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The potential of electrical power generation based on organic waste utilization at Tamangapa landfill Makassar

The potential of electrical power generation based on organic waste utilization at Tamangapa landfill Makassar

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Abstract. Waste is one of environmental pollution contributor. Waste utilization for electrical generation is an alternative solution. Based on existing data, average amount of waste at Tamangapa landfill Makassar in 2010-2016 were 223,637 tons. The organic waste was approximately 50%, around to 111,818 tons. With rotary kiln incinerator technology, the calculation result showed that existing organic waste (2010-2016) could to generate 29.678 MW of electrical power or 259,978.345 MWh of electrical energy. The prediction by trend analysis method states that in 2026, the amount of organic waste can reach 176,230,390 tons. It can generate 46.773 MW of electrical power or 409,735.657 MWh of electrical energy. This value is equivalent with construction of two distributed generation (DG) units with 2x30 MW capacities.

1. Introduction

Waste is a big problem for all of cities in the world. The increasing waste volume but not accompanied by adequate landfill capacity, will certainly create new problems. On the other side, the growth of electrical generation increases along with the electricity demand increasing. The power plant in terms of capacity is divided into two categories, centralized generation and distributed generation (DG) [1]. The distributed generation is generally directly connected to loads with up to 30 MW capacities. Now days, most of power plants is still using fossil fuels. It is non-renewable and not environmental friendly.

Until now, the potential of new energy for electrical generation is very abundant but has not been explored optimally. One of them is urban waste. The waste processing into electrical energy is divided into two types based on the process: biological processes that produce gas-biogas and thermal processes that produce steam [2]. There are two main classifications of waste, organic waste and inorganic waste. The waste that produced from biological materials that easily degraded by microbes or easily biodegradable is known as organic waste. The natural process can easily decipher this waste type. Waste originating from households generally is organic waste, namely food scraps, wrappers, vegetables, fruit peels, leaves and twigs. The organic waste can also come from market, agriculture, hotels and restaurants activities [3].

2. Incineration

Basically, incineration is solid waste conversion process into inorganic materials through combustion process at high temperatures [4]. The incineration process will convert organic matter containing H and C into carbon dioxide (CO_2) and water vapor (H_2O). The elements of sulfur (S) and nitrogen (N)

contained in waste will turn into SO_x and NO_x gas. The incinerator is combustion furnace with oxygen for waste processing into heat, gas, and inert ash at over 800°C temperatures [4].

There are several types of incinerators: rotary kiln, multiple hearths, fluidized bed, open pit, single chamber, multiple chamber, aqueous waste injection, and starved air unit. The rotary kiln incinerator has some advantages: able to process liquid waste, sludge and solids in large amounts. It also can reduce of waste volume with drastically and making burn completely [5].

3. Waste at Tamangapa landfill

Makassar is the capital of Sulawesi Selatan Province, Indonesia. The Makassar government has built a main landfill in Tamangapa area to collect the waste produced by the city residents. The land area of Tamangapa landfill is 14.3 hectares with open dumping system. The amount of transported waste to the Tamangapa landfill shows an upward trend every year. The amount of waste during 2010-2016 is shown in Table 1.

Table 1. Data of amount waste at Tamangapa landfill (2010-2016) [6]

Year	Weight (kg)	Weight (ton)
2010	194,451,059	194,451
2011	191,405,111	191,405
2012	203,419,001	203,419
2013	246,970,841	246,971
2014	247,162,733	247,163
2015	246,271,225	246,271
2016	235,780,704	235,781
Average	223,637,239	223,637

The waste production forecasting in Makassar (2019-2026) was carried out using trend analysis method approach, based on available data. The trend analysis uses simple regression with linear coefficients, where a set of data in the form of numbers obtained in a given period. The trend analysis can produce curve in straight line form or Y and X linear curves.

$$Y = a + bx.X \tag{1}$$

Y value was the dependent variable as forecasting result in a given year and X was a determinant variable (year variable). The a and b values were calculated by formula as following:

$$a = \frac{\sum Y}{n} \tag{2}$$

$$b = \frac{\sum XY}{\sum X^2} \tag{3}$$

The amount waste prediction at Tamangapa landfill for 2019 to 2026 is shown in Table 2 below. In 2026, the total waste can reach 352,460 tons.

