Analysis of Utilization of Electricity Renewed From Methane Gas Organic Waste Product

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Abstract. The aim of the study was to determine the amount of electrical energy generated from methane gas produced from the volume of waste. The research method is carried out by literature review and field surveys, as well as theoretical calculations. Data was collected at the Tempat Pembuangan Akhir (TPA) and Kendari City Sanitation Office, by meeting and interviewing people directly related to the landfill management process, communities in energy independent settlements, as well as in the municipal sanitation office. The results of the study revealed that the energy produced from the Tempat Pembuangan Akhit (TPA) Puuwatu in the daily average was 288,466.5332 kWh. The amount of electrical energy that has been utilized by the Pemukiman Mandiri Energi is 1,080 kWh. The untapped energy is 287,386.5332 kWh.

Keywords: Energy independent settlements, Methane Gas, Organic Waste, Electric Energy.

1 Introduction

Improved landfill performance, in addition to increasing the rate of degradation of treated waste and leachate, can also increase the economic value of waste, and support the economic activities of the community. "We also look forward to the role of universities, to support applied research, related to the development of science and technology in the waste sector," said Budi, who also presented the Professors of Waste from ITB, Enri Damanhuri [1]. According to the 2018 World Bank Group estimates, the annual global generation of waste was 1.3 billion tons and was expected to reach approximately 2.2 billion tons by 2025 [2].

From previous research, Kendari City Puwatu Landfill has the potential for electrical energy from methane gas generated from landfill activities. Puwatutan landfill methane gas in 2017 has the potential for electrical energy of 12,298,234.56 kWh. This potential continues to increase along with the increasing amount of waste entering the landfill. Based on the results of research by Nina Angriani and Ansar Suyuti in 2017, it is recommended that the waste processing system be an advanced product in the form of electrical energy in the Puwatu landfill can be applied in other landfills. Good waste management in addition to reducing

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environmental problems, can provide economic benefits for managers, government, and society. It is necessary to study and analyze the benefits and costs that may arise from the development of Puwatu landfill electricity and how the development strategy [3].

The existence of waste power plants in the Puuwatu landfill that has been running for about 10 years should have increased in terms of electrical energy generated from processing organic waste into methane gas used to run the power generation engine. For this reason, we intend to conduct a study entitled "Analysis of the use of electricity generated from methane gas produced by organic waste treatment" [4]

More than half of that trash ends up in land ills where it generates methane, a greenhaouse gas thats over 20 times more potent than carbon dioxida. This methane from waste can be used to produce energy [5].

The problem of solid waste management has been increased due to rapid increase of population, intensive agriculture and industrialization. Accumulation and improper methods of disposal of waste, including heaping, dumping, land filling and incineration, cause pollution and hazards to human and environmental health [6]. The environmental aspect of the biomass power also has been an interesting object discussed in some studies [7].

The problem formulation of this research is how much methane gas is produced from the amount of waste in Puuwatu Landfill and How much electricity is generated from the amount of methane gas produced [8]. The purpose of this study was to determine the amount of methane gas produced from the amount of waste in the Puuwatu landfill and to determine the amount of energy obtained from the amount of methane gas available.

2 Literature Review

2.1 Trash

Garbage is a material that is wasted or thrown away from the source of the results of human and natural activities that do not yet have economic value. As for the definition of waste, it is waste that is unwanted residual material after the end of a process. In most of the recent EU member countries, as well as Spain and Greece, instead, sanitary landfilling is still the most-adopted waste management strategy (>50%) [9].

2.2 Organic Waste

Organic waste is waste that can be decomposed by microorganisms or can rot like household waste in the form of food scraps and natural waste in the form of leaves and wood. The municipal solid waste (MSW) generated by households is considered the third largest anthropogenic source of methane (CH_4) emissions, constituting 11% of all global CH_4 emissions [10].

2.3 Methane Gas

Methane gas in English Methane gas with the chemical element CH_4, is a major component of biogas. Methane gas is the simplest hydrocarbon compound in the form of gas. The properties of methane gas [11]:

1. Chemical Properties: Molecular weight 16, Freezing point 900 C, Boiling point 111.7, Critical point 190, Critical pressure, Critical volume 99.0 cm / g mol
2. Physical Properties: Is a gas that is flammable, odorless, is a colorless gas, has a specification of a flame of 500 - 700 k.cal/m^3. So, methane is both odourless and colourless [12].

