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The Implementation of "WE R GREEN" Program in ADHI Construction Projects for CO2 Emission Efficiency

Abstract: - As the leading state-owned construction company in Indonesia, PT Adhi Karya (Persero) Tbk (ADHI) has taken certain steps to address sustainability issues, especially when it comes to improving the environmental quality of infrastructure projects. "WE R GREEN" is an environmental program that emphasizes water conservation (W), energy efficiency (E), waste management (R, which stands for remove, reduce, reuse, and recycle), and tree planting activity (GREEN). This study used a construction project in Depok as the sample, where every action has a close relationship with the environment. The purpose of this study is to determine the CO2 efficiency of some project activities following the implementation of the "WE R GREEN" initiatives. The data consists of water consumption, project office building usage, electricity consumption, solid waste production, and planted tree specification. According to the data, total CO2 emissions were 110,62 tons CO2e year prior to program implementation, and the emission has dropped to 73,59 tons CO2e annually following the initiatives. This concludes that the total of 37,03 tons CO2e per year, or 33%, are reduced. Assuming the same number of people and project activities throughout all 109 ADHI projects to put the program into practice. The estimated annual CO2 output would thus decrease 4.036,06 tons CO2e.

Keywords: CO2 emission efficiency, energy efficiency, green construction project program, water conservation

I. INTRODUCTION

Presently, the global community is experiencing the repercussions of climate change. Disruptions in natural cycles have given rise to diverse social and environmental challenges. The significance of the worldwide concern regarding climate change has garnered the focus of countries globally, Indonesia included, evident in their commitment to achieving net zero emissions by 2060 as established in the 2016 Paris Agreement [1].

These nations' dedication is evident in their Nationally Determined Contributions (NDC) for the 2020-2030 period. Indonesia formally endorsed the Paris Agreement on Climate Change during the High-Level Paris Agreement Signing Ceremony at the United Nations Headquarters in New York, United States, on Friday, April 22, 2016. Indonesia's commitment to addressing climate change aligns with the objectives outlined in the National Medium-Term Development Plan (RPJMN) 2020-2024 [2].

Through the Nationally Determined Contributions (NDC), the Indonesian Government has pledged to reduce Greenhouse Gas (GHG) emissions from 29% (unconditional scenario) to 41% (conditional scenario) by 2030, with a subsequent commitment to achieve "Zero Emission" by 2060. To realize these objectives, Indonesia has established regulatory frameworks. Sustainable Development adheres to Presidential Regulation Number 59 of 2017, later revised by Presidential Regulation. At the 2021 G20 Leaders' meeting in Rome, the Indonesian Government renewed its commitment to a 29% reduction in GHG emissions by 2030 and a 41% reduction [2].

Indonesia has engaged diverse segments of society, encompassing the private sector, academic institutions, corporations, local governments, and various community

groups, to actively participate in initiatives addressing climate change, covering both mitigation and adaptation aspects. Particularly within the corporate sphere, state-owned enterprises (BUMN) are not solely driven by profit motives for economic development; they also bear a social responsibility oriented toward enhancing societal well-being.

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PT Adhi Karya (Persero) Tbk. (ADHI) stands as one of Indonesia's state-owned enterprises specializing in construction services, infrastructure development, property, real estate, and EPC (engineering, procurement & construction). As a state-owned enterprise (BUMN), ADHI is steadfast in its commitment to ensuring the success of government programs and actively supporting endeavors to address climate change, aiming to safeguard and nurture life while preserving the environment through transparent and accountable governance. Presently, ADHI is concurrently managing a portfolio of 109 active projects.

To align with the government's initiatives aimed at reducing greenhouse gas (GHG) emissions and achieving the Net Zero Emissions (NZE) target, ADHI adheres to the guidelines outlined in the Circular Letter of the Ministry of State-Owned Enterprises, Number SE-6/ MBU/12/2022 [3]. ADHI commitment not only reflects the pursuit of NZE but also signifies support for governmental policies, as articulated in Presidential Regulation Number 98 of 2021, which outlines the implementation of the National Energy General Plan (NEK) to realize nationally determined contribution targets and exercise control over greenhouse gas emissions in national development [4].

