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Study the Relevance of the Development of a Garbage Power Plant to the Large Increase in Waste Volume in Indonesia

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Abstract-- Garbage endangers the community in terms of health, the economy, and the land that is taken up. Indonesia is a country with many waste piles, but there is waste management in terms of recycling, the use of computers, and other things, even from energy sources for power plants. The Waste Power Plant (PLTSa) is an electric power plant that helps add electrical energy for the PLN to be distributed to the community. The source of combustion and the driving point for garbage power plan (PLTSa) is waste; therefore, most of these locations are located in landfills in big cities. This research article aims to strengthen the argument that the development of PLTSa can be accelerated because the increase in waste piles every year will cause unmanaged waste to also increase. The results of studies and literacy studies show that the average managed waste pile is 15,000 tons/year and still leaves 5 million tons/year of waste that is not appropriately managed; however, the PLTSa capacity is still small at 10 MWh/year. It is necessary to increase the quality of waste containers as a source of PLTSa energy to reduce the amount of unmanaged waste.

***Keywords*— Waste Energy, Renewable Energy, Technology Development, Energy, Generators**

I. INTRODUCTION

Energy is a key component of the economy, whether it is used as a fuel, a raw resource, or an export good. As the world's population and economy both develop and improve, so do our demands for energy. Diverse energy resources, including fossil (coal, petroleum) and renewable sources, are required to satisfy Indonesia's energy needs. Given the current scenario, where every demand and activity necessitates a large amount of energy, it is obvious that a large amount of energy supply is required, but there will only be a small amount of energy revenue from sources other than renewable energy. Indonesia must thus optimize its usage of energy, particularly for energy with a very high threshold or that can be construed as having a big supply of energy.

A rise in garbage will have a negative effect if it is not handled effectively and can even result in environmental degradation that will spread more widely. Garbage is a source of energy that will always increase in step with people's daily usage. Environmental issues would start to appear in society when the trash is produced daily from human activities without any control or management of this waste. One of society's environmental issues that require effective management is the garbage issue. The World Health Organization (WHO) defines waste as everything that is no longer useful is not being utilized, is disliked, or everything that is thrown away results from human activity and does not occur naturally. Household garbage, which results from people's everyday activities, is one type of waste that may be easily discovered in the neighbourhood. [1]

As one of the major producers of trash, Indonesia's waste production is expected to rise dramatically each year, endangering the environment, human health, and other factors. Indonesia is a sizable nation with significant waste management issues. [1] According to study data obtained from the Ministry of Environment and Forestry (KLHK), Indonesia generates about 64 million tons of garbage annually, with organic waste controlling the composition of the waste. Paper and rubber trash come in second, followed by plastic waste and other wastes including metal, fabric, and glass (Agung et al., 2021). Trash may be divided into two categories based on type: organic waste and inorganic waste. Organic trash is garbage that bacteria with biodegradable qualities may quickly break down. Food scraps, leaves, and other waste products are examples of this kind of trash [2]. Ridwan defines inorganic waste as garbage that is very difficult to break down and that originates from industrial operations (such as the production of plastic or aluminium) or non-renewable natural resources (such as minerals or petroleum). [1] Plastic bottles, plastic bags, old beverage cans, glass, Styrofoam, and other materials are examples of inorganic garbage that can be found in the neighbourhood. [1]

According to the most recent data from the National Waste Management Information System (SIPSN), Indonesia generates 20,355,120.83 tonnes of solid waste per year, with a managed waste percentage of 74.01% from various sectors. However, 25.99% of the total waste is still poorly managed or amounting to about 29 tonnes per year.