Methane has been rising rapidly in theatmosphere over the past decade, contributing to global climate change. Methane is the second most important greenhouse gas behind carbon dioxide causing global climate change, contributing approximately 1 Wm^{-2} to warming when indirect effects are included compared to 1.66 Wm^{-2} for carbon dioxide [13].

Atmospheric methane levels rose steadily during the last few decades of the 20th century before leveling off for the first decade of the 21st century. Since 2008, however, methane concentrations have again been rising rapidly. This increase, if it continues in coming decades, will significantly increase global [14].

2.4 Calculation of Biogas Energy Capasity From Waste Raw Materials

1. Amount of total Solid (TS), Volatile Solid (VS). and Biogas Production

Based on the results of testing by Tanya Mc.Donald, Gopal Achari, and Bimbola Abiola in the article "Feasibility of Increased biogas production from the co-division of agricultural, municipal, and agro-industrial wastes in rulal communities". By testing biogas production made from organic waste, the conversion value of organic waste to Total Solid (TS) and Volatile Solid (VS) is obtained, as shown in Table 1 below. In this literature the value of VS is equivalent to the value of biogas produced.

Table 1. Potential Total Solid (TS), Volatile Solid (VS) and Biogas Production of organic wast [15]

Material Type (kg)	Total Solid (TS) (%)	Volatile Solid (VS) (%)	Biogas Production (m^2/kg TS)
Organic Trash	27.7	74.1	0.676

(Source: Agung Sulistiyo, 2010).

Based on the table above, the equation for calculating Total Solid, Solid Volatile, and biogas production is as follows [15]:

TS = 27.7% x Q (1)

VS = 74.1% x TS (2)

VBS = 0.676 x VS (3)

Information:

Q = Waste Potential (kg / day)

TS = Total Solid

VS = Volatile Solid (kg / day)
VBS = Volume of biogas production (m^3 / day)

2. Amount of Methane Gas Produced

To calculate the amount of potential methane gas produced in a landfill process.

Table 2. Amount of volume of methane gas from organic waste

Biogas Production ((m^3/day)	Amount of methane gas (%)
VBS	60

(Source: Agung Sulistyo, 2010)

Based on the table above, the equation for calculating gas is:
VGM = 60% x VBS (4)
Information
VGM = Volume of methane gas (m^3 / day)
VBS = Volume of biogas production (m^3 / day)

3. The Potential of Electrical Energy Produced

The potential of methane gas in m^3 must be equalized in units of electrical energy (kWh). In the book Renewable Energy Conversion, Transmission Storage, by Bent Seronsen, 1 m^3 of methane is equivalent to 6.13 x 10^7 Joules, while 1 kWh is equivalent to 3.6 x 10^7 Joules. So that 1m^3 of methane produces electricity of 9.36 kWh.

Table 3. Energy conversion of methane gas into electrical energy [15]

Type of Energy	Equivalent Energy
1 Kg Methane gas	6.13 x 10^7 Joule
1 kWh	3.6 x 10^7 Joule
1 m^3 Methane gas	9.9 kWh

(Source: Agung Sulistyo, 2010)

3 Research Methods

This research is a descriptive study with a quantitative approach, which was conducted at Puuwatu Landfill in Kendari City. Yusuf, 2013, stated that the descriptive method was a conscious and systematic effort to provide answers to a problem and / or obtain more in-depth and extensive information on a phenomenon by using quantitative research stages. In this case, to calculate the potential methane waste in Puwatu Landfill, Types and Sources of Data In this study include primary data and secondary data. Primary Data is data obtained directly at the research location. This data was obtained from field observations and through informant interviews. Primary data sources were obtained from the Puwatu Landfill, the Sanitation, Parks and Cemeteries Office of Kendari City, and the Southeast Sulawesi Province BAPPEDA. The primary data needed is the composition of waste in the Puwatu landfill, the volume of waste, the waste management policy in Kendari City and the regional energy development policy. Secondary data obtained through various sources of written reports, libraries and other documents. Secondary data sources are the City of Sanitation, Parks and Cemeteries Office of Kendari City, BPS Office, and from literature studies. Secondary data needed includes population data (population, population growth) and waste management data. In addition, secondary data was also obtained from documents relating to the use of landfill gas as energy. The calculation is done using references from the library.

4 Data Analysis

4.1 Data on waste volume from January to July 2018

It is obtained from the TPA Puuwatu Unit Pelaksana Teknis (UPTD) as follows:

Table 4. Amount of waste volume per month

Month 2018	Volume m^3
January	4,950.5
February	4,410.0
March	4,560.0
May	6,330.5
June	5,892.5
July	6,523.5
Total	32,667

4.2 Biogas Energy Capacity from Materials Raw Waste

Calculation of biogas energy capacity from waste raw material in Puuwatu landfill per month.

