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Application of Green Retrofitting Ready Mix Concrete Plant in Indonesia to Increase Financial Benefits and Reduce Environmental Issues: A Case Study

Mohammad Kholis Ardiansyah[1], Albert Eddy Husin[1*], Mawardi Amin[1]

[1] Department of Civil Engineering, Faculty of Engineering, Universitas Mercu Buana, Jakarta 11650 , Indonesia.

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ABSTRACT

Currently, the Indonesian government continues to encourage the realization of sustainable development. The green concept is a sustainable development trend in the construction material industry. The concrete industry plays a vital role as a supplier of concrete materials in construction, so its availability is essential. The role of concrete industry itself has a negative impact on the environment. Stakeholders increase the cost of green retrofitting so that the industry or building becomes eco-friendly. The research method was carried out using a process case study, namely, how to implement green retrofitting cost performance in the concrete industry using Value Engineering and Life Cycle Cost Analysis. Theoretically, the research results provide additional knowledge for academics; practitioners can provide problem-solving to get an overview of the implementation of the green concept in the industry regarding the flow of implementation and the benefits of savings in an environmentally friendly production process. The application of value engineering in the green retrofitting of the concrete industry has increased the cost performance of green retrofitting by 8.66% with a return of 3 years and 8 months and increased the functions and benefits of an eco-friendly and sustainable concrete industry.

1. INTRODUCTION

Today, the most important environmental problem is climate change. It is also one of the biggest problems in the whole world (Doan, Wall, Hoseini, Ghaffarianhoseini, & Naismith, 2021). According to the Environmental Performance Index (EPI) in 2022, Indonesia's ranking dropped to 164th from the previous year, 116, with an EPI Score of 28.20 out of 77.90. This rank proves that public awareness of the environment in all sectors needs to be increased. The Sustainable Development Agenda (SDGs) in 2030 declares a development shift towards sustainable development based on equality and human rights to promote social, economic, and environmental growth. Opportunities in achieving the United Nations' sustainable development goals are created by green building development (SDGs). However, instead of renovating the old structures, they create new constructions for green buildings (Hong, Ibrahim, & Loo, 2019). Green development is a crucial method to achieve sustainable development. Among the 17 SDGs, several indicators are closely related to the development of green industries, including clean water and sanitation, affordable and clean Energy, Industrial Innovation and Infrastructure, and Responsible Consumption no Production (Yuan et al., 2020).

The supply chain in the construction sector is a coordinated structure consisting of parties that contribute (directly or indirectly) to the project's overall success in producing construction products. In the world, the concrete

*Correspondence author.
E-mail : albert_eddy@mercubuana.ac.id (Albert Eddy Husin)

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industry or batching plant plays a vital role in the economy and development of a country because concrete is an essential material for infrastructure development (Favier, De Wolf, Scrivener, & Habert, 2018).

In Indonesia, the concrete industry and the need for concrete materials are predicted to increase according to the 2020-2024 National Medium-Term Development Plan (RPJMN). According to the Public Works and Housing Ministry, the estimation for construction materials needs, especially concrete, in the 2020-2024 fiscal year is predicted to increase by 8%. Environmental degradation, global warming, social inequality, and a shortage of natural resources are some unintended consequences of progress. The concrete industry negatively impacts the environment during its construction and production process. These impacts include waste, air dust, noise, and the excessive use of natural resources, especially water and energy. In the composition of perm3 concrete products, a material ratio of 7-15% water is required, cement 15-20%, fine aggregate 25-30%, and coarse aggregate 30-50%. The environmental impact of concrete manufacturing can be lowered by reducing the use of raw materials, reducing energy consumption, and following Best Management Practices (BMP) related to ready-mix concrete production (Kashwani, Sajwani, Ashram, & Yaaqoubi, 2014).

One proposed solution is establishing a "green" concept for industrial development that prioritizes environmental factors in its manufacturing process and operations (Susanti et al., 2017). Applying the green concept in the concrete industry in Indonesia still needs to be improved. In addition, the parameters for obtaining green concrete industry certification from related regulations still need to be added. Meanwhile, Europe and other developed countries have applied the green concrete industry concept by adopting the green Concrete Sustainability Council (CSC) concept. CSC promotes and demonstrates the concrete industry and eco-friendly products to generate the correct decisions in construction. CSC certification system in the concrete industry is applicable globally (Concrete Sustainability Council).

