange for the required function (Ren 2010)[17]. Value Engineering is conducted to produce innovative ideas that potentially could be integrated into the project by using the Function Analysis System Technique (FAST) diagram[18].

	Architectural Work	Structure Works	MEP Works	Etc. Works	Preparation Works	Earthworks
Amount	7,762,135,849	5,631,205,728	5,082,139,311	1,391,795,885	518,239,239	354,199,036
Percentage	37.43%	27.15%	24.50%	6.71%	2.50%	1.71%

FIGURE 1. Highest to Lowest Percentage of Costs with Pareto

From Pareto above, the percentage of architectural work is the highest and then structural work. So Value Engineering (VE) focuses on the work, so that VE results can have an impact on cost efficiency.

So that the FAST diagram will look like the image below, describing its function and looking for alternative substitutes:

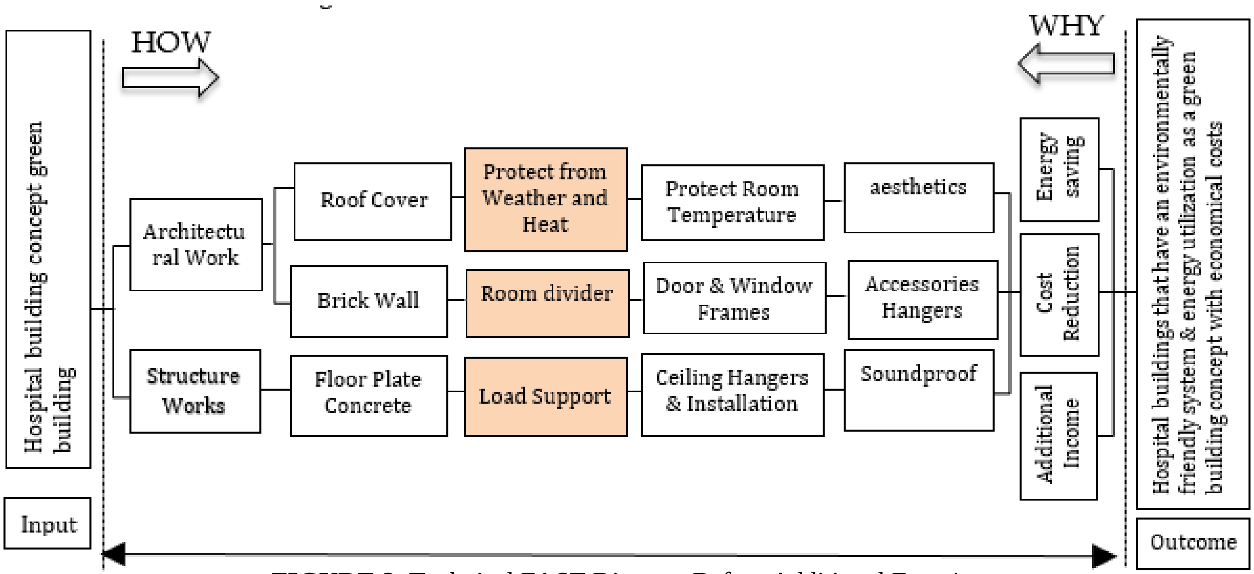

FIGURE 2. Technical FAST Diagram Before Additional Function

The 'how-why' logical model is used to identify, classify, develop and select functions that could create greater value and benefit to the project development [18].

From the FAST diagram, it is obtained several work items can be carried out by the VE process without reducing functions at a cheaper cost and environmentally friendly.

The results of the VE analysis see (Table 3.):

TABLE 3. Recapitulation of VE Function Analysis

Component	Function			Cost	After VE
	Verb	Noun	Kind	(IDR)	(IDR)
Roof Cover	Protecting	Building	Primary	340.236.611	301.039.231
Brick Wall	Dividing	Room	Primary	1.167.133.533	926.232.033
Floor Plate Concrete	Supporting	Load	Primary	1.303.140.807	1.040.740.099
Total Amount				2.810.510.950	2.268.011.362
Total VE (Cost – After VE)					542.499.588
Project Total Amount				20.739.715.048	20.197.215.460
Savings Percentage Value Engineering Green					2,62%

Lifecycle Cost Analysis (LCCA)

In the case study work item section that the researcher carried out, Lifecycle Cost Analysis (LCCA), there are two items, which are included in the Green building requirements, namely the provision of photovoltaic (PV) solar panel energy and the destruction of HTW waste (Hazardous and Toxic Materials). Both are mandatory requirements for Green buildings, namely Save Energy and Waste Reduce, moreover, hospitals produce a lot of standard HTW and infectious waste that needs to be destroyed immediately. The installation of solar panels in addition to helping lighten the load environment is also able to save costs from energy. VE is the systematic review of a project, product, or process to improve performance, quality, and/or lifecycle cost by an independent multidisciplinary team of specialists (Berawi, 2004)[19].

