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Potential of Electric Energy from Waste in Kaliurang Tourism Area, Sleman, Special Region of Yogyakarta

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Abstract

Kaliurang Tourism Area, located in Sleman Regency, is a very famous tourist area in Yogyakarta. The minimum number of visitors in one month is 35,742 people. A large number of visitors have the potential to produce waste, especially organic waste. Organic waste is often processed into energy sources, especially electricity. This study aims to determine the magnitude of the potential electrical energy generated from organic waste in the Kaliurang Tourism Area using the gasification process. Waste generated from visitors, especially organic waste and paper waste, is processed into charcoal. The charcoal produced is used as a feed for the gasification process. Synthetic gas produced from the gasification process is used as generator fuel. The calculation results show that the average garbage in the Kaliurang Tourism Area is 119.14 kgs per day. The processed waste is 66.9% or 79.7 kgs organic waste and 9.5% or 11.32 kgs of paper waste. Waste is processed into charcoal at 8.46 kg per day. Based on calculations obtained, the potential of the electric energy produced is 51.02 kWh. At the same time, the magnitude of the potential electrical energy produced is 0.23 kW.

Keywords: electric energy potential, waste, kaliurang tourism area, gasification

1. Introduction

One of the most famous natural attractions in Yogyakarta is the Kaliurang Tourism Area, which is located on Mount Merapi. Kaliurang Tourism Area is located in the Sleman Regency, precisely in Pakem District. Kaliurang Tourism Area includes many tourist attractions and continues to be developed to this day. Some tourism objects in Kaliurang which are famous and have the most visitors are Kaliurang Recreation Park, Gunung Merapi National Park (Kaliurang Tourism Forest), Lava Tour Area, and all Tourist Villages around Kaliurang, namely Ngipiksari Tourism Village, Sambi Tourism Village, Srowulan Tourism Village, East Kaliurang Village, and Turgo Tourism Village [1].

Figure 1. Entrance to Kaliurang Tourism Area [2]

Kaliurang is a tourism icon in Sleman Regency, so it is not from the waste problem. To maintain the comfort of the tourists, the Sleman Regency government invites residents to manage waste jointly. Also, Sleman Regency is a water buffer area for all regencies/cities in Yogyakarta Special Region Province [3]. In the 2019 National Waste Management Day Commemoration event (HPSN) by all the Technical Implementation Units (UPT) Conservation of Natural Resources and Ecosystems (KSDAE), the Ministry of Environment and Forestry in Kaliurang Tourism Area produced 170 kgs of waste consisting of 115.5 kgs of organic waste and 54.5 kgs of inorganic waste [4].

The calculation of the potential of electrical energy in the tourist area has been done, such as the potential of electrical energy in the Parangtritis Beach Tourism Area [5] and the Village Center Tourism Area in Bali [6]. Besides, several TPAs (landfill) have started to be used as power plants, such as the Waste Power Plant (PLTSa) at the Muara Fajar Landfill, Pekanbaru [7]. An analysis of the potential of electrical energy from urban waste in Yogyakarta was carried out by calculating wet waste with biogas and dry waste with gasification [8]. So some research on waste into energy, especially electrical energy, has been done a lot.

The technology often used to convert waste into electrical energy is gasification technology. In gasification technology, the raw material needs to be considered because it affects the initial flame [9]. Analysis of the potential of electric energy generated from portable gasification with duel fuel raw materials between rice husks and diesel with a 50 kVA is still quite abundant for the Yogyakarta area [10] and analysis of rice husks throughout Java [11]. Besides, gasification technology from organic charcoal waste from the fruit market waste in Yogyakarta obtained an efficiency of 11% [12]. So the use of gasification technology to convert waste, especially organic waste into electrical energy, has been done a lot.

There has been much discussion about waste management and waste segregation in the Kaliurang Tourism Area. However, a study of the potential of waste in the Kaliurang Tourism Area as alternative energy, especially electricity, has never been discussed. Therefore, here will focus on discussing the potential of

electrical energy generated from the amount of waste obtained in the Kaliurang Tourism Area.

2. Materials and Methods

2.1. Potential Waste

Potential waste in the Kaliurang Tourism Area depends on the location capacity and the number of visitors per day. Based on observations [1], several tourism objects in Kaliurang have visitors tamping capacity of 6,638 people/hectare/month in the Kaliurang Recreational Park Area, 7,029 people/hectare/month in the Mount Merapi National Park, 6,638 people/hectare/month in the Lava Tour Area, and 7,045 people/hectares/month in all Tourism Villages around Kaliurang. The number is quite large, but the level of visitor fluctuations is quite large, especially during holidays with weekdays. Based on data from the Central Statistics Agency (BPS) of Sleman Regency in 2016, the number of visitors every month can be seen in Table 1 [13]. Based on the data in Table 1, the highest number of visitors in December. When viewed from the month, the school holiday month shows the number of visitors is almost double the usual month.