Some of the problems identified from the application of the concept include high green investment costs compared to conventional buildings, lack of green concepts understanding, lack of eco-friendly products on the market, and lack of financial and non-financial support from the government (Pahnael, Soekiman, & Wimala, 2020). The problems of implementing the green concept include applying energy-saving systems, lighting, conservation, and water recycling. These cause an increase in green construction costs (retrofitting costs) by 10.77% (Kim et al., 2014).

Increased costs in green projects can be handled by reducing the investment costs of waste materials. Value Engineering (VE) has vital benefits for the civil engineering construction industry, significantly saving costs and increasing project benefits. Value Engineering (VE) is a systematic review of a project, product, or process by an independent multi-disciplinary specialist team to improve performance, quality, and life-cycle costs (Berawi, 2004, as cited in Husin, 2019). VE allows the civil engineering construction industry to save costs and increase project benefits. Life Cycle Cost Analysis (LCC) in VE is value-based and helpful in determining alternatives with the lowest cost and maximum feasibility (Husin, 2015).

The effect of Value Engineering and Life Cycle Cost Analysis on the improvement of green retrofitting cost performance in the concrete industry can be examined through the correlation between the concrete industry object factors and the concept of green retrofitting. The research purposes were to determine the correlation among the most influential factors on the improvement of green retrofitting cost performance based on Value Engineering and Life Cycle Cost Analysis in the industry and provide a flow of application of the green retrofitting concept in the concrete industry to facilitate implementation so that the Indonesian concrete industry is eco-friendly and sustainable. The research results can provide additional knowledge for academics, and practitioners can provide problem-solving to get an overview of implementing the green concept in the industry.

2. METHODS

The research location was one of Indonesia's largest Indonesian concrete industries - PT. XYZ. The research was held from April to June 2022. A case study on implementing the green retrofitting concept in the concrete industry was conducted based on primary, secondary, observation, literature review, and analysis data. Showed that just half of the systematic reviews had flowcharts. For the reader to grasp the whole research review process, researchers must provide a flow chart. (Vu-ngoc et al. 2018). The concept of case study research can be seen in Figure 1.

2.1. Green Retrofit Concept in Ready-mix Concrete Industry

The green concept is the process of building a structure based on the environment and efficient resources throughout the life cycle of the building, from design, construction, operation, maintenance, renovation, and deconstruction (Ebrahim & Wayal, 2020). Concrete Sustainable Council (2022) stated that ready-mix concrete values the environment, and obtaining a Concrete Sustainable Council certificate as green in developed European countries continues. 485 Concrete industries obtained Green certification in 2021 (Concrete Sustainability Council, 2022).

Identifying and applying green concepts in the concrete industry provide a platform to address interrelated global problems through cross-sectoral methods and initiatives. It also benefits the industry participants (Susanti et asl., 2017). This rating system is a method to evaluate the quality of eco-friendly green buildings. There are categories, criteria, and benchmarks in GREENSHIP with particular points (Rahmawati, Wisnumurti, & Nugroho, 2018). CSC assessment parameters can be seen in Figure 2.

Credit criteria parameters set by CSC include Management-(M) (33 points), Environment-(E) (73 points), Social-(S) (48 points) and Economy-(B) (25 Points).

Data is obtained from the field from observations, interviews of the Green expert team and the head of the local batching plant, collecting data, visits, and self-assessment inspections. Together are then processed referring to the intended Standard rating, namely using concrete sustainable council V.2.1 parameters, then the second step is to conduct an assessment with a team of Quality Enviro Management System (QEMS), 6 experts invited to the discussion; they are 2 experts in the field of green building, 2 experts in value engineering and 1 expert in QEMS and 1 expert in industrial batching plants, experts to get the actual points obtained, from these results, the third step is then carried out to carry out an Improvement and innovation plan to get the intended rating target, namely Gold with a minimum Gold rating with a minimum point of 65% of the total standard parameter value and Pre-requisites that must be met. The highest increase in point parameters is in the environmental aspect, where the results obtained by self-assessment are 13.5 points from 73 standard points.

