Analysis of production and potential utilization as electricity methane gas air dingin landfill

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Received 14th Des 2022; 1st Revision 9th Jan 2023; 2nd Revision 24th Jan 2023; Accepted 22th Feb 2023

Cite this https://doi.org/10.24036/jptk.v6i1.31823

Abstract: This study intends to analyze methane gas emissions resulting in landfill procedures. The magnitude of the impact of methane gas emissions on global warming from the waste sector, it is necessary to calculate the potential amount of methane gas emissions of Padang city waste in the Air Dingin Landfill so that it can be used for new energy potential as an alternative energy to replace fossil fuels no longer as a contributor to global warming. In this study, the methodology contains systematic steps in researching to achieve research objectives, namely conducting preliminary studies and literature studies, formulating problems, and setting research objectives as well as how to collect and obtain research data. The result of this study is that the Air DIngin Landfill in Padang City is still processing open dumping, with land that has been operated around 50% of the existing land area. The high operational costs are one of the reasons the sanitary landfill system cannot be done by the Padang City Government. Methane gas produced from 2020 - 2031 in the Air Dingin Landfill is produced from scenario 1 (waste directly landfilled) which is 43,289 gigagrams of CH_4 or 43,289 tons of CH_4 emissions. CH_4 emission scenario 2 (waste reduction by waste pickers in landfill) produced 43,267 gigagrams or 43,267 tons of CH_4. CH_4 emission scenario 3 (Reduction of waste at source, in the region, and in landfill) produced 40,944 gigagrams CH_4 or 40,944 tons of CH_4. After converting methane gas into electrical energy, the potential electricity in scenario 1 is 84.15 megawatts, scenario 2 is 84.10 megawatts and scenario 3 is 79.59 megawatts in 2031.

Keywords: Methane Gas; Electricity; Air Dingin Landfill; Padang City

1. Introduction

These conventional energy sources cause a lot of disruption to the environment by releasing large amounts of toxic gases and chemicals into the ecosystem. This pollution in turn causes global-scale phenomena such as global warming, air and soil pollution, acid rain, and biodiversity loss (Pant & Rai, 2021). Diminishing petroleum reserves lead to an increase in refined fuel prices. Given the increase in fuel prices due to the increase in world oil prices, the government is encouraged to deal with energy issues. One of the efforts to tighten fuel oil is to look for alternative renewable energy sources (Sriharti et al., 2018).

Methane is a gas that has the characteristics of having no odor, is non-color and is flammable when in the air with a concentration of 5-15% which can cause explosions and fires in landfills (final processing sites) (*Material Measurement Laboratory | NIST*, n.d.). According to (IPCC, 2006), the waste sector adds greenhouse gases to the atmosphere, especially from existing end money. It accounts for 3-4% of global greenhouse gas emissions. Although there are many types of greenhouse gases from this waste sector, CO2, CH_4, and N_2O are considered dominant and should be included in the national GHG inventory report.

Global methane emissions from landfills are estimated to be around 11.5% of total methane gas emissions (Environmental Protection Agency, 2013), while in Europe, an estimated 30% of methane emissions come from landfills (European Environment Agency, 2014), this happened in 2010. There are 400 landfills that on average operate with *open dumping* from the waste sector which produces 109.96 gigagrams of methane gas produced by Indonesia. This is due to the condition of wet landfills in Indonesia with a composition of organic waste that almost reaches 60%-70% (Purwanta, 2016). Methane content is very flammable when it is in an unopened place, whereas gas from landfill is potentially flammable which can have a dangerous impact (Gell et al., 2011). The explosion of a landfill due to methane gas occurred in Indonesia, namely on February 21, 2005, the Leuwi Gajah landfill (Bandung) exploded caused of a large deposit of methanogen (bacteria that decompose organic waste in the landfill as well as methane gas-producing bacteria) so that the incident caused 157 people to die and caused two villages around the landfill to be buried due to an explosion avalanche of garbage generation. Landfill gas has recently been the subject of research due to its potential energy use. GHG emission measurement in this case can represent the landfill situation to evaluate the efficiency of the gas recovery system in the landfill (Scheutz et al., 2011).

Air Dingin Landfill is a final waste processing site located in the city of Padang with a land area of about 30.30 hectares which uses active land with an area of 18.4 hectares and has been operating since 1986. In August 2013 according to waste data received the average amount of waste entering the Air Dingin Landfill of 607 tons/day. Landfill Air Dingin, receives waste with the largest composition of waste, namely organic waste, most of which is produced by traditional markets in the city of Padang. Air Dingin Landfill uses a controlled landfill, waste in the landfill is landfilled with covered soil not every day but per certain period. The magnitude of the impact of methane gas emissions on global warming from the waste sector, it is necessary to calculate the potential amount of methane gas emissions of Padang city waste in the Air Dingin Landfill so that it can be used for new energy potential as an alternative energy to replace fossil fuels no longer as a contributor to global warming.