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However, trash is also one of the possible energy sources for waste power plants (PLTSa), serving as the primary fuel for heating water and generating steam to power turbines, despite the risks associated with many landfills. This is well-known as a renewable energy substitute and has been employed in a number of Indonesian provinces. For example, PLTSa in Singkawang, Wonosari with an average waste energy source discussed PLTSa developed near Final Disposal Sites (TPA) as an extra source for local inhabitants and an additional electricity supply for PLN.[3] An average weight of 104,784.3 Kg per day yields 24,833.76 kWh per day, or 9,064.32 MWh per year, when converted to MWh.[3] The PLTSa in Bantargebang Bekasi, waste usage in Gede Bage, Bandung [4], and other regions, are both had been discussed.[5]

According to the numerous PLTSa studies already in operation, a significant amount of waste in Indonesia has been managed as a resource for combustion in PLTSa, but according to SIPSN data, there are an additional 5 million tons of waste that have not been managed properly. As a result, it is necessary to increase the fuel capacity for waste in PLTSa as one of the additional management containers to lower the value of unmanaged waste, and this article aims to equalize the urgent need that.

II. METHODOLOGY

The literature review study technique, often known as a literature review, was used to conduct this research. The literature review approach, is one in which researchers gather material from various sources.[1] The research for this paper was gathered from printed books, the internet, research reports, and publications published in scholarly journals [1]. When comparing the capacity of PLTSa with TPA stockpiles and annual increases, the discussion will focus on the study of the relevance of PLTSa development in various regions. The comparison's findings and calculation of potential residual waste will then serve as the basis for PLTSa's need to be further developed in the near future.

III. RESULTS AND DISCUSSION

The author cites a number of sources, including an earlier study that used data from many PLTSa-equipped landfills as well as information on rubbish stacks and their advancements.

1. Surabaya

The population of Surabaya, the second-largest city in Indonesia, was 2.8 million in 2017 according to BPS Province of East Java, 2018. The city's huge population is closely correlated with the high volume of trash that has accumulated from the activities of all its citizens. As a result, Surabaya needs the best waste management practices to reduce the buildup, which will grow every year. According to environmental service data, the garbage mounds change each years as follows:

Table 1. Data on Surabaya City Garbage Piles

No	Years	Garbage Heaps	
		Tons/Day	Tons/Year
1	2017	2.164	790.020
2	2018	2.205	805.189
3	2019	2.248	820.648
4	2020	2.321	835.560
5	2021	2.342	843.120

Source: Surabaya City Environment Service Data

This information indicates that Surabaya's garbage heaps are growing every year and will keep growing, but since the city's waste management capacity remains nominally unchanged, this will result in an imbalance between the handling of incoming and existing waste. There will be a variety of effects, such as the buildup of residual trash that is not handled and pollutes the environment, and creates health issues.

2. Pekanbaru

Pekanbaru is another urban area. Pekanbaru, one of the main cities and the capital of the province of Riau in the Sumatra area, is one of the cities on the island of Sumatra, or more specifically, in the province of Riau. Indah, Payung Sekaki, Bukit Raya, Damai Malpoyan, Tenayan Raya, Fifty, Sayle, Pekanbaru City, Sukajadi, Senapelang, Lumbai, and Lumbai Coast are among the 12 districts that make up Pekanbaru, which spans a distance of 632.26 km. Pekanbaru City had a population of 999,031 in 2013 and 1,011,467 in 2014, per BPS Research. Pekanbaru City's population in 2014 increased by 3.57% (34,473 people), or 1.24% (12,436 people), compared to 2013. Population and waste are correlated; the more people, the more garbage. With a population of 1,011,467, Pekanbaru City has a waste generation capacity of 0.3 x 1,011,467 = 303,440 kg or 303 tonnes/hour. The table below contains further information:

Table 2. Data on Pekanbaru City Garbage Piles

Years	Garbage Heaps		Garbage Volumes	
	Total (Kg)	Average (Kg/Day)	Total (m2)	Average (m2/Day)
2010	53.485.550	146.535	618.292	1,693,95
2011	78.7773.280	215.817	910.619	2.494,85
2012	79.579.000	217.430	917.425	2.513,49
2013	133.500.260	365.754	1.543.263	4.228,12
2014	144.532.700	395.980	1.670.798	4.577,53
2015	148.819.753	407.725	1.720.356	4.713,31