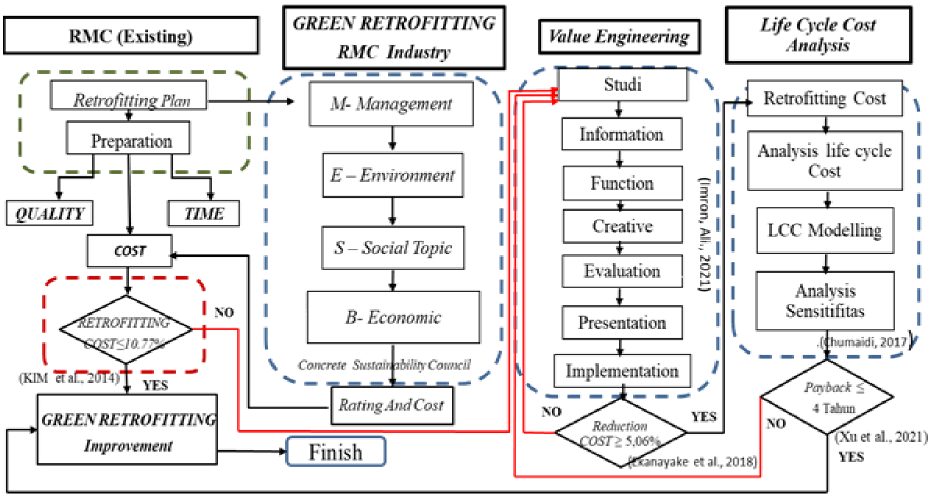

Figure 1. Flowchart of Application of the Green Retrofitting Concept with VE in the Concrete Industry to Improve Retrofitting Cost Performance

Figure 2. Rating Green RMC (Source: Concrete Sustainability Council, 2022)

2.2. Value engineering and Life Cycle Cost Analysis

In general, value engineering is a creatively organized method that aims to maximize the cost and performance of a facility or system. Over-cost checking methods are avoided so that required functions and the most affordable prices are discovered without compromising the required quality (Baghdady, 2018). The VE work plan was conducted as part of the project development. This study estimates that the creativity phase will generate original suggestions for possible projects (Berawi et al., 2015). According to Eng Karim Ragab in Planning and Project Controls Engineer SAVE International, the stages of planning Value Engineering activities include:

a. 1) Information stage, 2) function analysis stage, 3) creativity and innovation stage, 4) development stage, 5) decision analysis stage, 6) decision-making stage, 7) implementation stage, 8) recommendation stage, and 9) result (Husin, Karolina, Rahmawati, & Abdillah, 2022).
b. Functional Analysis System (FAST) Engineering Diagrams were used in Value Engineering to generate creative concepts that can be incorporated into projects (Berawi et al., 2015; Imron & Husin, 2022).

LCCA was especially useful when the project alternatives that met the performance requirements were similar, but the initial and operating costs differed. This situation requires comparison in choosing the one that maximizes cost savings (Fuller, 2006). The LCCA analytical approach assists in the discovery of the most economical option that fulfills the project objectives and contributes essential data to the overall decision-making process (Hatami & Morcous, 2016). The general steps for calculating LCC analysis were as follows:

a. Cost Breakdown Structure (CBS) – LCC Modeling without residual value -Life-cycle Cost Analysis – Sensitivity Analysis – Efficiency (Study, Correia, Samani, & Gregory, 2018).
b. Green buildings were prioritized throughout the project life cycle. It includes manufacturing materials, planning, design, construction, operation, maintenance and removal, and waste recycling (Liu, 2015).

3. RESULT AND DISCUSSION

The green industry prioritizes effectiveness and efficiency in the sustainable use of resources during production. This idea benefits society because it balances industrial development with the maintenance of environmental functions.

