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Green House Gas Emission Inventory and Energy Use of TPS3R Flamboyan Using Waste Reduction Model (WARM) V.15

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Abstract. Emissions are the result of human activities that increase the concentration of greenhouse gas gases such as CCl_2F_2, CO_2, N_2O, and CH_4, Increasing the attention of the gases above will increase the greenhouse effect which ultimately increases the earth's temperature. The existence of a waste management site can produce greenhouse gas emissions from vehicle transportation, composting processes, TPA to recycling. One of the roles of Flamboyan's TPS3R is to reduce the amount of plastic waste by recycling and composting and the residue will go to Cipeucang TPA for landfilling. This is an effort to reduce the amount of organic and non-organic waste, but the recycling, and composting. Landfilling processes can produce CO_2 in the waste processing and distribution process, so it is necessary to calculate the amount of CO_2 from the baseline management of municipal solid waste that will be compared with alternative municipal solid waste scenarios to see the conclusion of the analysis using the Waste Reduction Model (WARM) application. The objective of this journal is to calculate the greenhouse gas emission and energy use of TPS3R Flamboyan. The secondary data was obtained from TPS3R Flamboyan's management. The writer use description analysis. The inventory calculation result of GHG emission current condition and alternative condition are -5,24 and -6,5. Total energy use in the current condition is -58,79 and the alternative condition with HDPE recycling is -92,68. The inventory calculation result of GHG emission current condition and alternative condition are -5,24 and -6,5. Total energy Use in the current condition is -58,79 and the alternative condition with HDPE recycling is -92,68.

1 Introduction

Emissions are the result of human activities that increase the concentration of greenhouse gas gases such as Carbon dioxide, methane, chlorofluorocarbon, and nitrous oxide. Increasing the concentration of the gases above will increase the greenhouse effect which ultimately increases the temperature of the earth's surface. Data from the DKI Jakarta Environment Agency states that the sources of pollution in the capital city are divided into four, namely land transportation (75%), power and heating plants (9%), industrial combustion (8%), and domestic combustion (8%). The impact of the amount of CO_2 in the air is too much, fewer plants, and more CO_2 gas. The Ministry of Environment and Forestry (KLHK) noted that Indonesia's forests in 2021 will cover an area of 95.6 million hectares, this amount is equivalent to 50-51 percent of the total land area in Indonesia. This amount was recorded to be reduced from 2019 with a total forest of 125 hectares. The CO_2 will rise in the atmosphere and block the emission of heat from the earth so that the heat is reflected in the earth. As a result, the earth becomes very hot, again there is a greenhouse gas effect. The types of gases categorized as greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (N_2O), sulfur hexafluoride (SF6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). Of the several types of greenhouse gases, CO_2 is a major contributor to global warming [1]

Global CO_2 concentrations have increased significantly from year to year. The rate of increase in CO_2 concentrations in 1960 was around 0.7 ppm/year and rose to 2.38 ppm/year in 2014 [2]. Indonesia's role in the rate of increase in global CO_2 emissions also increased from 0.6% in 1990 to 1.2% in 2005 and rose again to 1.4% in 2015 [3].

Some of the effects of CO_2 as greenhouse gas emissions 1. Disrupt the balance of plant metabolism, which will accelerate the aging of cells in plants so that farmers can experience losses because the plants they plant die quickly. This shows the negative impact of increasing CO2 on plants. [4] 2. Heat stress from global warming

can reduce water resources and pastures for grazing, leading to reduced yields and affecting livestock. [5]

CO_2 is linked to climate change. Climate change is the most serious challenge facing the world today. A number of evidence show that there has been an increase in global temperatures, some of which are caused by human actions. Since 1960, the cause of rising temperatures on earth is the greenhouse effect which according to some experts is caused by the increasing content of carbon dioxide (CO_2) and other pollutant particles in the earth's atmosphere. Although natural processes are able to reduce CO_2 in the atmosphere, human activities release CO_2 into the air much faster than nature's ability to reduce it. [6] The waste management strategy chosen is determined based on the character of the waste [7] Some of the waste management processes are:

