



RENEWABLE ENERGY BUSINESS WASTE MANAGEMENT AT BANTARGEBAW TPST AS AN ALTERNATIVE FUEL FOR CEMENT INDUSTRY

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Abstract:

The Special Capital Region of Jakarta faces a significant challenge in managing approximately 7,500 tons of waste entering the Bantargebang Integrated Waste Processing Facility (TPST) daily. As an environmentally friendly solution, the Jakarta Environmental Agency has developed Refuse Derived Fuel (RDF) technology to convert waste into alternative fuel for the cement industry. This study aims to analyze the RDF production process at the Bantargebang RDF facility and evaluate the effectiveness of Mechanical Treatment methods applied to two waste types: Municipal Solid Waste (MSW) and Landfill Waste (LFW). A qualitative descriptive method was used, employing direct observation, interviews, and documentation techniques. The findings reveal that LFW is processed through natural sun drying, Trommel Screen filtering, and further drying in a Kiln Dryer. Meanwhile, MSW is separated into organic and inorganic components, with organics dried in the Sun Dry Bay and inorganics on a Drying Conveyor before RDF production. This method has proven effective in reducing waste volume and producing high-quality alternative fuel. The study highlights the potential of RDF as a sustainable urban waste management solution and emphasizes the importance of replicating such infrastructure in other regions.

Keywords: *waste management; alternative fuel; renewable energy; RDF*

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INTRODUCTION

Waste management in Jakarta is a serious problem that needs to be addressed immediately, considering the density of Jakarta's population, which produces around 7500 tons of waste per day (Haushofer 2018). The Indonesian government concerning Waste Management states that the remains of human and natural activities in solid or semi-solid form, both organic and inorganic, which are considered no longer useful, are often dumped into the environment (Mulyani and Milla 2024). Economic growth driven by buying and selling transactions has contributed to increased waste, but the behavior of people who depend on cleaning staff has ignored this problem. Such actions have the potential to damage the environmental ecosystem, including water, soil, and air (Aliaghaei et al. 2020).

Fresh Municipal Solid Waste (MSW) is waste generated from various sources in the DK Jakarta Province, distributed to the Bantargebang TPST (Ismangoen et al., 2022; Prihartanto et al., 2023). Urban waste comes from the community, which has sources of

coverage, namely household, office, school, residential, or village waste in the DK Jakarta area (Rini dan Hidayati 2022). The waste management process, until it is finally disposed of at the TPA, goes through several collections so that all waste can be transported from the Temporary Shelter (TPS). In its composition, fresh waste has characteristics that are dominated by household organic waste (Bernat et al., 2019; Sharma et al., 2019). This is one piece of information that reminds us that the largest source of waste comes from household waste. Organic waste comes from human remains and is easily decomposed naturally without human intervention. However, we cannot use this as an excuse not to protect the environment and reduce waste production. Furthermore, the second dominant type of urban waste is plastic, with a composition level of 9%. In 2019, through Governor's Regulation 142 of 2019 (Governor Regulation, 2019) concerning the obligation to use environmentally friendly shopping bags in shopping centers, supermarkets, and traditional markets, the government is encouraging plastic reduction to maintain environmental sustainability and cleanliness. The government has shown this focus on controlling the increased waste that is difficult to decompose. Furthermore, followed by residue with a percentage of 8%, paper 7%, and wood 6%, this waste is another result found in urban waste with an estimated increase in this percentage along with the increasing population of DK Jakarta (Suroto; Mulyati R., 2021). There is also hazardous and toxic waste (B3) with a percentage of 1%. See the image below for more details on the composition of urban waste that will be the refuse-derived fuel (RDF) technology source.

Table 1. Bantargebang Fresh Municipal Solid Waste (MSW) Characteristics

Component	Percent
Organics	53,00%
Plastics	9,00%
PET	6,00%
Papers	7,00%
Woods	6,00%
Textiles	3,00%
Rubbers	2,00%
Metals	2,00%
Glasses	3,00%
Residue	8,00%
Toxic and Hazardous	1,00%
TOTAL	100,00%

Source: Data processed (Adhi-Jakon 2021)



Figure 1. Fresh Municipal Solid Waste (MSW)

Landfill Mining Waste (LFW) is waste transported to the Bantargebang TPST by each waste transport vehicle through an unloading process to the disposal point in a relay. After the waste is disposed of at the disposal point, the waste will be leveled and compacted periodically to maintain the disposal point pile in a safe and stable condition. In general, old organic waste will decompose naturally in the landfill to reduce the volume of old waste. However, the decomposition rate of organic waste is lower than the increase in the volume of waste piled up in the landfill every day. According to laboratory research results, the largest composition of the landfill waste is humus soil and organic waste, most of which is dominated by food waste. We know that with the increasing population of DK Jakarta, which will continue to increase, food waste has the most significant amount in this landfill, with a percentage of 41%. Furthermore, the percentage of this figure is driven by the emergence of humus soil originating from the weathering of leaves and tree trunks, in addition there is also animal manure that has been decomposed by organisms in the pile of waste so that if we look at the pile of waste that has been piled up for years, various plants will appear. These plants appear due to the presence of phenol, aliphatic hydroxide, and carboxylic acid. The composition of old waste at the Bantargebang TPST can be seen in the picture below.