The independent observation and self-assessment results were a Gold rating of 127.3 (71.1%), with a planned increase in green retrofitting costs of 11.06%. The recapitulation of the self-assessment can be seen in Table 1 below:

An example of calculating points in an independent assessment is as follows:

The results obtained from the Assessment and Conformity Planning by the team are focused on Environmental Aspects and Energy and Water Efficiency parameters because they have significant points and see the need to be done innovation. The formation of an engineering team or VE team is needed to analyze the impact of the Cost increase in costs from the retrofitting plan. The data is processed and carried out studies and information to obtain the retrofitting Cost Value, namely BOQ, and make a Paretto diagram to obtain focus savings, then perform Function Analysis with FAST diagrams before and after implementation.

Table 1. Self-Assessment Recapitulation

Self-Assessment Recapitulation – CSC					
Code	Parameter	unit	Criteria CSC Standard	Assessment	Retrofitting Recognition
M	Management	Points	33	26.3	27.8
E	Environment	Points	73	13.5	41.5
S	Social	Points	48	42	42
B	Economy	Points	25	17	17
Total		Points	179	97.8	127.3
Total value		179	97.8		127.3
Percentage (min 65%)		100%	54.6%		71.1%

Table 2. Example Assessment for Item E- Environment

E- Environment					
Code	Parameter	unit	Criteria CSC Standard	Assessment	Retrofitting Recognition
E1	Life Cycle Impact	Points	6	0	0
E2	Land use	Points	5	3	5
E3	Energy & Climate	Points	22	1	12
E4	Air Quality	Points	7	2	5
E5	Water	Points	13	3	8.5
E6	Biodiversity	Points	0	0	0
E7	Secondary Materials	Points	15	2	8
E8	Transport	Points	5	2.5	3
E9	Secondary Fuels	Points	0	0	0
Total		Points	73	13.5	41.5
Percentage (min 65%)			100%	18%	57%

Bill of Quantity (BOQ) for retrofitting planning, then conducted Pareto Analysis to focus work and obtain cost performance efficiency. 80% of the total green retrofitting costs in the Pareto diagram is a budget focused on efficiency using value engineering. 83.9% at the initiation of the solar PV installation is the highest value, WWT utilization is 13.3%, Green assessment cost is 1.6%, and procurement of cover loading point is 1.2%.

The Pareto diagram in question can be seen in Figure 3

The FAST diagram existing Process and before the application of the eco-friendly concept and the VE process in the concrete industry is shown in Figure 4.

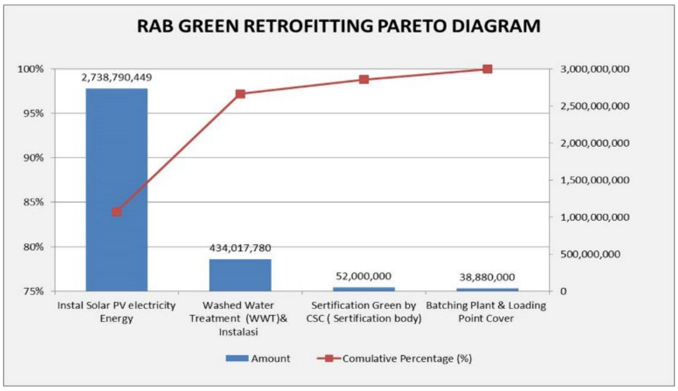

Figure 3. Pareto Diagram Information Stage

The FAST diagram existing before the retrofitting plan process is the actual condition of the concrete industry carried out the analysis. It can be seen that there needs to be an output of results with the aim of an environmentally friendly concrete industry. The “how-why” logic model was applied to discover, categorize, develop, and choose functions that can improve project development (Berawi et al., 2015; Imron & Husin, 2022). According to the retrofitting plan focused on Energy and Water Efficiency, Additional Functions can be seen in Table 3.

All concepts for VE were refined during the evaluation stage. The material selection idea of the green concept was summarized and calculated to fulfill the objectives of Value Engineering (Imron & Husin, 2022). Each Bill of Quantity (BOQ) element was chosen without exception, and each element should show an eco-friendly function.

. Value = Function / Cost, first proposed by Miles in 1961, was later revised to Function / Resources. Even yet, because it combines quantifiable (such as cost) and immeasurable (such as function) notions, its adaption needs to be revised (Woodhead & Berawi, 2022).