This initiative represents a tangible step taken by ADHI to address sustainability concerns, a necessity in contemporary ESG (Environmental, Social, and Governance) management, particularly in the context of infrastructure development projects. An example of such a project is the construction of a building where every activity closely interacts with the surrounding environment. Additionally, the project incorporates an environmental program known as "WE R GREEN", focusing on Water efficiency program, energy efficiency program, waste management program, and tree planting program. The aim is for this program to not only make a meaningful contribution but also serve as a model for addressing environmental issues within ADHI and at the national level.

II. CONDITIONS AND METHODS

A. Project Condition

Located in Depok City, West Java Province, the building construction project covers an area of 13,35 m^2. The project comprises the preparation, construction, and maintenance stages, with a current progress rate of 75%. The ongoing development entails the construction of a nine-level building, with the active involvement of 50 individuals in the project.

B. Research Method

This study is using primary and secondary quantitative data. The data is collected based on the condition before and after the program implementation. The carbon emissions resulting from each activity are calculated using conversion values and emission factor. Then, the total CO_2 efficiency per project can be calculated and projected to 109 ADHI projects.

C. Programs and Data Collection Method

- Water Efficiency Program

Currently, a limited number of individuals recognize that engaging in environmental conservation to address global warming and climate change can initiate from the consciousness and care of each person. Based on information provided by the Badan Pusat Statistik (BPS), merely 72.55% of Indonesia's populace enjoys access to sufficient clean water, falling short of the 100% target outlined in the Sustainable Development Goals (SDGs) [5]. The SDGs aim to attain universal and fair access to safe, affordable drinking water for everyone by 2030. Indonesia has set the targets and objectives outlined in the National Medium-Term Development Plan (RPJMN) 2020-2024 [2]. Hence, it is essential to implement water conservation programs starting now, and this can be achieved through various initiatives or practical actions to conserve water in the construction project [6]. The water source utilized in the construction project is groundwater wells. The water efficiency initiatives, including:

1. Employee Training and Awareness

The project educated the employees about the importance of water conservation and provided training on water-efficient practices. The is also a program to encourage a culture of responsibility and water stewardship.

2. Water-Efficient Fixtures and Appliances

The project upgraded the appliances to water-efficient fixtures and appliances, such as low-flow toilets, faucets, and irrigation systems. Ensure that all equipment meets or exceeds water efficiency standards.

3. Leak Detection and Repair

The project implemented regular inspections to detect and promptly repair water leaks in plumbing systems, fixtures, and infrastructure.

- Energy Efficiency Program

Energy is becoming more and more important to society as technology develops. The carbon emissions resulting from the use of electricity are measured by multiplying the emission factor of electricity by the number of electronic devices. The ratio of energy spent to the volume of activity or GDP is known as energy intensity. A nation's energy use is more efficient the lower the intensity value [7].

To lower emissions from using electronic equipment, the project uses electrical energy-saving measures within the parameters of the environmental program. The following are a few of the steps in this reduction program:

1. Training and socialization for project team

Inform staff members of the value of energy conservation and give them training in energy-saving techniques. Encourage an attitude of ownership and accountability for energy use.

2. High-Efficiency Lighting

Energy savings can be realized right away if all standard lights are replaced with LED ones. Higher illumination and lower electricity consumption are provided by high-efficiency lighting, like LEDs, as opposed to conventional lighting like incandescent or fluorescent bulbs. The necessity for frequent replacements is further decreased by their lifetime.

3. Energy-Efficient Appliances and Equipment

Installing energy-star-rated air conditioning units in the structure. By utilizing cutting-edge technology, these systems utilize less electricity for ventilation and cooling. Energy-efficient equipment and appliances, which are frequently identified by an energy star rating, are made to consume less electricity than conventional models, which lowers energy costs and has a less environmental impact.