Table 2. Bantargebang Landfill Mining Waste (LFW) Characteristics (Adhi-Jakon 2021)

Component	Percent
Humus Soil & Food Waste	41,00%
LDPE Plastic	34,00%
Non-LDPE Plastic	2,00%
Textiles	10,00%
Papers	5,00%
Rubber & Leathers	3,00%
Wood & Grass	2,00%
Hazardous Waste	2,00%
Metal	-
Glass	-
Others	1,00%
TOTAL	100%

Source: Data processed



Figure 2. Landfill Mining Waste (LFW)

In terms of its nature, waste is divided into two types, namely organic and inorganic.

1. Organic Waste

Organic waste consists of organic materials. It does not last long and rots quickly. This type of waste usually comes from living things. Examples are vegetables, rotting fruits, leftover rice, leaves, and so on. Soil microorganisms easily decompose organic waste. However, this type of waste will cause an unpleasant odor if not appropriately managed.

2. Inorganic Waste

Inorganic waste is waste that consists of inorganic materials. Inorganic materials include metal, plastic, glass, rubber, and cans. The nature of inorganic waste is durable and difficult to rot. Soil microorganisms do not easily decompose this waste. If disposed of carelessly, inorganic waste can cause soil pollution.

In order to process waste, one of the technologies suitable for use is Refuse-derived fuel (RDF) Based Waste Processing Technology. Refuse-derived fuel (RDF) is a fuel produced from various types of waste such as Fresh Municipal Solid Waste (MSW), Landfill Mining Waste (LFW), industrial waste, or commercial waste. RDF is a fuel from recycled waste with a high heat output value.

RDF-based waste processing technology has been used in various regions in Indonesia, but with a small capacity scale. For example, RDF technology in Cilacap has a waste input capacity of 120 tons per day and produces approximately 50 tons of RDF products per day, RDF technology at TPST Samtaku, Bali, has an input capacity of 100 tons per day and produces approximately 30 tons of RDF products per day, etc.

Abroad, RDF-based waste processing technology is also widely applied in Asian countries such as Singapore, Korea, China, and the Philippines, as well as European countries such as Austria, Germany, Spain, etc.

The purpose of writing this paper is to describe the right way to process waste, both Fresh Municipal Waste (MSW) and Landfill Mining Waste (LFW), and to evaluate whether the waste processing that has been applied to the Bantargebang RDF project is worthy of being a pilot project to be applied in other cities. Several relevant studies have been conducted on waste processing methods in various regions. These studies are summarized in the table below.

Table 3. Relevant Previous Research

Title	Author	Year	Research Result
Potential of Energy Municipal Solid Waste (MSW) to Become Refuse-Derived Fuel (RDF) in Bali Province, Indonesia	I Wayan Koko Suryawan, I Made Wahyu Wijaya, Kartika Sari, Iva Yenis Septiariva, Nurulbaiti Listyendah Zahra	(2021)	The lowest and highest potential heating value of MSW as a raw material for RDF in Bali is 9.58 and 17.71 MJ/kg, respectively. Field application shows that processing waste into RDF in pellets can reach ± 14.64 MJ/kg. The potential for GHG derived from MSW processing is 178 – 330 times.

