WASTE-DERIVED FUELS AS A RENEWABLE ENERGY SOURCE (PHYSICAL-CHEMICAL QUANTITY-QUALITY) COMPARED TO COAL

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Abstract

DKI Jakarta Province produces ±7,500 tonnes of waste per day, and this municipal waste is transported daily to the Bantargebang integrated waste management facility. The existing waste capacity of Bantargebang has reached 39 million tonnes. This waste can be used as a renewable energy source and replace the use of coal. This research aims to see the ability of waste derived fuel to substitute coal. The data was collected through a literature review and processed using the literature review method. The literature was searched using SINTA, Google Scholar and Scopus Index. Refuse Derived Fuel (RDF) can substitute coal in terms of the calorific value (CV) produced, but the water and ash content in RDF is relatively high compared to coal.

Keywords: *Bantargebang, Municipal Waste, Refuse Derived Fuel*

1. Introduction

DKI Jakarta Province is one of the largest waste-producing provinces in Indonesia. With a recorded population in 2023 of 10.68 million people (BPS, 2022). The daily waste generated by DKI Jakarta province reaches ±8,000 tonnes a day. Waste generated in DKI Jakarta Province (except Kepulauan Seribu) will be distributed and managed at TPST Bantargebang.

TPST Bantargebang is located in the city of Bekasi, West Java. It has been used to accommodate waste disposal from the DKI Jakarta area since 1989. TPST Bantargebang is managed by the DKI Jakarta local government with the concept of an Integrated Waste Management Centre (TPST). TPST Bantargebang has an area of 110 ha and has been owned by the DKI Jakarta provincial government since 1999. TPST Bantargebang, consists of six disposal zones based on the origin of waste and the type of waste disposed from DKI Jakarta (zones I - V) and Bekasi City (zone VI) (Mulana et al., 2014). The maximum capacity of TPST Bantargebang is ± 49 million tonnes (Sukwika & Noviana, 2020).

The volume of waste generated by DKI Jakarta province in a day can reach ± 8,000 tonnes / day, where the waste generated is 60% dominated by domestic or household waste and throughout the year recorded 3.11 million tonnes. Based on data from the Environmental Agency in 2022, the composition of waste entering Bantargebang TPST consists of 49.87% biodegradable waste, 17.24% paper, 3.18% wood, 1.48% glass, 1.08% metal, 0.90% cloth, 0.78% masks, 0.70% leather and 0.42% domestic hazardous waste. These wastes are distributed and managed based on their type to several temporary disposal sites and then end up in the Bantargebang integrated waste processing centre (TPST). The waste distributed to TPST Bantargebang is around 7,500 tonnes/day after undergoing processing before being transported. The waste processing system at TPST Bantargebang in several zones has been carried out with a landfill mining system.

On the other side, waste is one of the efforts that can be utilised as an alternative energy source in meeting domestic energy needs, especially in subsidising energy needs sourced from non-renewable natural resources. The use of energy sourced from non-renewable natural resources (fossils) in the form of coal is expected to run out in 2086 ((ESDM), 2021). Based on data from the Ministry of Energy and Mineral Resources, 2021, Indonesia's coal reserves are expected to run out in approximately 83 years if current production levels continue. While Indonesia itself has coal resources of 149,009 billion tonnes and the largest reserves of 37,6014 tonnes (Geologi, 2018).

Based on the above background, the need for renewable energy as part of substituting dependence on the use of non-renewable energy needs to be done. therefore the writing of this literature review is focused on examining the ability of waste and its derivatives as a renewable energy source compared to coal.

1.1. Purpose and Benefits

This study aims to analyse the ability of Refuse Derived Fuel (RDF) in terms of quantity - physical and quality - chemical to replace the use of coal as a non-renewable energy source.

The benefit of this research is to provide information and potential for the use of renewable energy sources based on urban waste management.

2. Method

The method used in this research is literature review. The articles used have the following characteristics: (1) journal articles, conference articles and grey publications; (2) contains aspects of waste management and its derivatives as a source of renewable energy; (3) is in the range of 2013 - 2023; (4) English and Indonesian language. Scientific literature was obtained through google scholar, SINTA and Scopus databases.

Articles were searched using the keywords "Bantargebang TPST waste management", "Refuse Derived Fuel (RDF) at Bantargebang TPST", "Potential renewable energy at Bantargebang TPST" and "Utilisation of waste and its derivatives as renewable energy".

Data analysis The data analysis used is thematic analysis, which is an analysis carried out by grouping the data into specific themes. grouping on specific themes.

3. Results

3.1. Literature Search and Description

The initial search of the three selected electronic databases yielded 200 articles. The articles were screened for titles and abstracts, leaving 50 titles accessible. The 10 articles selected met the inclusion criteria and the text was thoroughly reviewed. 40 articles were excluded because they were reviews of waste management at the Bantargebang Integrated Waste Management Site and were not about waste-to-energy technologies.