This function analysis method uses the FAST (Function Analysis System Technique) method which is described in a verb and noun format which is divided into two functions, namely Main Functions and Supporting Functions. See Figure 3. For the Technical FAST Diagram After Additional Function [19].

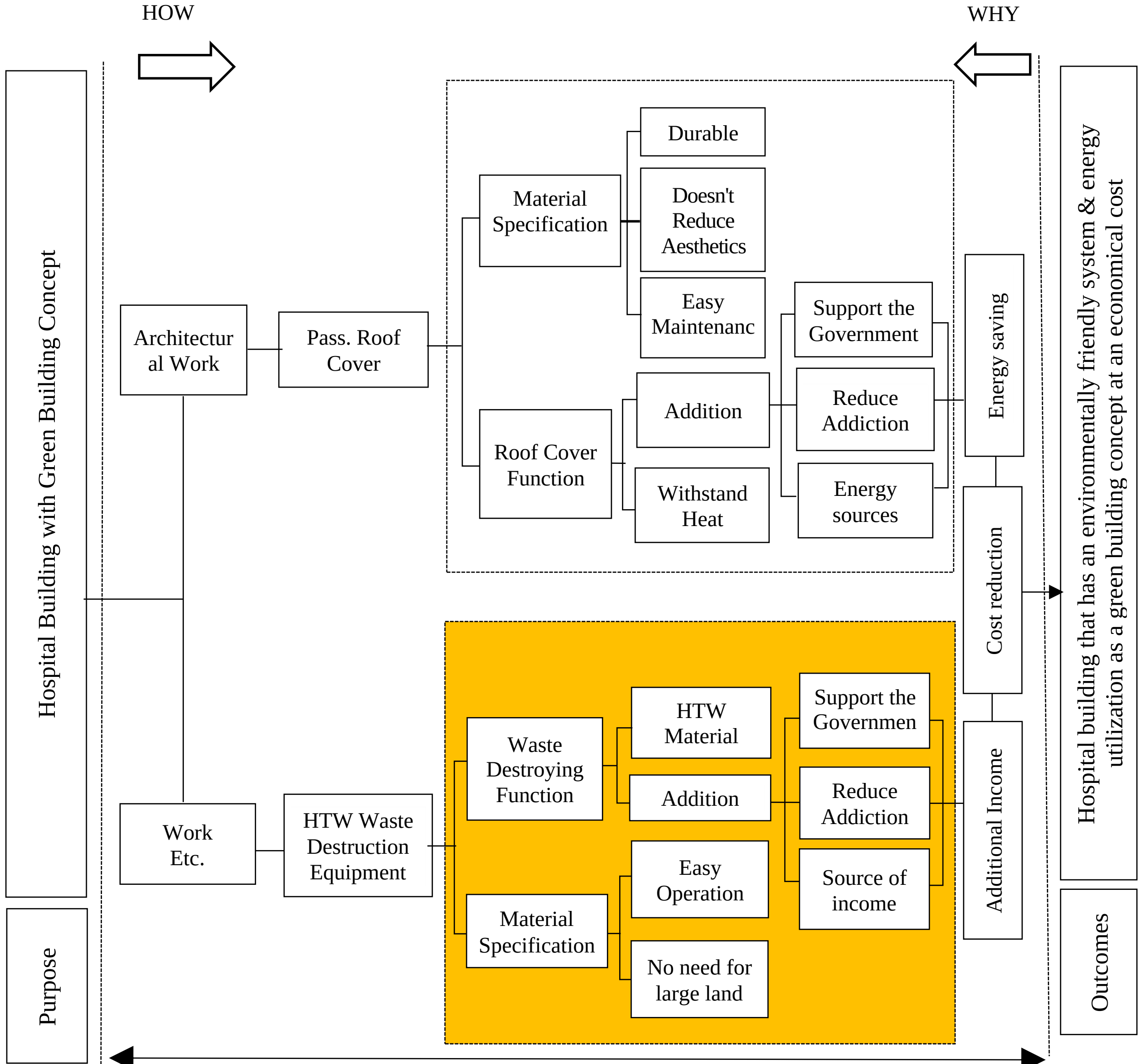

FIGURE 3. Technical FAST Diagram After Additional Function

Sustainable development principles in the built environment have encouraged researchers to focus on more efficient building envelopes [20] . The function identification is the preliminary step of executing a functional analysis. This phase involved function identification from the previous step then categorizing them according to each of their function [21].

In general, the LCC calculation steps are as follows:
Lifecycle Cost Analysis:

Cost Breakdown Structure (CBS)--LCC Modelling Without Residual Value--Lifecycle Cost Analysis --Sensitivity Analysis--Efficiency [22].

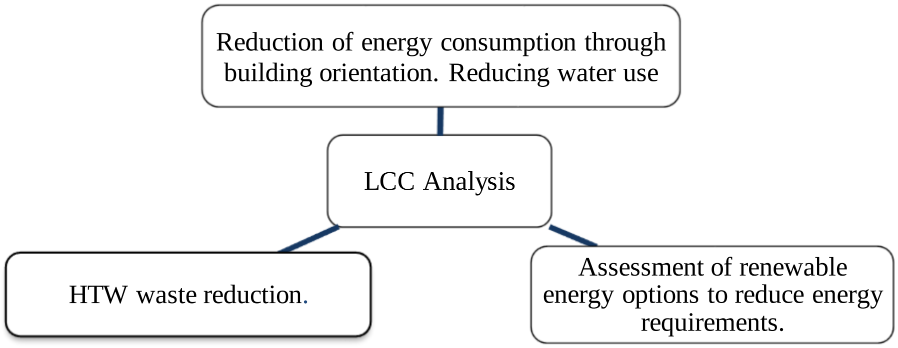

FIGURE 4. Value Engineering Plan

In this research, the addition of new investments is focused on reducing and destroying hazardous waste.

Green building is emphasized in the whole life cycle of the building. It includes building materials production, planning, design, construction, operation and maintenance and removal, recycling scrap the whole process, all links can be an efficient use of building resources, land saving, energy-saving and water saving [23].

Several obstacles in implementing *P.56/Menlhk-Setjen/2015* concerning Procedures and Technical Requirements for Management of Hazardous and Toxic Waste (HTW) from Health Service Facilities, among others, are the limited number of HTW waste processing companies that already have permits from the Ministry of Environment and Forestry, which are new there