2. Methods

Research methodology contains systematic steps in researching to achieve research objectives, namely conducting preliminary studies and literature studies, formulating problems, and setting research objectives as well as how to collect and obtain research data. This study was conducted to calculate the production of methane gas emissions resulting from the landfill process at the Padang City Air Dingin Landfill, project methane gas emissions for several years later, compile several waste reduction scenarios both from the source and those in the landfill and provide alternative technological solutions to manage methane gas produced to be lower. Methane emissions in landfill depend on the amount of waste processed, the type of waste, and the type of method of processing waste from the landfill.

This research stage starts with a literature study related to the research topic and collects data in the form of waste composition, and waste generation. In this study, what was measured was methane gas emissions resulting from the waste degradation process in the landfill. This study used the IPCC method with the help of IPCC 2006 software to calculate methane emissions produced. This study is compiled into several scenarios to compare the value of methane gas produced so that it can be determined which scenario is better and propose methane emission management technology so that methane gas emissions produced are not harmful to the environment so that they can be applied in Air Dingin Landfill.

Literature study

Literature studies are carried out by collecting information related to this research topic. This

stage contains information on municipal waste management, waste generation, waste composition, waste recycling potential, methane gas emissions, methane gas emission impacts, Air Dingin Landfill, and the IPCC Guideline 2006 methodology in calculating methane gas emissions produced and technology to manage methane gas emissions that have been produced.

Data collection

The data needed to support the preparation of this research report consists of secondary data and primary data. Secondary data is data obtained indirectly from the field by researchers and primary data is data obtained from, primary data in the form of field *observations* to complement data such as existing conditions on Padang city waste management.

Preparation of waste reduction scenarios that will be carried out at the Air Dingin Landfill

a. Scenario 1 (No waste reduction), This scenario is a scenario without any waste reduction efforts carried out at the landfill, so the waste that enters the landfill is immediately disposed of into the Air Dingin Landfill. This scenario was prepared to compare the value of methane gas emissions produced with scenario 2 and scenario 3.
b. Scenario 2 (existing condition), This scenario is the scenario of existing waste entering the Air Dingin Landfill, so the waste that enters the landfill is waste that has not been maximized in its waste processing in the area, but the recycled waste that enters the landfill is used by waste pickers in the Landfill besides that there are cows at the landfill site who participate in eating organic waste in the Air Dingin Landfill. This scenario was prepared to look at methane gas emissions resulting from existing scenarios and compare the value of methane gas emissions produced with scenario 1 and scenario 3.
c. Scenario 3 (waste reduction), This scenario was prepared to see methane gas emissions resulting from the planning scenario in the Padang City RTRW for 2030 and compare the value of methane gas emissions produced with scenario 1 and scenario 3.

Data analysis using IPCC

The analysis of this study used IPCC Inventory *software*. IPCC inventory software is used to calculate the production of methane emissions resulting from each of the scenarios prepared. Based on the Guidelines for the Implementation of the National Greenhouse Gas Emission Inventory Book II volume 4 related to the methodology of calculating gas emission levels in *excel* form. This method uses a Tier 2 accuracy level because it already has activity data in the form of waste composition.

3. Results and discussion

The composition of waste generation

Waste generated from landfill consists of market waste and residential waste. The largest composition of waste in the Landfill came from kitchen waste, which was 57.94%, followed by plastic waste at 10.35% and wood waste at 9.82%. One of the causes of kitchen waste being the most waste found in the Air Dingin Landfill is the lack of optimal processing of kitchen waste both at the source and in the landfill.

Population projections

Based on the Central Bureau of Statistics of Padang City 2012-2020, the population of Padang City is obtained as shown in Table 4.2. Population projection is carried out using 4 (four) methods, namely arithmetic, logarithmic, exponential, and geometric methods. The selection of the method used is by taking a correlation coefficient (R) that is close to the value of 1 or -1 and the smallest standard deviation value (S) of each method.

Calculation and projection of the amount of waste generation

Based on calculations, the generation unit of Padang City increased in 2012 was 0.936 kg/o/h, in 2021 it was 1.038 kg/o/h and in 2031 it was 1.151 kg/o/h. According to DKP, the waste produced in 2012 was 800 tons/day, while the waste transported to the landfill was 600 tons/day so if calculated the percentage of waste services transported to the landfill was 75%. The assumption of the percentage of waste transported to a landfill in 2012-2021 is 75% of the total waste generated, for 2022-2026 it is assumed that around 80% of waste is transported to a landfill and for 2027 to 2031 it is assumed that waste transported to landfill is around 85%.

Evaluation of Samah Management Scenario in Padang City

Evaluation of technical aspects of waste management in Padang City is carried out following the identification of problems in applicable regulations. The following is the description of the evaluation of waste management in Padang City.