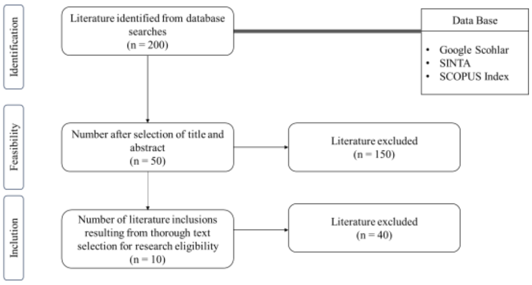

Figure 1. literature search and selection process

3.2. Integrated Waste Management Centre (IWMC) Bantargebang

Based on the results of articles collected and analysed by the author, the Bantargebang Integrated Waste Management Site is an asset of the DKI Jakarta Provincial Government and is the only final waste disposal site in the DKI Jakarta Province. The Environment Agency, (2023) states that the Bantargebang Integrated Waste Management Site has an area of 132.5 ha, consisting of 6 landfill zones covering 81.4 ha and 23.3 ha of infrastructure facilities. The capacity of the Bantargebang Integrated Waste Management Site in 2021 has reached 39 million tonnes. The average daily increase of waste in Bantargebang Integrated Waste Management in recent years is as follows

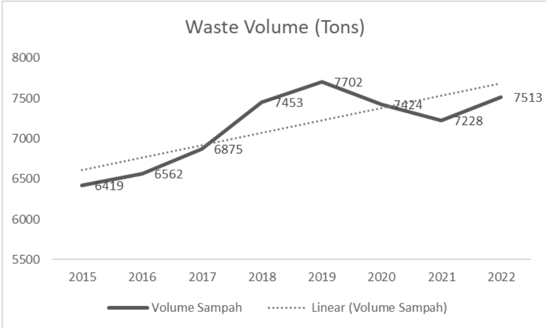

Figure 2. Graph of the waste volume increase

The composition of this waste is 49.87% biodegradable waste, 17.24% paper, 3.18% wood, 1.48% glass, 1.08% metal, 0.90% fabric, 0.78% mask, 0.70% leather and 0.42% household hazardous waste (KLHK, 2022).

Winahyu et al., (2019)The Bantargebang integrated waste management site has a system for using waste and its by-products as a renewable energy source, consisting of refuse derived fuel, a waste-to-energy plant, landfill gas management and composting.

Landfill gas management at the Bantargebang integrated waste management site started production in 2011 with 11 operating engines. These operating machines have a capacity of 16 MW and the current electricity production from landfill gas management is 3 MW (UPT TPST Bantargebang, 2023).

Composting is the result of the partial/incomplete decomposition of a mixture of organic materials that can be artificially accelerated by a population of various microbes under warm, moist, aerobic or anaerobic environmental conditions (Cahaya & Nugroho, 2004). The composting process at the Bantargebang integrated waste management site comes from the RDF plant process. The compost comes from the residue of the

RDF plant's lindfill mining. The amount of compost produced can reach 3 tonnes/day.

The waste-to-energy plant at the Bantargebang Integrated Waste Management Facility has a capacity of 100 tonnes/day and an electrical output of 700 kW/hour.

The management of waste and its derivatives into solid fuel or also known as Refuse Derived Fuel (RDF) has been operating at the Bantargebang Integrated Waste Management Site. The TPST Bantargebang RDF plant has been in operation since 23 June 2023 and processes up to 2,000 tonnes of waste and solid waste per day at TPST Bantargebang. The RDF product produced is Fluffy with a total production of 700-750 tonnes/day.

The management of municipal waste into renewable energy sources at the Bantargebang integrated waste management site can use the system described by (Nanda & Berruti, 2021) (Figure 3.)

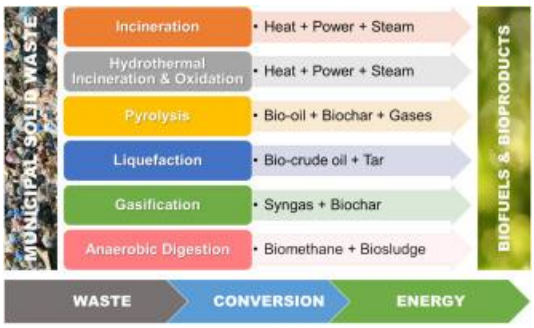

Figure 3. Conversion Of Municipal Waste To Energy

3.3. Refuse Derived Fuel (RDF)

Refuse Derived Fuel (RDF) is an alternative fuel produced from non-hazardous solid waste after certain processing. RDF is produced by taking solid waste such as household, commercial or industrial waste and removing the recyclable content such as paper, cardboard, plastic, metal, etc.