The development stage aims to improve the function standard of the research topic, arrange final recommendations and implementation plans, and review technical and financial aspects for developing the chosen alternative (Bahri et al., 2018). The preparatory steps for an overall thought or opinion investigation into the initial design (PV) are developing a description of the solution, assessing the life cycle costs of the original design, and providing the proposed new design. It is the steps of the development stage (Asrul & Ozanya, 2017).

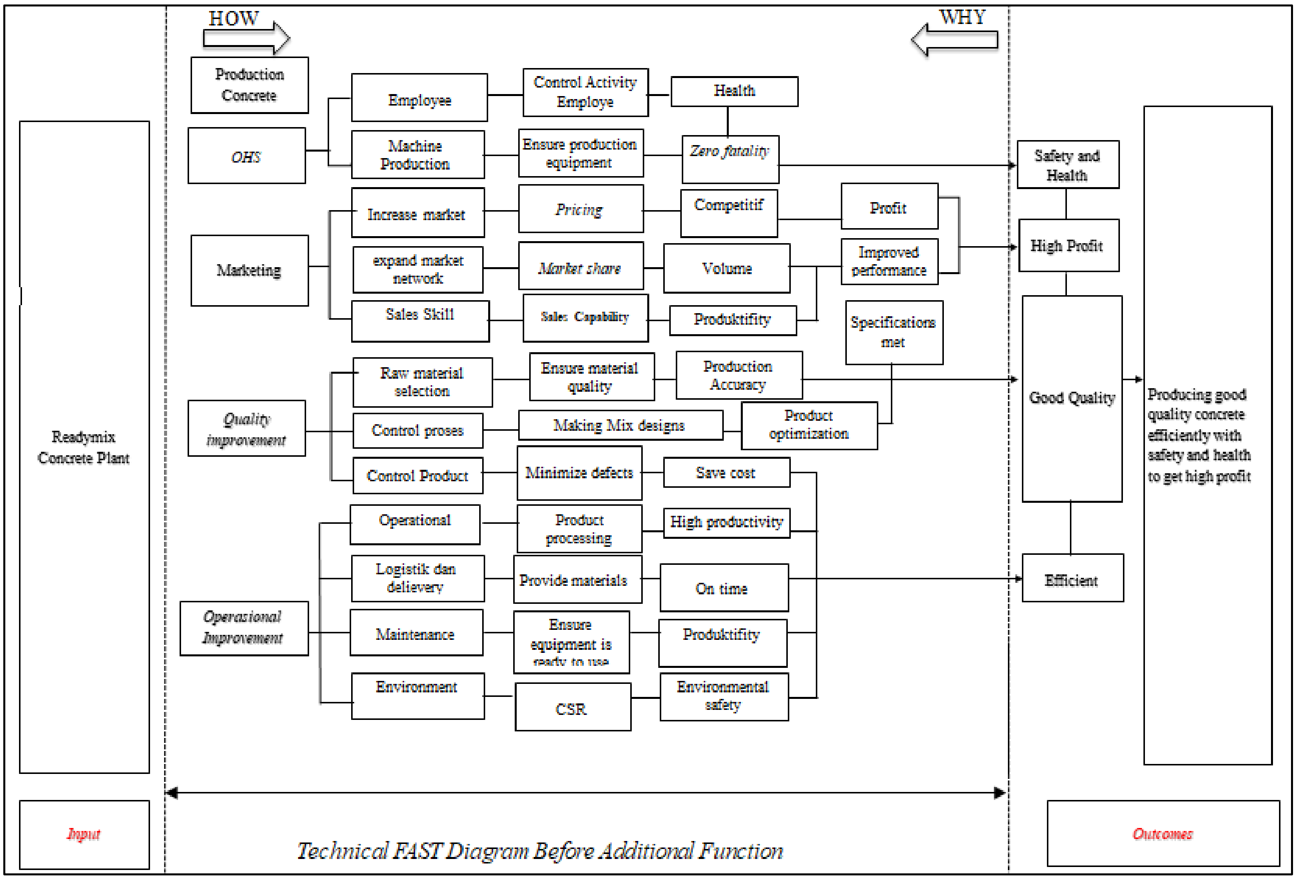

Figure 4. Concrete Industry FAST Diagram existing process and Before Additional Functions

