Refuse derived fuel potential in DKI Jakarta

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Abstract. Combustible waste fractions of municipal solid waste (MSW) which can not be easily separated or sorted, reused or recycled, may have a high calorific value (CV) that can be used in a fuel for energy recovery. The objective of this study was to explore the Refuse Derived Fuel (RDF) potential of municipal solid waste from DKI Jakarta to produce electricity and to promote it to be socially and politically acceptable. For this purpose, 24 samples of RDF were taken from Bantargebang, carbonized, molded and pressed to be briquette. All samples were analyzed for moisture, ash, and calorific value in the physical and chemistry Laboratory of ITB Bandung. The analysis of calorific value (CV) shows the CV difference of 1815.8 cal/g between the briquettes (8051.25 cal/g) and the RDF (9867.12 cal/g). The total waste DKI which can be used as briquettes 5253 ton/day or equivalent with 49154115 kWh/day. If the efficiency of electricity production from RDF was 25%, then Jakarta is able to generate electricity from RDF of 12288529 kWh/day or as much as energy needed by 573,480 middle-class households with energy needs of 642.84 kWh/month.

Keywords: briquette, calorific value, energy, RDF

1. Introduction

Combustible waste fractions of municipal solid waste (MSW) which can not be easily separated or sorted, reused or recycled, may have a high calorific value (CV) that can be useful in a fuel for energy recovery (Table 1).

| 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 %    |
| UK      | 18.7 kj/kg| 7-28 %   | 12 %    | 0.1-0.5 %| 0.3-1.2 %|

The MSW can be shredded, dried, baled to produce refuse-derived fuel (RDF) and then burned to generate electricity, thereby making good use of waste that otherwise might have ended up in landfill. Since the early nineties, producing RDF for energy recovery has been a popular waste management option. However, there is a problem found in RDF contents which sometimes contains hazardous
component, its quality varies. Therefore, it should be thoroughly analysed and tested to ensure the RDF is a fuel gained from non-hazardous waste.

The progress of technology leads RDF as an important energy alternative in the future. The developments in sensor-based sorting technology enabling the acquisition of RDF material volume to be much higher than ever before. Plastics, fibre, films, paper, cardboard, textiles and wood can all be recovered to an exceptionally high standard material, achieving purity level reaches of about 95% and yields up to 70%. In comparison, manual or semi-automated techniques typically recover just as much as 10-20% [1], [2].

Labour costs are significantly reduced as there is no manual picking anymore and from a quality perspective, it is possible to process and maintain higher throughputs, with consistent quantity and quality achievable within 24 hours a day [1].

DKI Jakarta with population of 9,607,787 [4], has the capability of processing 8291.650 tonnes per day of MSW. The processing of this waste will produce around 8.291650 tonnes of RDF per day [3], [4], [5].

This research is aimed at exploring the Refuse Derived Fuel (RDF) potential of municipal solid waste from DKI Jakarta to produce electricity as well as promote it to be socially and politically acceptable and technically feasible.

2. Research Method
Grab sampling was done at Bantargebang, Bekasi, West Java. The total waste volume per day is calculated based on total volume of the transport vehicles [6], [7].

The 24 waste samples were taken randomly and sequentially put into a box and 3 times dropped from a height of 20 cm to determine its density. The samples were then 7 days air dried, sorted into fractions of paper, plastic, glass, tetrapack, Styrofoam, pads/pampers, organic fraction, food scraps, textile and rubbers. After homogenization process, 200 g of all fractions, except metal and glass, were put into perforated cans and carbonized. The carbonized waste was then sieved 50 mesh, mixed with tapioca glue, molded, pressed to be briquette and laboratory analysed for CV, Moistur, ash content.

Water content was determined according to SNI 03-1971-1990 [8]. For this purpose, ± 10 grams of sample in porcelain cup was kept for 3 hours into oven at 105°C and for 30 minutes into desiccator, then finally it was weighed. Residu moisture: \( M = (w-d) \times 100\%; \) (M = moisture content (%); w = initial weight (g); d = weight after drying in grams in 105 °C oven)

Ash content was determined according to ASTM E 830-87 [9]. The remaining sample was heated at temperature of 550 °C and reheated in a furnace at 950 °C for 7 minutes. Then it was laid into desiccator and weighed. Ash content = \( (f / w) \times 100\%; \) (E = weight after heating in furnace 550 °C; f = weight after heating in furnace 950 °C; w = initial weight in g). Colorific value was analyzed using calorimeter.