are 6 companies, namely 5 in Java and 1 in East Kalimantan. The number of these companies is very low, when compared to the number of health care facilities in Indonesia, such as the number of hospitals (RS) as many as 2852 hospitals, 9909 *Puskesmas* and 8841 clinics. Meanwhile, the waste generated from health care facilities, especially hospitals and health centers, is 296.86 tons/day (October 2018) but on the other hand, the processing capacity of 3rd parties is only 151.6 tons/day.

HTW Waste Destruction Installation

The main function of waste disposal is to destroy Hazardous and Toxic (HTW) waste materials, its additional function is to support government programs to reduce environmental burdens, reduce dependence on third parties and as a source of income for hospitals see Figure 3. Because the hospital can save a large amount of expenditure on the waste and if the waste production itself is less than the capacity of the existing machine, it can receive waste disposal services from other health facilities.

"Health Care Waste" (HCW) or "biomedical waste (BMW)" includes any waste generated during the diagnosis, treatment or immunization of humans or animals in hospitals, pharmacies, laboratories, blood banks or veterinary medicine and research institutes [24].

The basics of sustainable HTW waste include [25]:
a) Classification and characteristics of hazardous waste sources,
b) Regulations governing HTW waste management and management programs,
c) Concept of "Audit Environment,"
d) The concept of " Pollution Prevention ",
e) Development of hazardous waste management systems and facilities, and
f) Integrated sustainable management and practices of hazardous waste

Comparison of the costs of the current waste disposal system is shown in Table 4. It can be seen that the microwave method is more economical.