- Waste Management Program

A practical and eco-friendly building approach, modular construction offers design and construction in the shape of a specific building. MOBOX (green project building) is adaptable to the requirements of projects. In terms of time and cost, the construction procedure is simple, quick, and easy to transfer. There will be less waste produced by using MOBOX.

According to the percentage of waste management techniques supplied by KLHK [8], landfill disposal looks to be Indonesia's main source of greenhouse gas emissions. This is demonstrated by the high rates of trash transportation to landfills in numerous provinces—DKI Jakarta, for example, sends more than 83% of its waste to landfills. Reducing garbage, recycling, refusing it, and employing effective waste management techniques can all help cut down on greenhouse gas emissions related to waste management, particularly those from landfills.

The "4R" tenets of refuse, reduce, reuse, and recycle encourage conscientious consumption and waste management. To reduce the environmental impact of projects, certain guidelines are applied.

Saying no to things or activities that are superfluous or contribute to the production of trash is part of refusing. Refusing single-use plastics like straws, bags, and water bottles, as well as promotional materials and products with unnecessary packaging, are a few examples. The high waste stream is avoided in the first place by turning down products that are not necessary.

Reduction is the process of using less resources and consuming less in order to minimize the quantity of waste generated. To minimize food waste, some strategies include meal planning, buying only what is needed, and selecting products with little packaging or buying in bulk to cut down on packaging waste. Reducing consumption lessens the demand for resources overall and lessens the environmental effect of the production and disposal of items.

Reusing entails figuring out how to put things to use more than once in order to prolong their life and decrease the demand for new ones. Examples include giving or repurposing products rather than throwing them out and using reusable bags, water bottles, and containers instead of disposable ones. Reusing objects reduces the need for energy and resources that would otherwise be required to produce new ones.

Recycling reduces the requirement for raw materials by recycling wasted materials to make new products. Recycling paper, glass, plastic, and metal in accordance with project requirements is one example, as is participating in recycling programs and sorting recyclables from non-recyclables. Recycling creates new products out of waste, keeping materials out of landfills and conserving resources.

- Tree Planting Program

Putting in place a tree-planting program is a great way to preserve the environment, sequester carbon, and maintain ecological equilibrium. Because the mango tree species is indigenous to the area and has adapted well to the local soil and temperature, it was chosen to be planted there. Mango trees are more likely to flourish and contribute to the ecology in the area.

III. RESULT AND ANALYSIS

A. Water Efficiency Program

Prior to starting the water efficiency program, the total amount of electricity used by the water pump while it is filling the water storage tank must be estimated. The used water pump is a Shimizu model that runs for 30 days a month and has a 750-watt power output. The CO_2 emissions prior to and following the implementation of the water efficiency program can be calculated by utilizing the power emission factor and the water pump operation hour.

Pre-Implementation Emission (5 hours) = Electricity consumption of water pump/month x Electricity emission factor
= 0,11 (MWh) x 0,87
= 0,0979 ton/CO_2eq/month
= 1,1745 tons/CO_2eq/year

Post-Implementation Emission (4 hours) = Electricity consumption of water pump/month x Electricity emission factor
= 0,09 (MWh) x 0,87
= 0,0783 ton/CO_2eq/month
= 0,9396 ton/CO_2eq/year

As a result, the generated carbon emissions were reduced by 20%. The water storage tank has a 500-liter capacity, and filling it takes 20 minutes. The water storage tank was filled three times, as indicated by the one-hour variation in water pump operation. As a result, the program has cut back on daily water use by 1.500 liters.