The information on recycling potential of waste components was obtained through interviews with waste picker and waste collector. According to recyclers and waste collector, the damaged paper can not be sold and only 50% of the organic waste and the food waste can be recycled.

3. Results and Discussion
The highest CV is obtained from the residual component of garbage and rubber waste. Components of garbage/pampers waste residues have high CV, but the moisture content in these components is also high. The CV of a material is strongly influenced by the content of the substance in it (Tabel 2).
Table 2. Recycling Capacity (RC).

| Componets       | % -RC |
|-----------------|-------|
| Paper           | 30-40 |
| Plastic Bottles | 100   |
| Glass Bottles   | 100   |
| Tetrapack       | -     |
| Styrofoam       | -     |
| Pampers         | -     |
| Organic waste   | 50    |
| Food waste      | 50    |
| Platic bags     | -     |
| Textile         | -     |

Table 3. Average of moisture, ash content and CV of DKI Jakarta waste componets.

| Component          | Moisture (%) | Ash content (%) | CV (cal/g) |
|--------------------|--------------|-----------------|------------|
| Plastic bag        | 12.43        | 23.27           | 6216.6     |
| Tetrapack          | 15.79        | 23.88           | 5951.21    |
| Styrofoam          | 13.86        | 25.11           | 5686.20    |
| Textile            | 22.72        | 22.33           | 7036.90    |
| Organic& Food rest | 19.94        | 24.30           | 5926.83    |
| Pampers            | 27.13        | 23.31           | 6171.90    |
| Rubber             | 23.05        | 26.17           | 6808.57    |
| Total              | 134.92       | 168.37          | 43798.21   |
| Average            | 19.27        | 24.05           | 6256.89    |

3.1. Calorific Value of RDF Bricket

Result of laboratory analysis of calorific value, moisture content, and ash content from briquette sample are as follows (Table 3, 4, 5)

Table 4. 3 briquette of waste residue.

| Moisture | Ash Content |
|----------|-------------|
| 33.86 %  | 44.72 %     |

Table 5. 4 Briquette CV.

| Per Component | CV           |
|---------------|--------------|
| 6235.39 cal/g |              |
| 9867.12 cal/g |              |
| 8051.25 cal/g |              |
| 1815.86 cal/g |              |
| 22.55%        |              |

The following data are collected from invoices that describe electricity usage and charge of low income cluster houses in Ciracas (Table 6).
### Table 6. Metering charges of low income cluster houses of R1 450 VA class with tariff Rp. 415,-/kWh in Ciracas, East Jakarta.

| Number | PLN(Rp)/month | Customer Number | Name     |
|--------|---------------|-----------------|----------|
| 1      | 111,227       | 5471.0239.700   | Chaniago |
| 2      | 236,933       | 5471.0238.7063  | Jalil    |
| 3      | 210,068       | 5471.0238.7048  | Erdi     |
| 4      | 61,363        | 5471.0238.7089  | Erni     |
| 5      | 3,95          | 5471.0234.8292  | Jalil    |
| 6      | 81,132        | 5471.0238.7071  | Robby    |
| 7      | 88,735        | 5471.0238.9830  | Zubaidi  |
| 8      | 44,319        | 5471.0237.3790  | Tan      |
| 9      | 162,929       | 5471.0234.0476  | Aang     |
| 10     | 53,760        | 5471.0238.9814  | Hadi     |
| 11     | 385,697       | 5471.0236.1308  | Amri     |
| 12     | 45,143        | 5471.0234.8306  | Suryo    |
| 13     | 8,357         | 5471.045.3860   | Suryo    |
| 14     | 68,46         | 5471.0245.3878  | Ari      |
| 15     | 8,703         | 5471.0280.5455  | Roni     |
| 16     | 16,896        | 5471.0280.5463  | Opik     |
| 17     | 355,369       | 5471.0245.3886  | Petrus   |
| 18     | 54,267        | 5471.0247.3693  | Puspo    |
| 19     | 32,978        | 5471.0247.3723  | Sumari   |
| 20     | 17,633        | 5471.0247.3731  | Sumari   |
| 21     | 58,829        | 5471.0247.3749  | Ratna    |
| 22     | 64,404        | 5471.0247.3756  | Ratna    |
| 23     | 46,664        | 5471.0247.3685  | Laksmono |
| 24     | 65,925        | 5471.0247.3707  | Wiarso   |
| 25     | 11,12         | 5471.0247.3715  | Wiarso   |
| 26     | 5,069         | 5472.0001.7792  | Agus     |
| 27     | 18,432        | 5471.0234.8314  | Emilia   |
| 28     | 102,927       | 5471.0233.6455  | Laksmono |
| 29     | 213,733       | 5471.0239.0718  | Wiarso   |
| 30     | 507,003       | 5471.0239.0734  | Puspo    |
| 31     | 118,641       | 5471.0234.8322  | Ratna    |
| 32     | 5,242         | 5471.0236.1294  | Novi     |
| 33     | 53,253        | 5471.0238.9806  | Hendro   |