Source: Data from the Pekanbaru City Environmental Service

Monica did study on Pekanbaru city's trash statistics. The primary fuel source for PLTSa is garbage collected in Pekanbaru City, which also has the ability to be processed or burned. As a result of the existing waste situation, we may plan to utilize a power plant (PLTSa), which generates 9 MW of electricity and has a calorific value of 2500 kcal/kg of trash entering it with a water content ratio of 30%. [1]

3. Yogyakarta

32.50 km^2 or 1.02% of the province's Special Region of Yogyakarta's total area, which is made up of 14 districts and 45 villages, is occupied by the city of Yogyakarta. The Sleman district forms Yogyakarta's northern border. Sleman and Bantul are located west and east, while the Bantul district is located north and south. With a current density of 8,964 inhabitants per square meter, Yogyakarta is a popular tourist destination for both domestic and international visitors. The Piyungan TPA, which covers an area of 16 hectares and is the largest final disposal site in the Special Region of Yogyakarta, is part of the city of Yogyakarta's solid waste management system. In Ngablak Hamlet, Sitimulyo Village, Piyungan District, Bantul Regency, is where you can find the Piyungan Landfill. The City of Yogyakarta will be one of the three simultaneous locations whose garbage will be used by the Piyungan TPA. Sleman Regency and the Bantul Regency. The data on garbage sent to the Piyungan TPA are included in the table below to help explain the dispersion of waste.

Table 3. Garbage Entering TPA Piyungan City of Yogyakarta

Years	Months	Masa (Ton)
2018	Mei	12.278
	Juni	13.823
	Juli	14.699
	Agustus	16.389
	September	13.614
	Oktober	17.276
	November	17.769
	December	17.822
2019	January	18.034
	February	16.415
	Maret	19.441
	April	17.744

Source: Piyungan landfill data

The amount of garbage that the City of Yogyakarta sends to the Piyungan TPA is 592 tons/day, which is equal to 17,744 tons/month, based on information on waste heaps that are gathered and processed there. Piyungan now has a location that is 16 hectares in size, making it a suitable technology for this degree of heating technology. Waste with a low water content of 20% can be used to fuel heating systems like PLTSa. The same idea underlies how a solar power plant operates. When compared to coal-fired power plants, PLTSa has the benefit of not requiring the acquisition of many raw materials. The EBTKE Ministry of Energy and Mineral Resources' energy conversion estimates show that Yogyakarta City TPA can produce 25 MW of electrical power using thermal technology.[1].

4. Samarinda

The city of Samarinda comes next. On the island of Borneo, specifically in the province of East Kalimantan, sits Samarinda City. It is the seat of the Province of East Kalimantan and the most populated city in Borneo. Given that Samarinda metropolis is a large metropolis, estimations of its trash may be derived from the total. According to the Central Bureau of Statistics for Samarinda City (2015), the city's population is 812,597. According to Samarinda City's BAPPEDA Regional Development Planning Agency. The city of Samarinda had a bigger growth in the garbage in 2012, totaling 995,449 m3, compared to the previous four years (2009 to 2013), which were noted as the first four years of rubbish availability. utilized as a source of electricity. (Huda, 2020). With a huge population comes a great amount of garbage production, and the table below will provide the waste data for Samarinda City. This information on garbage is gathered from Sambutan TPA, one of the cities of Samarinda's landfills.