A. Composting.

Composting is a method of managing organic waste that aims to: reduce and change the composition of waste into useful products. Composting is one of the processes of processing organic waste into compost new materials such as humus. Compost is generally made from organic waste which comes from leaves and animal dung, which are intentionally added to balance the nitrogen and carbon elements so as to speed up the decay process and produce an ideal C/N ratio. Manure from goats, chickens, cows or factory-made fertilizers such as urea can be added in the composting process. Compost quality standards are said to be ideal if they meet the standard criteria as stated in SNI 19-7030-2004. WARM models composting as resulting in carbon storage nitrogen and phosphorous fertilizer offsets, and minimal CO_2 emissions from transportation and mechanical turning of the compost piles. Composting also results in CO_2 emissions from the decomposition of source materials, which include leaves, brush, grass, food waste and newspaper. B. Landfilling. Landfill is a place for storing burned waste / garbage, located in a layer of soil shallow, can be exploited economically and politically. Like a golf course, land rain attracts decomposition problems (decomposition of garbage) and the formation

of methane layers exposed to coal. Should be closed to avoid and monitoring as a tool good control so that the unknown things can be answered. The products obtained from aerobic decomposition are acids and alcohols, consumed by micro-organisms that produce methane and carbon dioxide. Gas Methane causes gas conditions to enter the house. Fist (1967) reported concentrations of explosion in his research another gas produced anaerobically is hydrogen sulfide foul-smelling and explosive [8] C. Recycling. Recycling is the process of turning used materials into new materials with the aim of preventing waste that could actually be useful, reducing the use of new raw materials. Recycling can also be defined as the reuse of unused materials or goods in other forms.

Several methods to reduce emissions from waste can be carried out, for example, such as carrying out waste management and utilizing technology properly, which can reduce the amount of CO2 from greenhouse gases and be able to generate electricity so that it is beneficial to the community [9] or applying a zero waste strategy to reduce carbon emissions in a sustainable manner [10]. Additionally, it is possible to implement a number of features of the hierarchical waste management approach, including energy recovery, composting, and recycling as well as minimizing trash and reusing products that may still be utilized. to reduce waste's contribution to greenhouse gas emissions [11]

One of the greenhouse gases (GHG) that can contribute to the greenhouse effect and ultimately lead to global warming is methane gas (Global Warming). Only a tiny portion of the approximately 450 TPAs in large cities now using an open dumping method have been transformed into controlled landfill. The amount of rubbish that might be produced annually by Indonesia's 45 major cities is 4 million tons. 11,390 tons of methane gas, or 239,199 tons of carbon dioxide, may be generated annually. This number represents 64% of the waste emissions from 10 major cities, including Jakarta, Medan, Surabaya, Semarang, Palembang, Bekasi, Depok, Makassar, Bandung, Depok, and Tangerang. [12]

Plastic is one of the waste that can turn into CO_2 if it is combusted. Plastic is a material made from naphtha which is a petroleum derivative product obtained through a refining process. Characteristics of plastics that have very strong chemical bonds so that a lot of the material used by the community comes from plastic. However, Plastic is a non-biodegradable substance, therefore products created from it will eventually become garbage that soil bacteria find challenging to break down and will damage the environment. There are six forms of plastic, including Polyethylene Terephthalate (PET), Polystyrene (PS), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE), Polypropylene (PP), High Density Polyethylene (HDPE), and Others, depending on the type of product. (Hartulistiyoso, et al, 2014). Typically, the composition of plastic trash is 46% polyethylene (HDPE and LDPE), 16% polypropylene (PP), 16% polystyrene (PS), 7% polyvinyl chloride (PVC), 5% polyethylene terephthalate (PET), 5% acrylic acid butadiene styrene (ABS), and other polymers. Today, polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC) account for more than 70% of all plastics manufactured (PVC). research that were done focused on these four categories of polymers.