Table 2. The amount of waste prediction at Tamangapa landfill (2019-2026)

Year	Weight (kg)	Weight (ton)
2019	283,094,280	283,094
2020	293,003,780	293,003
2021	302,913,280	302,913
2022	312,822,780	312,822
2023	322,732,280	322,732
2024	332,641,780	332,641
2025	342,551,280	342,551
2026	352,460,780	352,460

4. Electrical generation

In this research, rotary kiln incinerator technology was chosen for electrical energy conversion. The amount of organic waste during 2010-2016 was assumed to be 50%. The average amount was 111,818,643 kg. Based on previous study, the calculation of electrical generation was used criterion: 1 kg of organic waste could produce 3.1 kWh of electrical energy [7].

W = total of organic waste x 3.1
= 111,818,643 x 3.1
= 346,637,793 kWh

The electrical power generated was:

$$P_{in} = \frac{346{,}537{,}793}{(365x24)}$$

P_{in} = 39,571 kW
= 39.571 MW

Based on the assumption of 75% efficiency value, the optimal electrical power was:

P_{opt} = 75% x 39,571 kW
P_{opt} = 29,678 kW
= 29.678 MW

The optimal electrical energy was:
= 29,678 x 365 x 24
= 259,981.47 kWh
= 259.981 MWh

The calculation of electrical generation from organic waste in 2010-2016 years is shown in Table 3. The average value was 39.6 MW for electrical power and 111,818.6 MWh for electrical energy.

Table 3. The calculation of electrical generation in 2010-2016

No	Year	Organic Waste (kg)	Electrical Energy (MWh/year)		Electrical Power (MW)	
			Gross	Optimum	Gross	Optimum
1	2010	97,225,500	301,399.050	226,049.288	34.406	25.801
2	2011	95,702,500	296,677.750	222,508.313	33.867	25.400
3	2012	101,709,500	315,299.450	236,474.588	35.993	26.995
4	2013	123,485,500	382,805.050	287,103.788	43.699	32.774
5	2014	123,581,500	383,102.650	287,326.988	43.733	32.800
6	2015	123,135,500	381,720.050	286,290.038	43.575	32.682
7	2016	117,890,500	365,460.550	274,095.413	41.719	31.289
	Average	111.818.643	346,637.793	259,978.345	39.570	29.678

Table 4. The prediction of electrical generation in 2019-2026

No	Year	Organic Waste (kg)	Electrical Energy (MWh/year)		Electrical Power (MW)	
			Gross	Optimum	Gross	Optimum
1	2019	141,547,140	438,796.134	329,097.101	50.091	37.568
2	2020	146,501,890	454,155.859	340,616.894	51.844	38.883
3	2021	151,456,640	469,515.584	352,136.688	53.598	40.198
4	2022	156,411,390	484,875.309	363,656.482	55.351	41.513
5	2023	161,366,140	500,235.034	375,176.276	57.104	42.828
6	2024	166,320,890	515,594.759	386,696.069	58.858	44.143
7	2025	171,275,640	530,954.484	398,215.863	60.611	45.458
8	2026	176,230,390	546,314.209	409,735.657	62.365	46.773

The prediction of electrical power generation from 2019 to 2026 is shown in Table 4. In 2026, the electrical power will reach to 46.773 MW, equivalent with 409,735.657 MWh of electrical energy. Based on data analysis above, the distributed generation based on organic waste can be built with 30 MW capacities. In 2026, the distributed generation can be developed with 30 MW additional capacities. Thus, the total distributed generation capacity will be 2x30 MW.

5. Conclusion

The average of waste production at Tamangapa landfill Makassar was 223,637 tons/year for 2010-2016. The amount of organic waste was assumed to be 50% of the total waste or 111,818 tons per year. The suitable method for organic waste converting into electrical energy is rotary kiln incinerator technology. The existing organic waste is estimated be able to generate 29.7 MW of electrical power or 10,832.4 MWh of electrical energy. In 2026, the estimated of electrical power generation can reach 62.4 MW, equivalent with of 546,314 MWh of electrical energy.

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