Table 4. Samarinda City Garbage Piles Data

No	Years	Garbage weight (Tons/Day)	Garbage weight (Tons/Year)
1	2015	297	2.603,717
2	2016	827,78	7.251,352
3	2017	858,39	7.519,494
4	2018	877,54	7.801,127

Source: City of Samarinda Environment Agency Data

Unwaru claims that it is certain that the electrical energy produced at the Sanbutan Landfill Samarinda City would reach a value of 684,693,866 KWh in 2019 and will rise every year until 2034 based on data analysis of PLTSa Sanbutan City Samarinda Landfill. The estimated amount of power produced at Sambutan TPA in 2019 was 2,822,107.61 kWh, and it will rise to 2034. The PLTSa electrical components utilized in PLTSa TPA Samburan in Samarinda City are implemented using the Janbacher J 320 GS gas engine, which has a total output of 1,063 kW from two units. [1]

5. Semarang

The city of Semarang is the capital of the Central Java province and is also one of the province's cities. It is well known that PLTSa uses a thermal incineration method to turn organic waste into power and a gasification process to turn inorganic waste into electricity.[6] The study data used in this publication were generated in the Semarang municipal landfill. The waste production statistics needed for the analysis and calculations in the table were collected from the Jatibarang TPA office, which is under the supervision of the Semarang DLH office.

Table 5. Semarang City Waste Producer Data

Years	Waste Production/Day		Volume of Garbage Raised/Day	
	m^3	Tons	m^3	Tons
2009	4527,2	1131,8	3395,4	848,9
2010	4602,6	1150,7	3544,0	886,0
2011	4679,2	1169,8	3696,6	924,1
2012	4757,1	1189,3	3853,3	963,31
2013	4836,3	1209,1	4014,1	1003,3
2014	4916,7	1229,2	417,3	1044,8
2015	4998,7	1249,7	1249,7	4348,8
2016	5080	1270,13	3897,04	974,26

Source: Waste Production Data of Jatibarang Landfill, Semarang City

According to studies on waste-to-energy utilization (PLTSa) plans at the Jatibarang TPA, the amount of electricity produced annually over the following five years (2017–2021) will be 84,627.02 MWh in 2017, 82,308.43 MWh in 2018, and 83,627 MWh in 2019. MWh per year, followed by 83,179.35 MWh per year in 2020 and 83,434.88 MWh per year in 2021. The generator produced 9,525.63 kW [1].

6. Bekasi

Bantar Gebang Bekasi's TPA reached 9,932,142.24 m^3 in the middle of 2008.[7] This is in accordance with research and investigations. It is estimated that TPA Bantar Gebang receives about 7,000 tons of garbage per day. From the data collected, it turns out that the waste accumulate came from

residential (household) and non-residential waste in the last 3 years, where in 2008 the volume of waste for Java was 29,413,336 m3/year or 44%, 2008 the type of waste from kitchens the volume of waste is 22.2 million tons/year (58%) and in 2009 there was an increase for the Jakarta area, including from 6,594.72 tons/day it is estimated to be 7200 tons/day in 2020 [7].

What is the potential for landfill gas (LFG) produced from the Bantar Gebang landfill trash pile, Bekasi Regency, according to Rajagukguk (2020)? How much electrical energy can be produced from the landfill gas in the Bantar Gebang dump in the Bekasi Regency? Is it thus viable to construct a 200 MW waste power plant (PLTSa) in the Bantar Gebang landfill in the Bekasi Regency? To develop the potential for landfill gas produced by the rotting of organic waste at the Bantar Gebang Final Disposal Site (TPA) in Bekasi Regency as a substitute for electrical energy, and to generate the capacity for electrical energy that may be generated from landfill gas a 200 MW energy source based on the findings of economic feasibility studies (Feasibility Study) of load, energy, factors influencing the choice of power generation technology, project financial results NPV (Net Present Value), IRR (Internal Rate of Return), and PP (Payback Period), as well as regulations governing the legality of constructing power plants [7].