Plastics may be divided into two categories, non-renewable and renewable, based on the basic material. Plastics are split into two categories based on how quickly they break down in nature: bioplastics, which are easily biodegradable, and conventional plastics, which are more difficult to biodegrade. Vegetable resources, which are renewable major crops, are used to make biodegradable polymers. Therefore, the production of vegetable materials can be sustainable and bioplastics can be degraded faster because they are environmentally friendly. The starch-based biodegradable plastic that can apply to an environmentally friendly packaging material has an excellent opportunity developed in Indonesia. [13]. Bio-PE (Bio-Poly Ethylene); HDPE (High Density Poly Ethylene): PLA (PolyLactic Acid); PHA (Poly Hydroxy Alkanoate); PHB (Poly HydroxyButyrate); PP (Poly Propylene); PBT (Poly Butylene Terephthalate); PBS (Poly Butylene Succinate), LDPE (Low Density Poly

Ethylene). However, since the technology is still in its early stages of development, biodegradable plastic costs more than traditional plastic. [14]

Not only plastic that can turn into CO_2 if it combusted, E-Waste also. Electronic garbage, sometimes known as e-waste, is another kind of solid waste that is possibly expanding at the greatest rate in many industrialized nations. This category includes outdated computers, televisions, phones, and other electronic gadgets. There is growing concern about this kind of waste. Governmental rules may be necessary to control the recycling and disposal of certain materials found in electronic equipment, such as lead, mercury, and cadmium.

The properties of solid waste vary greatly between towns and countries. For instance, American garbage is often lighter than garbage from Europe or Japan. In the US, less than 10% of MSW is made up of food waste, and the majority of it is made up of paper and paperboard goods. The remaining materials include a combination of yard waste, wood, glass, metal, plastic, leather, fabric, and other random items. This sort of MSW weighs around 120 kg per cubic meter when it is loose or uncompacted (200 pounds per cubic yard). Geographical location, economic climate, the season of the year, and several other factors all affect these numbers. Before designing and constructing any treatment or disposal facility, it is important to carefully examine the waste characteristics of each community. [15]

TPS3R is a Reduce, Reuse, Recycle Waste Management Site. In this study, the data come from TPS3R Flamboyan, Reni Jaya, and Banten. The objective of this journal is to calculate the greenhouse gas emission and energy use of TPS3R Flamboyan The analysis method for collecting the data used quantitative data with description analysis. The data used from TPS3R Flamboyan.

2 Method

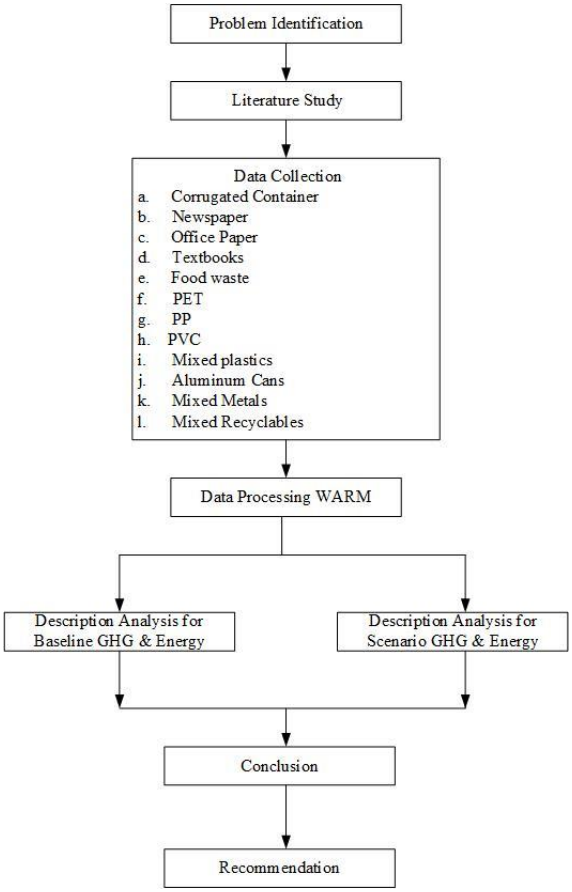

Figure 1. Research Framework (Personal Data, 2022)