B. Energy Efficiency Program

Based on from the electrical energy consumption data of the project, the carbon emission values are as follows:

Pre-Implementation Emission = Electricity consumption/month x Electricity emission factor
= 0,80 (MWh) x 0,87
= 0,7036 ton/CO_2eq/month
= 8,4438 tons/CO_2eq/year

Post-Implementation Emission = Electricity consumption/month x Electricity emission factor
= 0,65 (MWh) x 0,87
= 0,5725 ton/CO_2eq/month
= 6,8705 tons/CO_2eq/year

Through the implementation of the project's emission reduction program, the amount of energy used for supporting operations was reduced by 0,1057 MWh per month or 1,573 MWh per year when compared to the prior level. This resulted in an 18% reduction in the carbon emissions that were generated.

C. Waste Management Program

- Green Project Building

The emission calculated is the emission of the mobilization of the green project building kit using MOBOX and the mobilization of the building material of the conventional building prior to the program.

Table 1. Value for the Emission Calculation

Item	Value
Truck Fuel rate	5 liters/km
Fuel density	910 kg/m^3
NCV	42,12 TJ/Gg
CO_2 Emission factor	73.900 kg/TJ
CH_4 Emission factor	3 kg/TJ
N_2O Emission factor	0,6 kg/TJ

Table 2. The Global Warming Potential Value

Compound	Global Warming Potential 100 (AR6)
CO_2	1
CH_4 (Fossil)	29,8
N_2O	273

Table 1 and Table 2 value is used for calculating the total emission which consist of carbon dioxide, methane, and nitrogen dioxide with the following equations.

$$Fuel\ Mass\ (kg) = \frac{Total\ Distance\ (km)\ x\ Fuel\ Rate\ \left(\frac{L}{km}\right) x\ Fuel\ Density\ \left(\frac{kg^3}{m}\right)}{1.000} \quad (1)$$

$$Total\ Energy\ Consumption\ (TJ) = \frac{Fuel\ Mass\ (kg)\ x\ NCV\ (TJ/Gg)}{1.000.000} \quad (2)$$

$$Emission\ \left(ton\frac{CO_2eq}{Month}\right) = Total\ Energy\ Consumption\ x\ Emission\ Factor\ x\ GWP100 \quad (3)$$

$$Total\ Emission\ \left(ton\frac{CO_2eq}{Month}\right) = \frac{CO_2\ Emission\ +\ CH_4\ Emission\ +\ N_2O\ Emission}{1000} \quad (4)$$

The distance between the project and ADHI warehouse is 29 km. Prior to the program, the truck had to carry the conventional building material for 5 times journey. By using the equation, the total emission calculated is 49,455 tons Co_2eq. After using the MOBOX project building, the truck had to carry the MOBOX material for only 3 times journey. The total emission calculated becomes 29,673 tons Co_2eq. By changing the material of the building project, the emission has reduced 40%.

- Project Waste Transportation

The calculated emission is the result of moving the solid waste to the landfill both before and after the program using a truck. The value in Tables 1 and 2 as well as the equations 1-4 from the previous program emission computation is also used in this section. The project is located 14,4 km from the closest landfill. The truck had to transport the garbage on 17 trips a month prior to the program. The total emission determined by applying the equation is 4,174 tons CO_2eq/month or 50,096 tons CO_2eq/year. Following the implementation of the 4R program, there was a decrease in the overall amount of trash and the truck only needed to transport it 15 times. After computation, the total emission equals 3,683 tons CO_2eq/month or 44,202 tons CO_2eq/year. The waste management program implementation resulted in a 12% decrease in emissions.

- Waste at the Landfill

Estimating the quantity and kinds of gases emitted during the breakdown of organic waste is necessary to calculate waste emissions at a landfill. Methane (CH_4) and carbon dioxide (CO2) are the two main greenhouse gases released by landfill. However, they also release trace amounts of other volatile organic compounds.