The literacy study conducted is an elaboration of literacy data from each region in Indonesia and will be equated with an increase in landfill waste. PLTSa has been built in various areas in big cities, but the capacity of PLTSa is not yet sufficient due to the g amount of waste piled up, because the average electricity capacity in PLTSa is around 10 MWh/year with an average capacity of processed waste of 15,000 tons/year, if present, the average waste processing that utilizes is around 70% of the total waste pile for PLTSa fuel.[8] However, in the latest data from SIPSN, there is still around 25% of waste that has not been managed properly or around 5.29 million tonnes/year with an annual percentage increase of 2.8%, so this needs to be considered and needs to be addressed to reduce the value of the percentage of waste unmanaged so that it can help the community in terms of health and also the economy around the TPA or PLTSa.[9][10][11][12]

IV. Conclusion

Citing a number of earlier studies as a source of information on Indonesia's potential for using waste energy as a source of renewable energy, it is stated that Indonesia, a nation with a large and growing waste stream, has a great deal of potential to do so in the future. In Indonesia, for example, it is simple to obtain waste-derived energy. In the future, Indonesia's energy security has a lot of promise, provided that it is managed well.

An attempt should have been made to generate effective waste management based on the data that has been collected as a reference for equity about the development of PLTSa. According to the discussion's findings, if waste is not managed properly, there will be a very noticeable increase in its impact in the future. One of the benefits of good waste management is that it will make PLTSa an energy source and improve residents' quality of life economically. It will also increase managed waste so that waste does not build up and infect those living nearby the TPA with diseases.

References

[1] Unwaru, K. A., Sudarti, S., & Yushardi, Y. " Analysis of the Use of Organic and Inorganic Waste for Waste Power Generation Technology in Several Big Cities in Indonesia." *Science and Technology Journal, 5*(2), 255-263, 2022

[2] Damayanti, G. P., Waluyo, W., & Candrakirana, R. "Waste Management Through Waste Power Plants in Indonesia to Achieve Net Zero Emissions." *PLEDOI (Law and Justice Journal), 2*(1), 79-92, 2023.

[3] FARUQ, U. I. " Study of the potential of municipal waste as a waste power plant for Singkawang City." *Electrical Engineering Tanjungpura University*, *2*(1), 2016.

[4] Purwaningsih, M. R. " Analysis of the social benefit costs of the existence of the Gedebage waste power plant for the surrounding community" *Journal of Regional and Urban Planning, 23*(3), 225-240, 2012.

[5] Sahda, N. T., Sentosa, J. M., & Adhani, L. "Boiler Efficiency Analysis using the Direct Method at the Bantargebang Waste Power Plant" *Journal of Engineering Environmental Energy and Science*, *1*(1), 39-48, 2022.

[6] Setyono, J. S., Mardiansjah, F. H., & Astuti, M. F. K. " Potential for New Energy and Renewable Energy Development in Semarang City" *Riptek Journal*, *13*(2), 177-186, 2019.

[7] Rajagukguk, J. R. " Feasibility Study of Waste Power Plant Design (PLTSa) as a 200 MW Electrical Energy Source" *Environmental Engineering Scientific Media*, *5*(1), 51-61, 2021.

[8]Sukwika, T., & Noviana, L. " "Sustainability status of integrated waste management at TPST-Bantargebang," Bekasi: Using statistical rapfin. *Environmental Studies Journal*, *18*(1), 107-118, 2020.

[9] Kadang, J. M., & Sinaga, N. " Development of Waste Conversion Technology for Effective Waste Processing and Sustainable Energy" *Teknika*, *15*(1), 33-44, 2016.

[10] Laksmono, Rudy. " Energy and Environmental Economics Lecture Materials". June 13 2023.

[11] Qodriyatun, S. N. " Waste power generation: Between environmental problems and accelerated renewable energy development." *Aspiration: A Journal of Issues*, *12*(1), 63-84, 2021.

[12] Surachman, E. N., & Handayani, D. " Education on Financial Feasibility Assessment of Waste Management Projects for Environmental Non-Governmental Organizations (NGOs) in Indonesia" *Pengmasku*, *2*(2), 173-178, 2022.]

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