Title	Author	Year	Research Result
Application of Refuse-Derived Fuel (RDF) Plant in Piyungan Landfill Municipal Solid Waste Management	Diananto Prihandoko, Chandra Purnomo, Primanda Widyaputra, Nasirudin Wahyu Kiky	(2022)	The results of the study show that the application of the RDF plant of the Piyungan landfill can potentially reduce the volume of the waste disposed into the landfill by 43% annually on average in the period of operational years. The application of the Piyungan Landfill's RDF plant is considered feasible as long as some assumptions and parameters are met. The sensitivity analysis shows that the tipping fee and the operational cost of the RDF plant highly influence the project's economic feasibility. The RDF plant in the Piyungan Landfill is feasible to apply with an NPV of IDR 281.46 billion, an IRR of 24%, and a payback period of 6 years. The tipping fee should not decrease by more than 40%, and the operational cost of the RDF plant should not be more than 120%. High transportation costs could result in the economic infeasibility of the project.
Study of the Potential of Refuse-Derived Fuel (RDF) at the Cipayung Final Disposal Site (TPA) to Meet Industrial Quality Standards and Environmentally Friendly	Gathut Gunadi, Taufik Nur Isman, Ridwan Alawi, Alvian Hadinata, Tambunan, Prawoto, Eka Maulana	(2023)	The potential for waste at the Cipayung Final Disposal Site (TPA) can produce RDF with a calorific value of 29.04 MJ/kg, or the equivalent of 9,294,413 MJ/day. To get an environmentally friendly RDF, a calculation is made using the percentage of plastic waste (0%) and rubber waste (0%). And the results obtained were 15.82 MJ/kg, which still met the industry's RDF requirements (12.56 MJ/kg). The potential for environmentally friendly RDF at the Cipayung TPA is 79,640.00 kg/day, and energy of 9,294,413 MJ/day will be obtained.
Solid waste management by RDF production from landfilled waste to renewable fuel of Nonthaburi	Udorn Rahothona, Maneerat Khemkhaoa, Prangtip Rittichote Kaewpengkrowa	(2023)	To effectively manage landfill waste in Thailand, a multi-step separation process is necessary to improve the quality of landfill waste by removing the incombustible prior to utilization as a renewable fuel in power plants. The multi-separation can effectively convert LW to RDF, which can be applied as a renewable fuel. They are considered good fuels for power plants and could be potential end-users of RDF in Thailand.
Evaluating Refuse-Derived Fuel (RDF) Production from Municipal Solid Waste (Case Study: Cilacap Regency RDF Plant)	Esti Maulidayanti, Manis Yuliani, Muhammad Haqqiyuddin, Robbani, Wiharja, Erliza Hambali, Dwi Setyaningsih	(2024)	The technical feasibility of the RDF manufacturing process and product quality at the Cilacap RDF Plant for the cement industry has been successfully evaluated. Based on the research results, waste in Cilacap Regency is dominated by food waste with a high water content and low calorific value. Through the biodrying process, the calorific value of the waste increases significantly, although it has not reached a level equivalent to coal. The RDF production process at the Cilacap RDF Plant uses the mechanical biological treatment (MBT) method, effectively lowering the waste's water content through the biodrying process.

Source: Data processed

RESEARCH METHOD

The study began with direct observation and documentation of the stages of the RDF production process carried out at the Bantargebang RDF Factory. The quality of RDF products was evaluated by testing water content, calorific value, and Size. Based on the results obtained, the RDF will be compared with the requirements in the Regulation of the Ministry of Industry of the Republic of Indonesia in 2017 regarding Refused Derived Fuel (RDF) as an alternative fuel in the cement industry. This is to evaluate whether the RDF produced from waste processing in Bantargebang is in accordance with the regulations, so that it can be a reference for waste processing in other places.

The basis for selecting RDF technology in waste processing in Bantargebang is that waste, both Fresh Municipal Solid Waste (MSW) and Landfill Mining Waste (LFW), has a very high calorific value to be used as alternative fuel, as shown in the table below.

Table 4. Caloric value from waste (Damanhuri 2010)

No	Sample	Bomb Calorimeter	LHV	Calotific Value (kcal/kg)			
				Proximate Analysis		Dulong	
				1	2	3*	3**
	Paper						
1	HVS	3024,24	2884,84	4234,29	1143,01		3591,18
2	Carton	3602,18	3359,17	4118,58	1154,28	6648,26	
3	News Paper	3845,53	3618,95	4238,47	1306,64	4205,97	
4	Megazine	2598,95	2476,51	3646,23	992,02	2712,36	
5	Ricepaper	4246,92	3920,67	4167,29	1288,89		3591,18
6	Cardboard Box	4487,07	4093,09	4257,12	1284,39	3571,67	
	Plastic						
7	PETBottle(no.1)	5450,85	5252,42	4445,83	1382,24	11680,56	
8	HDPE Sheet(no.2)	11207,00	11169,58	4444,73	1386,33		6307,50
9	PVC Sheet(no.3)	5187,91	5138,23	4332,82	1360,11	5448,78	
10	LDPE(no.4)	12318,40	12195,08	4505,66	1356,34		6307,50
11	PPCup(no.5)	11912,80	11903,06	4426,95	1380,54		6307,50
12	PS(no.6)	11285,50	11269,80	4273,86	1379,38	9645,22	
	Food and Market Waste						
13	Mixed Food	5162,21	1437,86	3727,54	737,10	4466,11	
14	Wrapping Leaves	4638,37	975,59	4069,59	573,85		4154,72
15	Shell and Fibre Coconut	4684,11	3407,90	4446,86	1291,42		3915,63
16	Vegetable	4568,29	689,85	4205,94	248,60		4466,11
17	Fish	5837,12	1567,48	3497,23	581,39		4466,11
18	Grease	9891,62	5065,61	4442,10	1213,95	9155,28	
19	Meat	7154,78	2597,33	4359,15	1034,45		
20	Bone	4464,42	1570,90	3169,97	638,29		6951,46
21	Fruit	5064,86	392,54	4337,90	-828,00	4347,01	
	Garden Waste						
22	Leaf	3998,02	1632,60	3644,07	958,76		4154,72
23	Grass	4153,51	906,08	7365,52	567,68		4154,72
24	Branch	4715,66	1997,45	4211,09	1096,14		3915,63
	Textile and Rubber						
25	Towel	4435,10	4239,45	4301,44	1348,27		4357,78
26	Jeans	4271,05	4010,65	4393,74	1372,21		4357,78
27	shirt	4836,68	4664,32	4413,66	1365,93		4357,78
28	Rubber	5202,15	5106,45	4218,60	939,96	8598,61	
	Kompos						
29	Raw	2125,75	675,26	2402,29	420,93		4137,50
30	1/2 Raw	2091,90	979,05	2291,37	484,83		4137,50
31	Rap	1669,73	936,04	1854,94	415,31		4137,50
32	Residue	2211,65	980,02	3007,37	680,21		4137,50