Table 3. The Parameter for the Waste Emission Calculation

Fixed Parameter		
Variable	**Symbol**	**Value**
Model correction factor	ϕ	**90%**
Model adjustment factor	f	**0**
Global Warming Potential of LFG	GWP_{CH4}	**27,2**
Oxidation factor: there is a soil or compost cover	OX	**0,1**
Fraction of methane in the LFG	F	**50%**
Fraction of degradable organic content (DOC) that can decompose	DOC_f	**50%**
Semi-aerobic managed site	MCF	**0,5**

$$Emission = \varphi\ (1\text{-}f)\ *\ GWP_{CH4}\ *\ (1\text{-}OX)\ *\ 16/12\ *\ F\ *\ DOC_f\ *\ MCF\ *\ \Sigma\Sigma\ w_{j,x}\ *\ DOC_j\ *\ e^{-kj(y\text{-}x)}\ *\ (1\text{-}e^{-kj}) \quad (5)$$

The total amount of emissions that have been delivered to the landfill area is determined using the values in Table 3 and Equation 5. Tables 4 and 5 below display the results of the pre- and post-implementation program emission calculations.

Table 4. Pre-Implementation Waste Emission Calculation at Landfill

	Food	**Paper**	**Wood**	**Garden waste**	**Plastic, glass**	**Weight (kg)**
Waste-wj (kg)	310,00	224,00	550,00	113,00	2820,00	4017,00
DOCj	15%	40%	43%	20%	0%	
Decay Rate - kj	0,4	0,07	0,035	0,17	0	(kg CO_2eq)
Emission (kg CO_2eq)	**56,292**	**22,243**	**29,869**	**12,974**	**0**	**121,378**

Table 5. Post-Implementation Waste Emission Calculation at Landfill

	Food	**Paper**	**Wood**	**Garden waste**	**Plastic, glass**	**Weight (kg)**
Weight-wj (kg)	217,00	156,80	440,00	50,00	2740,00	3603,80
DOCj	15%	40%	43%	20%	0%	
Decay Rate - kj	0,4	0,07	0,035	0,17	0	(kg CO_2eq)
Emission (kg CO_2eq)	**39,405**	**15,570**	**23,895**	**5,741**	**0**	**84,611**

The project's waste management program was put into action, and as a result, the landfill's total amount of deteriorated solid waste decreased annually by 0,441 tons of CO_2 equivalent. As a result, the generated carbon emissions were reduced by 30%.

D.Tree Planting Program

Every day, a mango tree measuring one meter takes in 1,247 kg of CO_2. The data comes from a study that calculated absorption values and determined the ability of urban forest plants to absorb CO_2 based on the pace at which tree leaves photosynthesize. The project will plant twenty mango trees in the designated location. Consequently, each month these trees will offset 0,748 tons of CO_2e.

E. Total CO_2 Emission Efficiency

As shown in Table 6, the overall CO_2 emission efficiency of the WE R GREEN program is determined by adding up all the program's emissions.

Table 6. The Calculation of Total CO_2 Emission Efficiency

Program	**Carbon Emission (ton/CO_2eq/year)**				
	Pre Impelentation	**Post Implementation**	**Efficiency**		
Water Efficiency	1,175	0,940	0,235	20%	
Energy Efficiency	8,444	6,871	1,573	19%	
Waste Management					
Waste Mobilitation	50,096	44,202	5,894	12%	
Waste at Landfill	1,457	1,015	0,441	30%	26%
Green Project Building	49,455	29,673	19,782	40%	
Tree Planting		-9,103	9,103		
Total Carbon Emission	**110,626**	**73,598**	**37,028**	**33%**	
Total 109 Projects	**12058,215**	**8022,150**	**4036,064**		

Over the course of all 109 ADHI projects, assuming a constant population and project activities, CO_2 emissions are expected to decrease by 33%, or approximately 4.036,06 tons CO_2e annually.

IV. CONCLUSION

The adoption of the "WE R GREEN" program in ADHI project, which combines water efficiency (W), energy efficiency (E), waste management (R), and tree planting (GREEN), will cut 37,03 tons/CO_2 equivalent annually overall. Assuming the same number of people and project activities throughout all 109 ADHI projects, it is predicted that CO_2 emissions will drop by 33%, or roughly 4.036,06 tons CO_2e per year.

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