IPCC Methane Emissions Calculation and Comparison

The results of the comparison of methane gas emissions in scenarios 1, 2, and 3 can be seen in Figure 1.

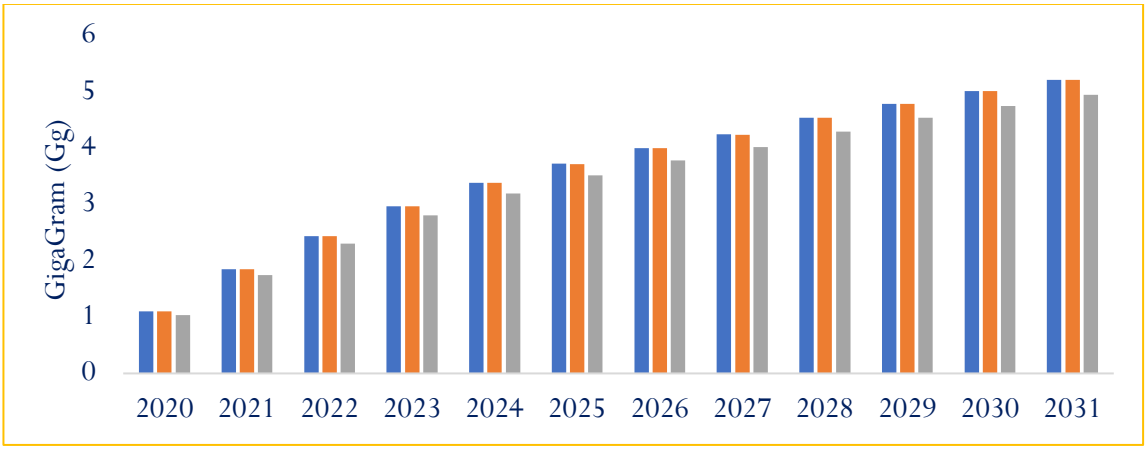

Figure 1. Comparison of Methane Gas Emissions Scenarios 1, 2 and 3

Conversion of methane gas into electricity

The calculation was carried out from the first year to the 12th year and added up the total electric potential obtained from the conversion of methane gas into electricity. The potential electricity generated from the conversion of methane gas into electricity is scenario 1 of 84.15 megawatts, scenario 2 of 84.10 megawatts, and scenario 3 of 79.59 megawatts. In 2013 is the largest electricity potential because the amount of electric potential is influenced by the quantity of incoming waste. Methane gas that produces electricity is expected to be utilized to have good economic benefits.

Methane gas emissions continue to increase over time both in scenarios 1, 2, and scenario 3. The increase in methane gas emissions is directly proportional to the increase in the amount of waste generated annually. The scenario that generates the most methane gas emissions comes from scenario 1. Scenario 1 (without reduction) has total emissions from 2020-2031 of 43,289 gigagrams of CH_4 or 43,289 tonnes of CH_4 emissions, the largest due to the absence of a waste reduction process both at the source and at the landfill. What is being sought to reduce methane gas emissions at landfills is by reducing waste. Scenario 2 with the help of scavengers reduces

recycling waste in the form of recycled plastic waste and cardboard by an average of 1 ton per day so that in scenario 2 it can reduce methane gas emissions to 43,267 gigagrams or 43,267 tons of CH_4. Scenario 3 with a reduction in the percentage of waste sourced and at the TPA, whether recycling food waste for composting, plastic, or paper, by 30 percent, so that the methane gas emissions produced from 2020-2031 are 40,944 gigagrams of CH_4 or 40,944 tons of CH_4. Based on Figure 1 it can be concluded that scenario 3 is the smallest scenario in producing methane gas emissions.

4. Conclusion

The result of this study is that the Air Dingin Landfill in Padang City is still processing open dumping, with land that has been operated around 50% of the existing land area. The high operational costs are one of the reasons the sanitary landfill system cannot be done by the Padang City Government. Methane gas produced from 2020 - 2031 in the Air Dingin Landfill is produced from scenario 1 (waste directly landfilled) which is 43,289 gigagrams of CH4 or 43,289 tons of CH4 emissions. CH4 emission scenario 2 (waste reduction by waste pickers in landfill) produced is 43,267 gigagrams or 43,267 tons of CH4. CH4 emission scenario 3 (Reduction of waste at source, in the region and landfill) produced is 40,944 gigagrams of CH4 or 40,944 tons of CH4. CH4 emissions are least produced by scenario 3, where waste reduction in the form of composting and recycling is carried out from the source and in the landfill. After converting methane gas into electrical energy, the potential electricity in scenario 1 is 84.15 megawatts, scenario 2 is 84.10 megawatts and scenario 3 is 79.59 megawatts in 2031.

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