TABLE 4. HTW Waste Destruction Process Cost per Kg

Method	***Capacity (kg/hour)***	***Capital Cost (US$ x 1000)***	***Operating Cost (US$/kg)***
Autoclave	23-3,600	30-1780	0.13-0.36
Chemical Treatment	11-6800	20-890	0.15-2.20
Microwave	23-410	70-710	0.10-0.42
Incineration	250-4000	120-6000	0.15-0.30

A high technology incinerators with air pollution control

Researchers study the technical specifications of products that are on the market and are very likely to be applied in the hospital under review. Whether or not we consider it in terms of the green process and the green result and the investment deserves to be calculated using Lifecycle Cost Analysis.

Calculate the investment price in the 8th year of operation using:

$$F = P \times (1+ i)^n$$

If the initial investment price P = IDR 4,383,000,000; i = 10 %; n = 8 years
F = IDR 4,383,000,000 x $(1+0.1)^8$ = IDR. 9,395,349,754
Initial fee = IDR 9,395,349,754/(12x8) month = IDR. 97,868,227/month
After the initial cost is obtained, the investment value is calculated within a period of 8 years, as shown in Table:

TABLE 5. Investment value of HTW Waste Destroyer

Depreciation	**8 years**		
Unit Cost / month			**IDR 97,868,227**
Operational Cost			
Electricity cost			
Total Waste/day (Kg)	400		
Total Waste/Cycle (Kg)	25		
Total Cycle/day	16	9 hours	
Electricity consumption/cycle (KWH)	10		
Cost per KWH	IDR 605		
Total Consumption/day(KWH)	160		
Total Electricity Cost/day	IDR 96,800		
Total Electricity Cost/month			IDR 2,904,000
Operator Fee			
No. Operator	2 persons		
Salary/month	IDR 4,250,000		
Total salary/month			IDR 8,500,000
Maintenance/Consumable Fee			
Number of cycles/day	16		
Number of cycles/month	480		
Maintenance/cycle costs	IDR 105,000		
Maintenance fee/month			IDR 50,400,000
Periodic Test			
Bacillus Test	2,500,000		
4x test per year	10,000,000		
Cost per month			IDR 833,333
Total Operational Cost/month (A+B+C+D)			IDR 62,637,333
Total cost per Month (+Depreciation)			IDR 160.505.560
Total cost up to 8 years			IDR 15,408,533,754

HTW Waste Destroyer Investment Repayment	
Total Waste/day	400 (Kg)
Cost/kg	IDR 25,000
Cost/day	IDR 10,000,000

The total cost of destroying HTW per month is IDR 300,000,000

Savings per year IDR 3,600,000,000

Payback Period	= Total Investment / Savings per year.
Payback Period	= IDR 15,408,533,754/ IDR 3,600,000,000
Payback Period	= 4.28 Years 4 Years 3 Months.

Without calculating the residual value (salvage value), investment as an additional function for HTW waste destruction can be environmentally friendly and profitable in terms of investment.

With this short repayment, hopefully, it can encourage project owners or investors to invest in the field of waste disposal, both for hospitals and other health services. Because there are still many hospitals and health facilities that are not transparent in reporting where HTW waste is destroyed because of the high price.

Besides being able to bring in profits, this waste destroyer can also help ease the burden on the environment which is currently so heavy and overcapacity. With this waste destruction facility, the hospital can add value in increasing its class and maintaining the class that has been achieved.

CONCLUSION

Based on research from the Budget Plan (BOQ), technical specifications and drawings of the plan, the Green material selection process and the Lifecycle Cost process can be concluded as follows:

1. Replacement of conventional materials to green with Value Engineering analysis turns out to be able to save costs that can be felt directly by the Project, namely 2.62% or IDR 542,499,588
2. Return on capital for procurement of HTW waste destroyer = 4.28 Years 4 Years 3 Months for BEP. Without calculating the residual value (residual value), investment as an additional function for HTW waste destruction can be environmentally friendly and profitable in terms of investment.
3. Based on the results of the analysis, the hypothesis that the increase in cost performance using the Lifecycle Cost Analysis (LCCA) method in the Green Hospital project is proven.

The relationship between Value Engineering and LCCA with Green Hospital is to solve some of the problems in forming green buildings, namely the cost overrun of planning and implementation as well as feasible and profitable investment prospects.

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