1. January 2018

For conversion from m^3 to Kg then at times with 169.44, so:

$4950.5 m^3$ equivalent to = 4950.5 x 169.44
= 838,812.7 Kg / Month
= 838,812.7 / 30 days
= 27,960.424 Kg / Day

TS = 27.7% x Q
= 27.7% x 27,960.424
= 7,745.037448 kg

VS = 74.1% x TS
= 74.1% x 7,745.037448 kg
= 5,739.0727 kg

VBS = 0.676 x VS
= 0.676 x 5,739.0727 kg
= 3,879.613 m^3

For details, from January to July can be seen in the following table:

Table 5. Q and VBS values

Month	Q (kg/day)	VBS (m^3)
January 2018	27,960.424	3,879.613
February 2018	24,907.68	3,456.0336
March 2018	25,754.88	3,573.5857
May 2018	35,754.664	4,961.0931
June 2018	33,280.84	4,617.8414
July 2018	36,844.728	5,112.3435
TOTAL	184,503.22	25,600.5103

4.3 Methane Gas Production

Energy production in biogas is comparable to the production of methane gas
VGM = 60% x VBS
Information:
VGM = Methane gas production (m^3 / day)
VBS = Volume of biogas production (m^3 / day)
1. January 2018
VBS = 3,879.613 m^3
VGM = 60% x VBS
= 60% x 3,879.613
= 2,327.7678 m^3 / day
For details, from January to July can be seen in Table 6

Table 6. Methane Gas Production Value (VGM)

Month year	VBS (m^3)	VGM (m^3)/day
January 2018	3,879,613	2,327.7678
February 2018	3,456.0336	2,073.6202
March 2018	3,573.5857	2,144.1514
May 2018	4,961.0931	2,976.6559
June 2018	4,617.8414	2,770.7048
July 2018	5,112.3435	3,067.4061
TOTAL	25,600.510	15,360.3062

4.4 Electricity Energy Produced

From Table 3, 1 m^3 of methane gas equals 9.39 kWh
E = VGM x FK (Correction Factor)
= VGM x 9.39
1. January 2018
VGM = 2,327.7678 m^3 / day
E = VGM x 9.39
= 2,327.7678 x 9.39
= 21,857.7396 kWh
For details, from January to July can be seen in the following table:

Table 7. VGM and Electric Energy Value

Month 2018	VGM (m^3)	E (kWh)
January	2,327.7678	21,857.7396
February	2,073.6202	19,471.2933
March	2,144.1514	27,950.7905
May	2,976.6559	27,950.7905
June	2,770.7048	26,016.9184
July	3,067.4061	28,802.9433
Total	**15,360.3062**	**144,233.2666**

Amount of electrical energy in year:
E Year = E Total x 2
= 144,233.2666 kWh x 2
= 288,466.5332 kWh

4.5 Estimated Electricity Energy

Estimates in the daily average value from January to July 2018, the energy produced from the Puuwatu landfill in the daily average is 288,466.5332 kWh. Whereas the energy flowing through the Independent Energy area the number of houses is 125 houses and each house has 450 VA (2 Ampere MCB), then the daily count used to fulfill the energy independent region is as follows:
125 x 360 watts = 45,000 watts
= 45 kw x 24 hours
= 1,080 kWh
So that the untapped energy from the potential at Puuwatu Landfill is as big as:
E Not = 288,466.5332 kWh - 1,080 kWh
= 287,386.5332 kWh

5 Conclusion

The conclusion obtained from this study is the amount of methane gas produced from the annual Puuwatu landfill is 15,360.3062 m^3 and the amount of energy generated is 288,466.5332 kWh.

Compared to other big cities in Indonesia, the amount of methane gas acquisition in Puuwatu Kendari City is very small. This is very much determined by the amount of rubbish produced by the people of Kendari City, which only ranges from hundreds of tons per day compared to big cities like Surabaya, Palembang, Makassar, Bandung, Bekasi, with an average of 1500 tons to 2800 tons per day.

So, it is very natural that the government, in this case the Ministry of Energy and Mineral Resources, has launched the construction of a Waste-Generated Power Plant in several cities that produce very large amounts of waste per day between 1500 tons per day to 2800 tons per day. And not including the city of Kendari.

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