Research location :

Figure 2. (A) TPS3R Flamboyan, (B)TPA Cipeucang , (C) Service Area TPS3R flamboyant on google earth

A. TPS3R Flamboyan located on Jl. Flamboyan No.31, Pamulang Bar., Kec. Pamulang, Kota Tangerang Selatan, Banten 15416. TPS3R Flamboyan is the waste collection place where the researcher take data from. -6.357703524147587, 106.73115079613783
B. TPA Cipeucang is the landfill area where the residue trash from TPS3R will be deliver. TPA Cipeucang addressed Jl. Kapling Nambo No.51, Serpong, Kec. Serpong, Kota Tangerang Selatan, Banten 15310. -6.324769153029707, 106.65912109613757
C. Service area TPS3R Flamboyan are 287 houses Reni Jaya on RT 001-006, 35 houses Gardena RT 003 RW 006 and 15 public shophouses on RT 003 RW 006, Time periode is June 2020.

Data Collection

The independent variable in tons a. Corrugated Container b. Newspaper c. Office Paper d. Textbooks e.Food waste f. PET g. PP h. PVC i. Mixed plastics j. Aluminum Cans k. Mixed metal l. Mixed recyclables m.HDPE

The dependent variable : a. CO_2 carbon dioxide in metric ton of CO_2 equivalent in baseline and Scenario waste management b. Energy use in million BTU for baseline and Scenario waste management

Software use in this study is WARM (Waste Reduction Model) Software. The Application that writer use is Waste Reduction Model (WARM) Version 15. It is available in Excel Formation. It was created by the U.S Environmental Protection Agency (EPA) to help Solid Waste Planner and Organization estimate Green House Gas (GHG) emission Reductions From Several Different Waste Management Practice. For given time period under each scenario by material type and by management practice, the mode allows to customize the result based on project specific landfill gas recovery practice, anaerobic digestion practice and transportation distance. The objective of the research is to calculate Green House Gas in metric tons CO_2 Equivalent (MTCO2E) and to see energy analysis to estimate GHG emission reduction from several different waste management practice. The way how to interpret the result is If a GHG emission value is negative, it means that those emissions have been avoided during the management of that specific material type and/or scenarios. Likewise, if an energy consumption is negative, it means that the modelled scenario avoids the consumption of that amount of energy. If the total change between the alternative and baseline scenario is negative, then the alternative scenario will result in fewer GHG emissions, energy

consumption, or economic impacts than the baseline, and vice versa. Only those materials for which data has been entered on the "Scenarios" step will be presented in the results.

Table 1. Baseline Data in WARM (Personal Data, 2022)

Number	Type of waste	Weight	Description
1	Corrugated Container	0,15	Recycled
2	Newspaper	0,014	Recycled
3	Office Paper	0,25	Recycled
4	Text Books	0,04	Recycled
5	Food Waste	1,565	Composted
6	PET	1,0	Recycled
7	PP	0,114	Recycled
8	PVC	0,607	Landfilled
9	Mixed Plastic	0,04	Recycled
10	Aluminum Cans	0,050	Recycled
11	Mixed Metal	0,030	Recycled
12	Mixed Recyclables	0,693	Recycled
13	HDPE	0,1	Landfilled

Table 2. Scenario data in WARM (Personal Data, 2022)

