

# 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).

**Table 1.** Quality standard 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 %
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 high 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, Moisture, ash content.

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

Ash content was determined according to ASTM E 830-87 [9]. The remaining sample was heated at temperature of  $550^{\circ}\text{C}$  and reheated in a furnace at  $950^{\circ}\text{C}$  for 7 minutes. Then it was laid into desiccator and weighed. Ash content =  $(f / w) \times 100\%$ ; ( $E$  = weight after heating in furnace  $550^{\circ}\text{C}$ ;  $f$  = weight after heating in furnace  $950^{\circ}\text{C}$ ;  $w$  = 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
<i>Tetrapack</i>	-
<i>Styrofoam</i>	-
<i>Pampers</i>	-
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
<i>Tetrapack</i>	15.79	23.88	5951.21
<i>Styrofoam</i>	13.86	25.11	5686.20
Textile	22,72	22.33	7036,90
Organic& Food rest	19.94	24.30	5926.83
<i>Pampers</i>	27.13	23.31	6171.90
Rubber	23.05	26.17	6808.57
<b>Total</b>	134.92	168.37	43798.21
<b>Average</b>	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.

<b>Moisture</b>	33.86 %
<b>Ash Content</b>	44.72 %
<b>CV</b>	9867.10 cal/g

**Table 5.** 4 Briquette CV.

Per Component	6235.39 cal/g
Briquette CV	9867.12 cal/g
Average of CV	8051.25 cal/g
CV-Diference	1815.86 cal/g
Deviation	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	54.71.0238.9814	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
<b>Avgerage</b>	<b>104,611</b>		

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,- per 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 countries whose having 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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#### References

- [1] <http://www.recyclingwasteworld.co.uk/site/contact-form.aspx?> accessed on May 2, 2017 at 7 pm)
- [2] Taparugssanagorn K, Yamamoto K, Nakajima F, Fukushi K. Evaluation of waste-to-energy technology: economic feasibility in incorporating into the integrated solid waste management system in Thailand. The IE Network Conference, 2007, 91-96.
- [3] Widyatmoko dan Sintorini, 2002. Menghindari, Mengolah dan Menyingkirkan Sampah. Abdi Tandur, Jakarta.
- [4] Badan Pusat Statistik [BPS]. (2016). Jakarta dalam angka 2016. Jakarta: BPS
- [5] BPS, Bappenas, & UNFPA. (2013). Proyeksi penduduk Indonesia 2010-2035. Jakarta: BPS
- [6] Badan Standardisasi Nasional. 1994. SK SNI 19-3694-1994 Tentang Metode Pengambilan Dan Pengukuran Contoh Timbulan Dan Komposisi Sampah Perkotaan. Jakarta : Balitbang DPU

- [7] Badan Standardisasi Nasional. 2002. SK SNI 19-2454-2002 Tentang Tata Cara Teknik Operasional Pengolahan Sampah Perkotaan. Jakarta : Balitbang DPU.
- [8] Badan Standardisasi Nasional 2011. SK SNI 185/KEP/BSN/11/2011 SNI 1971:2011 - Cara uji kadar air total agregat dengan pengeringan. BSN: Jakarta.
- [9] ASTM International 2004. Standard Test Method for Ash in the Analysis Sample of Refuse-Derived Fuel 1. United State.
- [10] Widyatmoko 2011. Pengelolaan Sampah. Universitas Trisakti. Jakarta.