**Average 104,611**

The analysis of calorific value (CV) shows the CV difference of 1,815.8 cal/g between the briquettes (8,051.25 cal/g) and the RDF (9,867.12 cal/g). This 22.5 % of deviation is related to the complexity of the material homogenization process. The briquette CV average of 8,051.25 cal/g is equivalent to 8,051,250 kCal/ton or 9357,3416 kWh/ton.

DKI Jakarta generates MWS 8,291,650 kg / day. Of that number only 66% ie 5,472,490 kg/day can be transported to Bantargebang Landfill [10]. Therefore the total waste that can be prodused to RDF = 5,472,490 kg/day - (metal + glass component) kg/day = 5,472,490 kg/day - (4% of 5,472,490) kg/day
= 5,253,590.44 kg/day = 5,253,590 kg/day = 5,253 tons/day or equivalent to 5,253 ton/day x 9357.3416 kWh/ton = 49,154,115 kWh/day.

If the efficiency level to produce electricity from RDF is 25%, then Jakarta can produce 12,288,529 kWh/day or as much as energy needed by 573,480 middle-class households with energy consumption of 642.84 kWh/month or 21.428 kWh/day (12288529 kWh/day: 21,428 kWh/day/households = 573479,98 households).

The basic electricity tariff of low income household or the 450 VA of R1 household class is Rp. 450,-/kWh. Based on the data obtained the average electricity needed by the R1 class of 450 VA is 244.512 kWh/month (8.2 kWh/day). Therefore the energy of 12,288,529 is enough to supply 1,498,601 low income households.

4. Conclusion
Jakarta generates MWS 8,291,650 kg/day, but only 66% of that, ie 5,472,490 kg/day can be transported to Bantargebang Landfill [10] and only 5,253 tons/day can be used as RDF to produce electricity of 12,288,529 kWh / day or as much as energy needed by 573,480 middle-class households.

RDF offers a very strong commercial opportunity. It seems to be optimistic, even it’s just the tip of the iceberg. DKI Jakarta Government needs to be encouraged to adopt commercially viable alternative fuel such as RDF. The developments in sensor-based sorting technology enabling to achieve optimal purity rates and much higher volumes of high value material than manual picking. Plastics, fibre, films, paper, cardboard, textiles and wood can all be recovered to an exceptionally high standard material. It is possible to process and maintain higher throughputs, with consistent quantity and quality achievable within 24 hours a day.

Creating the RDF processing machinery with a small footprint to make it suitable for small-scale operations is also achievable. Local companies can cooperate with one of the coutes who have experience with RDF to create sensor-based sorting technology so that after all valuable fractions had been recovered, only the smallest amounts of residue would be destined for the precarious RDF route.

RDF will be an important fuel for the future. RDF can be an alternative energy source as well as a solution to solve recycled waste problem in Jakarta, helping the citizens to reduce their reliance on fossil fuels and avoid landfilling this residual waste. With a high CV, RDF can be used in facilities such as cement kilns.

There should be continuous campaign about RDF to make it socially and politically acceptable, to create confidence in the market. It must be tested and evaluated in an appropriate and standardized way and declared that RDF is a fuel made from non-hazardous waste components and in compliance with environmental regulation. It must be produced to a range of specifications to meet customer requirements. Deeper research of RDF is indispensable and technically feasible.

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