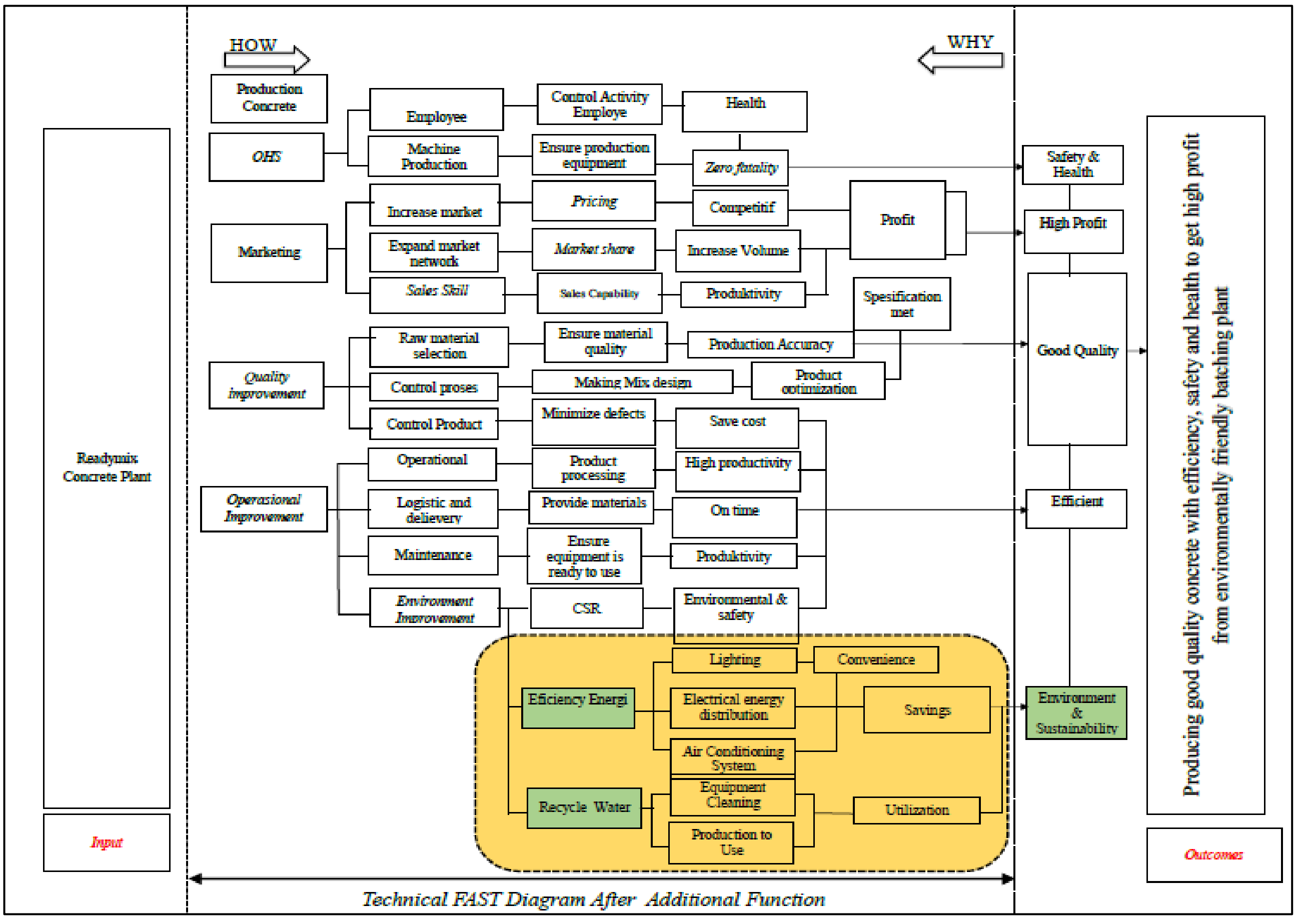

Figure 5. Concrete Industry FAST Diagram after Additional Functions (Source: Research Data Processing, 2022)