Number	Type of waste	Weight	Description
1	Corrugated Container	0,15	Recycled
2	Newspaper	0,014	Recycled
3	Office Paper	0,25	Recycled
4	Text Books	0,04	Recycled
5	Food Waste	1,565	Composted
6	PET	1,0	Recycled
7	PP	0,114	Recycled
8	PVC	0	Reduction in the first place
9	Mixed Plastic	0,04	Recycled
10	Aluminum Cans	0,050	Recycled
11	Mixed Metal	0,030	Recycled
12	Mixed Recyclable	0,693	Recycled
13	HDPE	0,1	Landfilled to recycled

Data Processing and Output in WARM

WARM compares the emissions and offsets resulting from a material in a baseline and an alternative management pathway in order to provide decision-makers with comparative emission results. For example, WARM could be used to calculate the GHG implications of landfilling 10 tons of office paper versus recycling the same amount of office paper. The general formula for net GHG emissions for each scenario modeled in WARM is as follows:

Net GHG emissions = Gross manufacturing GHG emissions - (Increase in carbon stocks + Avoided utility GHG emissions)

This equation should only be considered in the context of comparing two alternative materials management scenarios in order to identify the lowest net GHG emissions

.3 Results and Discussion

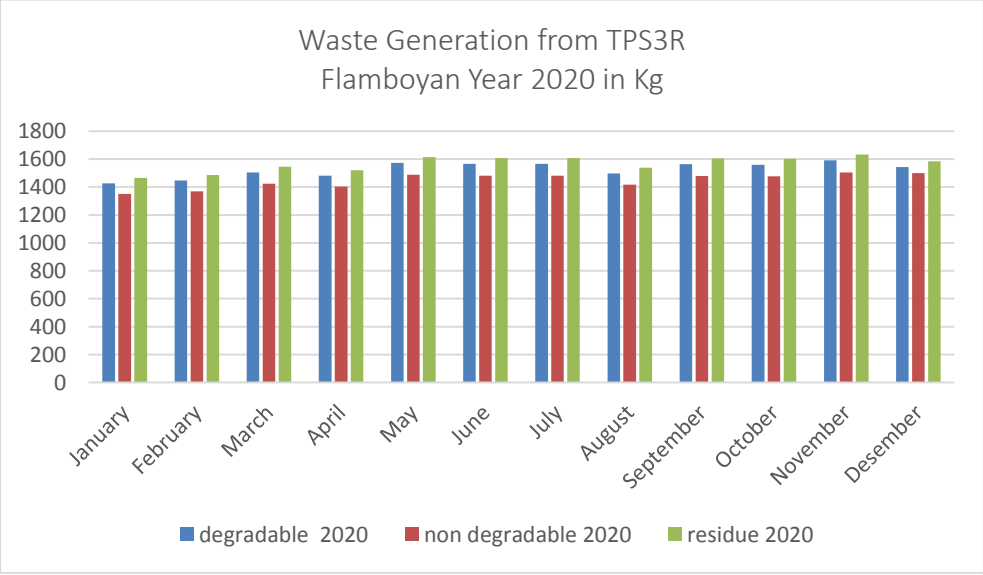

Figure 3. Waste Generation from TPS3R Flamboyan Year 2020 in Kg

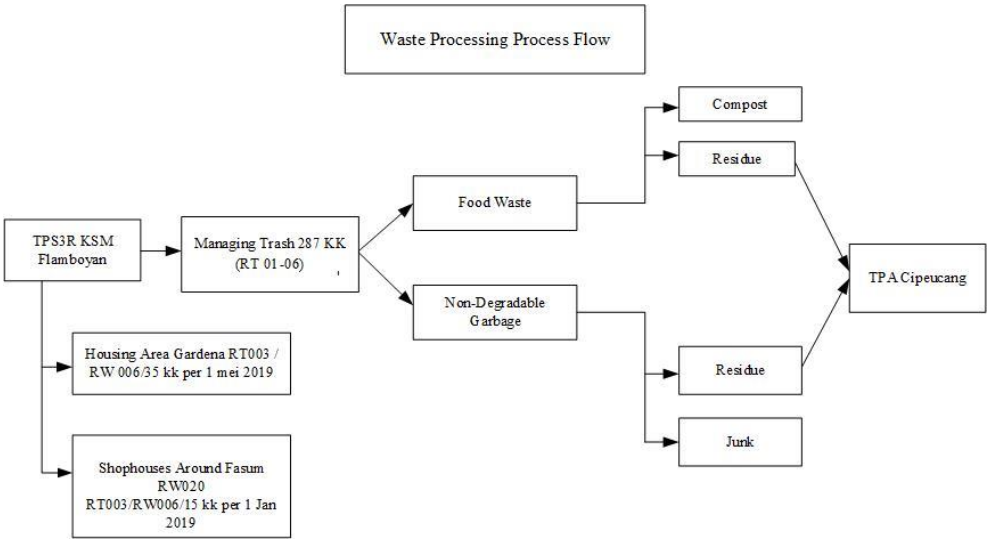

Figure 4. Waste Processing flow in TPS3R Flamboyan

The flow of the TPS3R Flamboyan waste processing process, namely waste is divided into 2 parts, namely degradable waste (food waste) and non degradable waste. Degradable waste (Food waste) will be sorted which can be used as compost and which are not so that it becomes a residue that will be taken to the TPA Cipeucang final waste disposal site. For non-degradable waste, it will be separated into junk which will be sold to third parties, and the rest such as coffee wrappers and pampers including residue to be taken to third parties' TPA Cipeucang final disposal site. The amount of waste that enters in 2020 is 217.816 kg and the residue that went to TPA Cipeucang is 75.234.

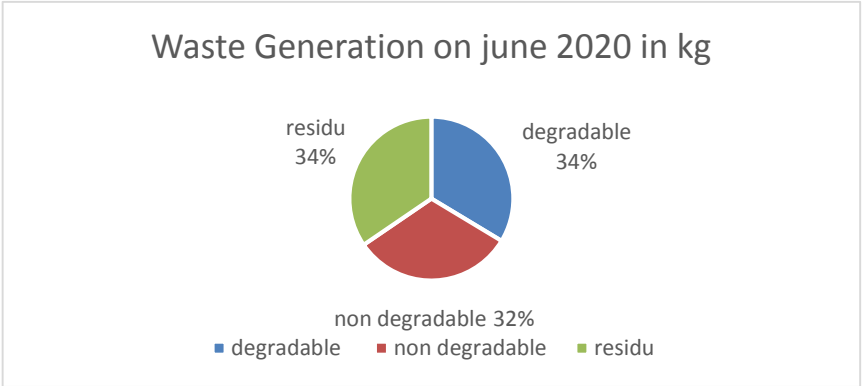

Figure 5. Waste Generation on June 2020 in Kg

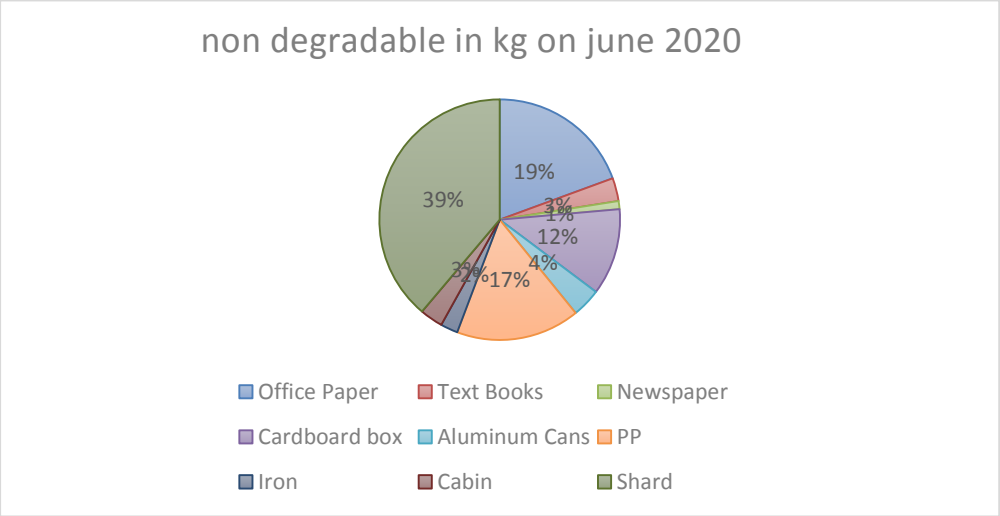

Figure 6. nondegradable waste on June 2020 in Kg

Alternative Data Scenario (Source Reduction)