Table 1. Number of visitors to the Kaliurang Tourism Area in 2016

No	Month	Number of visitors	No	Month	Number of visitors
1	January	107,587	7	July	96,368
2	February	63,791	8	August	39,284
3	March	60,353	9	September	73,570
4	April	55,717	10	October	73,570
5	May	79,247	11	November	66,679
6	June	35,742	12	December	167,634
				Total	**919,542**

For analysis and continuity of the process, the data taken is the minimum data, i.e., the number of visitors in June 2016 amounted to 35,742 people. At the same time, each person can produce a waste of 0.1 kg/person/day [14]. Whereas the composition of waste produced in the Kaliurang Tourism Area is as shown in Table 2 [14], which will be analyzed here is organic waste and paper type waste.

Table 2. Waste Composition

No	Trash Type	%	No	Trash Type	%
1	Organic Waste	66.9	3	Plastic	9.1
	Plant	49.7		PETE	3.0
	Leftovers	17.2		LDPE	0.2
2	Paper	9.5		PS	0.7
	Tetrapack	0.6		PP	3.8
	Duplex	8.4		HDPE	0.5
	Newspaper	0.1		PVC	0.5
	Cardboard	0.2		Other	0.4
	HVS	0.2	4	Residue	14.5

2.2. Process Energy Conversion

The process of analyzing the conversion of waste, especially organic waste into electrical energy with the gasification process, can be seen in Figure 2 [5]. Where waste is processed is organic waste by 66.9% and paper waste by 9.5%. Organic waste is assumed to be a wet waste, while paper waste is assumed to be a dry waste.

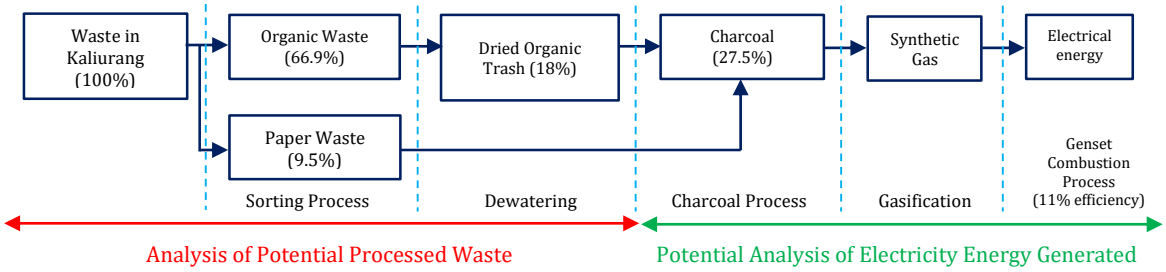

Figure 3. Flowchart analysis of the electrical energy potential of waste

3. Results and Discussion

3.1. Waste Potential Analysis

Based on the number of visitors to the Kaliurang Tourism Area in June 2016 amounted to 35,742 people. Where the average waste potential of each person is 0.1 kg/day. The number of visitors per month is the total number of visitors each day in that month. Then, the amount of waste produced in a day can be calculated using Formula 1.

$$\Sigma \text{ Wastes} = (\Sigma \text{ Tourist} \times \text{AWM}) / 30 \quad (1)$$
$$= (35{,}742 \text{ people} \times 0.1 \text{ kg}) / 30$$
$$= 119.14 \text{ kgs/day}$$

Information:
Σ Wastes : Total of waste on the Kaliurang/day
Σ Tourists : Number of tourists/day
AWM : Average waste a month

Based on Formula 1, the amount of waste in Kaliurang is 119.14 kg/day. Furthermore, to get the amount of dry waste to be processed, the calculation of Formula 1 is followed by the calculation of Formula 2 to Formula 5.

$$\Sigma \text{ TOW} = \Sigma \text{ Waste} \times \text{OWP} \quad (2)$$
$$= 119.14 \times 66.9\%$$
$$= 79.70 \text{ kgs/day}$$

$$\Sigma \text{ TOWD} = \Sigma \text{ TOW} \times \text{PRDP} \quad (3)$$
$$= 79.70 \times 26.92\%$$
$$= 21.46 \text{ kgs/day}$$

$$\Sigma \text{ TPW} = \Sigma \text{ Waste} \times \text{PWP} \quad (4)$$
$$= 119.14 \times 9.5\%$$
$$= 11.32 \text{ kgs/day}$$

$$\Sigma \text{ TWRP} = \Sigma \text{ TOWD} + \Sigma \text{ TPW} \quad (5)$$
$$= 21.46 + 11.32$$
$$= 32.77 \text{ kgs/day}$$

Information:
Σ TOW : Total of organic waste
Σ TOWD : Total of organic waste with dewatering
Σ TPW : Total waste of paper
Σ TWRP : Total waste ready to process
OWP : Organic waste percentage
PWP : Paper waste percentage
PRDP : Presentation of reducing dewatering process

The amount of organic waste that will be processed into charcoal is 32.77 kgs/day. It can be said that the potential for organic waste generated by the Kaliurang Tourism Area is 32.77 kgs/day. The summary of the calculation results from Formula 2 to Formula 5, can be seen in Table 3.