Once the recyclable materials have been separated, the remaining treated solid waste is then converted into fuel by drying it, grinding it into small granules and often compacting it into briquettes or pellets. This RDF can then be used as an alternative fuel for electricity generation or heating, replacing fossil fuels such as coal.

The advantage of using RDF is that it can reduce the amount of solid waste sent to landfill while generating energy. However, there are also challenges related to the quality of RDF, potential pollution and the management of residual waste from the RDF process. (Breeze, 2018).

RDF quality standards used in some continental European countries (Widyatmoko, 2018) (Table 1).

Table 1. Quality Standart of RDF

States	CV	Moisture	Ash	Sulfur	Chlorine
Finland	13-16 kj/kg	25-35%	5-10%	0.1-0.2%	0.3-1.0%
Italy	15 kj/kg	Max. 25%	20%	0.6%	0.6%
United Kingdom	18,7 kj/kg	7-28%	12%	0.1-0.5%	0.3-1.2%

In Indonesia, the quality standard used to assess the quality of RDF refers to SNI 8966 of 2021 (Table 2.).

Table 2. Quality Standart RDF in Indonesia

Parameters	Unit	Class 1	Class 2	Class 3
Organic material	%	95	87.5	80
calorific value (CV)	Kj/Kg	20,000	15,000	10,000
Carbon	%	15	10	5
Volatile	%	65	70	75
Water content	%	15	20	25
Ash	%	15	20	25
Total sulfur	%	1.5	1.5	1.5
Chlorine	%	0.2	0.6	1.0
Mercure	Mg/Mj	0.02	0.03	0.08
Potassium	%	5	10	15

3.3.1. RDF at the Bantargebang integrated waste management site

The RDF plant at the Bantargebang integrated waste management site processes 2,000 tonnes of waste per day. 1,000 tonnes/day of old waste and 1,000 tonnes/day of new waste are processed. The RDF produced from these 2,000 tonnes of waste is 700-750 tonnes in fluff form.

Excavated waste at the Bantargebang integrated waste management site has the potential to be used as RDF because it is dominated by combustible waste material and has a relatively high calorific value (7.31 Mj/Kg) (Rifai & Ardiatma, 2022).

The calorific value analysis carried out showed the following results (Widyatmoko, 2018):

Table 3. Briquette Calorific Value

Peer Component	6,235.39 cal/g
Briquette CV	9,867.12 cal/g
Avarage of CV	8,051.25 cal/g
CV-Diference	1,851.86 cal/g
Deviation	22,55%

Residue produced;

Table 4. Briquete of waste residu

Residu Type	Persentage
Moisture	33.86%
Ash Content	44.72 %
CV	9867.10 cal/g

The RDF produced requires pre-treatment to reduce moisture content (shredding or drying), the use of waste particles >10 mm in diameter, or the blending of waste quantities to achieve high calorific value and low ash content, and the removal of hazardous materials from the waste. (Resmianty et al., 2022).

3.4. RDF in Coal Energy Substitution

The ability of RDF to replace coal can be assessed by the calorific value (CV) of the two energy sources. The CV of coal is determined by the type of coal used by the industry. In general, the calorific value of coal is as follows (Arisandy et al., 2017):

- Peat, calorific value (CV) below 1,700-3,000 Kcal/Kg, hygroscopic by nature.
- Lignite, calorific value (CV) below 1500-4500 Kcal/Kg, hygroscopic by nature.
- Bituminous coal, calorific value (CV) 7000-8000 Kcal/Kg, black colour, non-hygroscopic, low ash and water content (5-10%).

Compared to the calorific value of RDF, the calorific value produced by RDF can replace the use of coal on a calorific value basis. (Table 5.)

Table 5. Comparison of RDF and coal

Parameters	Units	Calorific value (CV)
Briquette (Widyatmoko, 2018)	Kcal/Kg	9,867,12
RDF landfill mining (Rifai & Ardiatma, 2022)	Kcal/Kg	4819,220
Coal lignite	Kcal/Kg	1,500 – 4,500
Coal Bituminuos	Kcal/Kg	7,000-8,000

Here's a comparison of water and ash content (Table 6.)

Table 6. Ash content and Moisture

Parameters	Ash Content	Moisture
RDF	44,72%	33.86%
Peat Coal		90%
Lignite Coal	10-40%	25-40%
Bituminuos Coal	5-15%	3-15%

In terms of moisture and ash content, RDF has a higher content than lignite and bituminous coal.

4. Conclusions and Suggestions

4.1. Conclusions

In general, the use of RDF from municipal waste can reduce and produce renewable energy sources. The calorific value produced by RDF can replace the use of lignite and bituminous coal, but the moisture content and ash content are relatively high compared to coal.

4.2. Suggestions

Further research needs to be carried out on the ability of RDF to reduce existing waste at the Bantargebang Integrated Waste Management Site and to analyse the potential of RDF after pre-treatment of water content reduction and shredding.

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