In this analysis, source reduction is measured by the amount of material that would otherwise be produced but is not generated due to a program promoting waste minimization or source reduction. Source Reduction refers to any change in the design, manufacture, purchase or use of materials or products (including packaging) that reduces the amount of material entering the waste collection and disposal system. Source reduction conserves resources and reduces GHG emissions. The avoided GHG emissions are based on raw material acquisition and manufacturing processes for the industry average current mix of virgin and recycled inputs for materials in the marketplace. There are no emissions from end-of-life management because it is assumed that a certain amount of material or product was never produced in the first place.

Source reduction can result from any activity that reduces the amount of a material or agricultural input needed and therefore used to make products or food. In addition to the activities above, there are limited circumstances where the emission factors can be used to estimate GHG benefits of substituting one material or product for another material or product. In this study, waste that can be recycled will be recycled, such as 0,1 tonne of recycled HDPE from sources usually landfilled, and Waste reduced from the beginning cut without using PVC by 0.61 tons.

WARM Analysis Result for GHG

Table 3. GHG emission from baseline waste management (WARM Application, 2022)

GHG Emissions from Baseline Waste Management ($MTCO_2E$): -5,24

Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	0,15	-	-	NA	NA	(0,47)
Newspaper	0,01	-	-	NA	NA	(0,04)
Office Paper	0,25	-	-	NA	NA	(0,72)
Textbooks	0,04	-	-	NA	NA	(0,12)
Food Waste	NA	-	-	1,57	-	(0,18)
HDPE	-	0,10	-	NA	NA	0,00
PET	1,00	-	-	NA	NA	(1,04)
PP	0,11	-	-	NA	NA	(0,09)
PVC	NA	0,61	-	NA	NA	0,01
Mixed Plastics	0,04	-	-	NA	NA	(0,04)
Aluminum Cans	0,05	-	-	NA	NA	(0,46)
Mixed Metals	0,03	-	-	NA	NA	(0,13)
Mixed Recyclables	0,69	-	-	NA	NA	(1,98)

GHG emissions from baseline waste management is -5,24 MTCO2E. GHG emissions in the current and alternative scenario in TPS3R Flamboyan waste management system was calculated by using WARM model. Alternative scenario with respect to the composition and capabilities of TPS3R Flamboyan solid waste systems have been set up. Note : A negative value indicates an emission reduction, a positive value indicates an emission increase.

Table 4. GHG Emission from Alternative Waste Management Scenario(WARM Application, 2022)

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): -6,50

Material	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	0,15	-	-	NA	NA	(0,47)
Newspaper	-	0,01	-	-	NA	NA	(0,04)
Office Paper	-	0,25	-	-	NA	NA	(0,72)
Textbooks	-	0,04	-	-	NA	NA	(0,12)
Food Waste	-	NA	-	-	1,57	-	(0,18)
HDPE	-	0,10	-	-	NA	NA	(0,08)
PET	-	1,00	-	-	NA	NA	(1,04)
PP	-	0,11	-	-	NA	NA	(0,09)
PVC	0,61	NA	-	-	NA	NA	(1,17)
Mixed Plastics	-	0,04	-	-	NA	NA	(0,04)
Aluminum Cans	-	0,05	-	-	NA	NA	(0,46)
Mixed Metals	-	0,03	-	-	NA	NA	(0,13)
Mixed Recyclables	NA	0,69	-	-	NA	NA	(1,98)