Table 3. The amount of potential organic waste from the total of waste per day

No	Trash Type	%	Garbage (kg)	ΣTOWD (kg)	ΣTWRP (kg)
1	Organic waste	66.9	79.70	21.46	21.46
2	Paper waste	9.5	11.32	-	11.32
	Total	**76.4**	**91.02**	**21.46**	**32.77**

3.2. Electrical Energy Potential Analysis

Based on the calculation of the potential waste discussed earlier, organic waste that is ready to be processed into charcoal for gasification feed is 32.77 kgs/day. The next process in the making of charcoal, where the weight loss of charcoal produced is 25.82% [15] from the weight of organic waste that is ready to be processed. Thus, the amount of charcoal that can be produced can be calculated as in Formula 6.

$$\Sigma \text{ Charcoal TWRP} = \Sigma \text{ TWRP x RCP} \quad (6)$$
$$= 32.77 \text{ x } 25.82\%$$
$$= 8.46 \text{ kgs/day}$$

Information:
Σ Charcoal TWRP : Total of organic waste charcoal
RCP : Reducing of charcoal process

The organic waste charcoal obtained is 8.46 kgs/day. Then next calculate the energy recovery potential (ERP) [8] the net calorific value (NCV) of organic waste charcoal is 5,185.33 [12]. Furthermore, the calculation of energy analysis obtained is calculated using Formulas 7 to Formulas 9.

$$\text{ERP} = \Sigma \text{ Charcoal TWRP x NCV x } (1/860) \quad (7)$$
$$= 8.46 \text{ x } 5{,}185.33 \text{ x } (1/860)$$
$$= 51.02 \text{ kWh}$$

PGP = ERP / (24 hours) (8)
= 51.02 / 24
= 2.13 kW

NPP = PGP x CE (9)
= 2.13 x 11%
= 0.23386 kW
= 233.86 W

Information:
ERP : *Potential Energy Recovery* (kWh)
NCV : *Net Calorific Value* (kcal/kg)
(1/860) : Constants
(if the weight in tons becomes 1,000/860)
PGP : *Potential Power Generation* (kW)
NPP : *Potential Net Power Generation* (kW)
CE : *Conversion Efficiency* (%)

Potential electrical energy generated from the gasification process which has an efficiency value of 11% is 0.23386 kW or 233.86 Watt. A summary calculation of the analysis of the potential of electrical energy from organic waste that is ready to be processed can be seen in Table 4.

Table 4. Calculation of electrical energy analysis produced

No	Information	Abbreviation	Total	Unit	Formula
1	Amount of organic waste	Σ TOW	32.77	kg/day	-
2	Percentage of the shrinking process	RCP	25.82	%	-
3	Amount of organic waste charcoal	Σ Charcoal TWRP	8.46	kg/day	Σ TOW x RCP
4	*Net Calorific Value*	NCV	5285.33	kcal/kg	-
5	*Potential Energy Recovery*	ERP	51.02	kWh	Σ Charcoal TWRP x NCV x (1/860)
6	*Potential Power Generation*	PGP	2.13	kW	ERP / (24 hours)
7	*Conversion Efficiency*	CE	11.00	%	-
8	*Potential Net Power Generation*	NPP	0.23	kW	PGP x CE

Looking at the calculation results in Table 2 and Table 3, it can be concluded that with the amount of garbage as much as 119.14 kgs/day in the Kaliurang Tourism Area, it can be processed into electrical energy using a gasification process of 0.23 kW. The electricity of 0.23 kW is minimal, and maybe it can only be used for lighting several food stalls or public roads. If the only LED lamp is 20 watts, it can be used to light as many as 11 LED lights.

IV. Conclusion

Based on the results of the study that has been described, it can be concluded that the potential of electrical energy from the process of gasification from organic waste in the Kaliurang Tourism Area is as follows:

1. The amount of garbage produced by tourists in a day is 119.14 kgs. The waste that can be treated is 79.7 kgs of organic waste and 11.32 kgs of paper waste;
2. The amount of waste that is ready to be processed is 32.77 kgs, and then charcoal is processed to produce as much as 8.46 kgs per day;
3. Energy potential calculated from the calorie value of organic waste charcoal is 51.02 kWh;
4. The efficiency of the generator using 100% fuel from synthetic gas (syngas) is 11%, the electrical power obtained is 0.23 kW;
5. Based on the enormous potential of electrical energy generated from the processing of organic waste in the Kaliurang Tourism Area, it should be added to the waste generated from several other tourism objects around Kaliurang.

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