Table 3. Eco-Friendly Additional Functions in the Concrete Industry

No	*Work item*	*Analysis Function*
1	*Efficiency Energy*	*Lighting* *Electrical energy distribution* *Efficiency* *Sustainable and environmentally friendly*
No	***Work item***	***Analysis Function***
2	*Recycle Water*	*Raw material* *Production Operational Use* *Utilization and efficiency* *Sustainable and environmentally friendly*

The work items in this case study on the VE and LCCA processes were energy efficiency and recycled water to add 57% points for the environment-(E) parameter of the total 73 points.

3.1. Energy Efficiency

Energy-efficient buildings with proper design will result in lower utility invoices than conventional buildings (buildings without an energy efficiency strategy) (Gunawan, 2012). The concrete industry using PV solar energy could reduce 17,165.05 Kg CO^{2e}. If the system was started in January (rather than January 2019), it could reduce about 9% carbon footprint per month and about 205,980.6 Kg of CO2e in a year. In other words, the solar system can save production efficiency and be eco-friendly (Rasheed, 2020).

In this case study, the concept of energy efficiency using solar panels was useful to obtain more benefits and improve the function of the eco-friendly concrete industry. The roof area for solar power plants in the PT. XYZ batching plant area was as follows:

The office roof area was 15 m × 30 m = 450 m^2

The roof area of the Stockpile was 15 m × 45 m = 675 m^2

So, the total roof area was 1125 m^2. The maximum PV used was 2.38 × 1.09 = 2.59 m^2.

Maximum calculation Total Solar Module =

$$\frac{\text{Batching plant roof area } (m^2)}{\text{Module surface area } (m^2)} \quad (1)$$

Table 4. Green Retrofitting Cost Before and After VE

Component	Function		Cost Before VE (IDR)	Cost After VE (IDR))
	Verb	Noun		
Efficiency Energy	Lighting and Energy Operations	Sustainable and environmentally friendly	2.738.790.449	2.462.290.449
Water Recycle	Utilization and Savings	Sustainable and environmentally friendly	434.017.780	427.955.780
Cover Loading Point	Dust Reduction	Sustainable and environmentally friendly	38.880.000	38.880.000
Certification Green	Assessment green Lable	Sustainable	52.000.000	52.000.000
Total (IDR)			3.263.688.229	2.981.126.229
Total VE (Cost before-after) (IDR)			282.562.000	
Percentage Saving base on Value Engineering (%)			**8.66%**	

Table 5. Monetary Benefit for Efficiency Energy and Recycle water

ITEM	MONETARY BENEFIT				REMARK
	AMOUNT	UOM	VALUE/ UOM (IDR)	TOTAL (IDR)	
Saving Energy	176000	Kwh	1.142	200.946.240	40% of rate capacity 550KVA
Excess Energy for CSR	10000	Kwh	1.142	11.417.400	Cost CSR /month
Water Saving	385.61	M3	45.000	17.352.450	Target saving 50% (25% for Raw material and 25 % flashing)
Total Monetary Benefit/ Month (IDR)					**229.716.090**
Total Benefit /Year (IDR)					**2.756.593.080**

The maximum installed solar panels was 1125 m2: 2.59 m2 = 445 pcs solar panels. The installed power for the factory area was 555 KVA, a voltage of 380V, and 3 phases. The calculation used the DOD (Depth of discharge) assumption, 80% battery, and 4.5 hours PSH (Peak Sun Hours). The VE team used software to calculate the off-grid solar panel system, resulting in a minimum solar panel capacity of 151.29 KWp. If using a 550 wp Monocrystalline type of solar panel, the total solar panel was 275 pcs of solar panels < 445 maximum solar panels for the number of solar panels with a batching plant roof area. The number of batteries with a capacity of 48V 70AH was 165 pcs, and a 15KW inverter was 11 pcs. The installed generator and PLN could be allocated for other benefit values, while the generator was used to back up when the system was off during operation.