The alternative waste management scenario has a -6,50 MTCO2E GHG emission. It is greater than the baseline waste management GHG emission, which is -5,24 MTCO2E. It indicates that compared to baseline management, the alternative scenario would produce larger emission reductions. Table 2 shows that the TPS3R Flamboyan's present waste management system has an emission of greenhouse gases rate of -5,24 MTCO2E. The effect of source reduction increased recycling, and composting on emissions of greenhouse gases was examined in the alternative scenario. The model's output shows that this state's greenhouse gas emissions were -6,50 (MTCO2E). Source reduction and recycling can significantly lower greenhouse gas emissions, according to model results.

WARM analysis result for Energy Use

Table 5. Energy Use From Baseline Waste Management (WARM Application, 2022)

Energy Use from Baseline Waste Management (million BTU): **-58,79**

Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total Million BTU
Corrugated Containers	0,15	-	-	NA	NA	(2,27)
Newspaper	0,01	-	-	NA	NA	(0,23)
Office Paper	0,25	-	-	NA	NA	(2,52)
Textbooks	0,04	-	-	NA	NA	(0,04)
Food Waste	NA	-	-	1,57	-	1,14
HDPE	-	0,10	-	NA	NA	0,03
PET	1,00	-	-	NA	NA	(28,59)
PP	0,11	-	-	NA	NA	(5,07)
PVC	NA	0,61	-	NA	NA	0,16
Mixed Plastics	0,04	-	-	NA	NA	(1,40)
Aluminum Cans	0,05	-	-	NA	NA	(7,64)
Mixed Metals	0,03	-	-	NA	NA	(2,00)
Mixed Recyclables	0,69	-	-	NA	NA	(10,36)

Table 6. Energy Use From Alternative Management Scenario (WARM Application, 2022)

Energy Use from Alternative Waste Management Scenario (million BTU): **-92,68**

Material	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total Million BTU
Corrugated Containers	-	0,15	-	-	NA	NA	(2,27)
Newspaper	-	0,01	-	-	NA	NA	(0,23)
Office Paper	-	0,25	-	-	NA	NA	(2,52)
Textbooks	-	0,04	-	-	NA	NA	(0,04)
Food Waste	-	NA	-	-	1,57	-	1,14
HDPE	-	0,10	-	-	NA	NA	(4,48)
PET	-	1,00	-	-	NA	NA	(28,59)
PP	-	0,11	-	-	NA	NA	(5,07)
PVC	0,61	NA	-	-	NA	NA	(29,22)
Mixed Plastics	-	0,04	-	-	NA	NA	(1,40)
Aluminum Cans	-	0,05	-	-	NA	NA	(7,64)
Mixed Metals	-	0,03	-	-	NA	NA	(2,00)
Mixed Recyclables	NA	0,69	-	-	NA	NA	(10,36)

The model calculated Energy Use from Baseline and Alternative Waste Management system. Based on Table 3 energy Use from Baseline was “58,79 -“million BTU and from the alternative scenario was “-92,68-“ million BTU(table 4). Results show energy usage reduces when using an alternative scenario. Energy use for

transportation based on distance, HDPE Baseline from TPS3R to TPA Cipeucang is 12 km, HDPE Alternative from TPS3R to 3rd Party Reni jaya is 150 m.

4 Conclusions

The conclusion is the inventory calculation result of GHG emission current condition and alternative condition are -5,24 and -6,5 and Total energy use in the current condition is -58,79 and the alternative condition with HDPE recycling is -92,68.5 Recommendation

Considering the significance of GHG emissions and Reni Jaya's population expansion, which increased garbage creation, selecting the best waste management alternatives may significantly contribute to lowering GHG emissions. Choosing the right waste management system might also help the government economically. To be both ecologically and economically viable, the most practical solution for waste treatment should be chosen based on the nature of the trash and the facilities already in place in Pamulang.

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