3.2. Recycle Water

The large-capacity concrete industrial wastewater provided a vivid example of this phenomenon. This waste comes from the concrete manufacturing process, industrial washing waste, and washing mixers after making concrete (Widodo, 2010). Liquid waste or wastewater is liquid waste from homes, businesses, workplaces, industries, and other public places. This waste contains components or substances that can damage human health or life and disrupt environmental sustainability (Kencanawati, 2016). The concept of utilizing and using wastewater requires specific handling. Reducing the use of clean water in the concrete industrial process can add benefits and eco-friendly functions. Wastewater treatment in the concrete industry aims to reduce wastewater pollutant parameters according to quality standard requirements or certain qualities for reuse.

The selection of Washed Water Treatment (WWT) design must be focused on the type of waste produced in the concrete industry. The main goal is to use recycled water for re-production and focus on wastewater quality and the quantity of wastewater produced for clean water efficiency. The wastewater treatment is designed based on the process's order divided into primary, secondary, and tertiary treatments. The design of the Washed Water Treatment (WWT) pond in the VE process was as follows:

Figure 6. WWT Image for Benchmark

The calculation of pipe installation was used to distribute 25% of production material to replace clean water. Then, it was also used for washing truck mixers, plant operations, and water sprinklers. The planned wastewater capacity was 95 m3. The distribution of recycled water was expected to save 50% of the use of clean water each month. In addition, the concrete industry business stakeholder will benefit. Energy efficiency and recycled industrial water provided the benefits of saving production processes. Life cycle costing is a powerful tool for quantifying costs over time due to price changes (Dwaikata & Ali, 2018).

Table 6. Feasibility Analysis of Applying Green Concept in the RMC Industry

FEASIBILITY ANALYSIS					
Information	**2022**	**2023**	**2024**	**2025**	**2026**
Net Income (IDR)	(3.400.625.114)	1.180.096.672	1.373.504.739	1.512.225.006	1.693.766.771
PV Value (IDR)	-3.400.625.114	983.413.893	953.822.735	875.130.212	816.824.253

Table 7. NPV, IRR, Return Period, and BCR Result

Criteria Investment			Value		Remark
NPV (IDR)			1.938.825.115		FEASIBLE PROJECT
IRR			39.75 %		FEASIBLE PROJECT
Payback Period	3	Year	8.6	Month	FEASIBLE PROJECT
Benefit Cost Ratio			1.63		FEASIBLE PROJECT

Investment analysis requires an analyst to examine the net present value (NPV) and internal rate of return. The analysis also required other indicators, such as return periods, to choose the suitable investment. Internal Rate of Return (IRR) and Net Present Value (NPV) was used to indicate a project's feasibility. Decision makers used the NPV approach to evaluate the investment of money today with future returns after considering value, time, and money (Weber, 2014). The calculation of the investment value for the application of the eco-friendly concept in the concrete industry can be seen in Table 6 below:

In the first year, industry players will incur high costs as initial capital to obtain the Green concept. The calculation of monetary benefits obtained each year will reduce capital costs and get benefits and benefits from implementing the Green Concept with positive value results for the NPV calculation.

The VE and LCCA calculations showed that the green concept in the industry could be applied. The rate of return in the calculation of the LCCA analysis was 3 years 8 months according to the predetermined target of < 4 years.

3. CONCLUSION

From the previous explanation, the conclusions of the application of the Green Concept for the concrete industry with the VE method are as follows:

- Regarding the flow of implementation and the benefits of saving in an environmentally friendly production process, the application of value engineering to the green retrofitting of the concrete industry has been proven to increase the cost performance of green retrofitting by 8.66% with a return of 3 years and 8 months and to increase the functions and benefits of the concrete industry which are environmentally friendly and sustainable.
- The research hypothesis is that improving the green retrofitting cost performance in the concrete industry using value engineering methods can be feasible, eco-friendly, and more profitable for the government and stakeholders in the future.

The novelty of this research is applying the green retrofitting concept for Indonesia's concrete industry with VE and adding eco-friendly functions in the concrete industry process to incentivize the government to provide benefits for industries that implement the green concept.

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