* Tchobanaglou Data

** Assumption from Tchobanaglou Data

Source: Data processed

Indonesian regulations regarding Quality Refused Derived Fuel (RDF) are as follows:

1. The Ministry of Industry of the Republic of Indonesia in 2017 regarding Refused Derived Fuel (RDF) as an alternative fuel in the cement industry.

Table 5. RDF Characteristics Based on Criteria Accepted by Cement Companies in Indonesia
(Ministry of Industry of the Republic of Indonesia 2017)

Quality Parameter	Unit	Value
Gross Calorific Value, min	Kcal/kg	≥ 3000
Cl	%	≤ 0,75
S	%	≤ 1
Moisture Content	%	≤ 20
Size	mm	≤ 50
Type	-	Fluff
Na ₂ O	%	≤ 0.5
K ₂ O	%	≤ 1
MgO	%	≤ 2
P ₂ O ₅	%	≤ 1
TiO ₂	%	≤ 0.5
<i>Trace Element</i>		
Hg	ppm (Dry), max	5
As	ppm (Dry), max	15
Cd	ppm (Dry), max	10
Cr	ppm (Dry), max	250
Pb	ppm (Dry), max	300
Sb	ppm (Dry), max	70
Co	ppm (Dry), max	200
Ni	ppm (Dry), max	200
Cu	ppm (Dry), max	200
V	ppm (Dry), max	200
Zn	ppm (Dry), max	3000
Se	ppm (Dry), max	10

Source: Data processed

2. SNI 8966:2021 Regarding Solid Fuel for Power Generation (“SNI 8966:2021 Regarding Solid Fuel for Power Generation” 2021)

Table 6. SNI 8966:2021 Regarding Solid Fuel for Power Generation

No.	Test Parameter	Units, min./max.	Class		
			1	2	3
1	Organic Material Content ^{a)}	%, min.	Organic ≥ 95	$87.5 \leq \text{Organic} < 95$	$80 \leq \text{Organic} < 87.5$
2	Sizing				
	Fluff	Minimum - mm	0.297	0.297	0.297
		- Mesh No.	50	50	50
		Maximum - mm	2.38	2.38	2.38
		- Mesh No.	8	8	8
	Pellet				
	Diameter	mm, min.	6 ± 1.0	6 ± 1.0	6 ± 1.0
		mm, max.	10 ± 1.0	12 ± 1.0	12 ± 1.0
	Length	mm	$3.15 \leq P \leq 40$	$3.15 \leq P \leq 40$	$3.15 \leq P \leq 40$
	Bricket				
3	Diameter	mm, min.	50	50	50
		mm, max.	70	70	70
	Length / Thickness	mm, min.	20	20	20
		mm, max.	70	70	70
3	Density				
	Fluff	g/cm ³ , min.	0.4	0.4	0.4
	Pellet	g/cm ³ , min.	0.8	0.7	0.6
	Bricket	g/cm ³ , min.	0.9	0.9	0.9
4	Water content ^{b)}	%-weight	< 15	< 20	< 25
5	Ash content ^{b)}	%-weight	< 15	< 20	< 25
6	Volatile substance Concentration ^{b)}	%-weight, max.	65	70	75
7	Fixed Carbon Cocentration ^{b)}	%-weight	> 15	> 10	> 5
8	Calorific Value (Net) ^{b)}	MJ/kg, mean ^{d)}	≥ 20	≥ 15	≥ 10
9	Total Sulfur Concentration ^{b)}	%-weight	≤ 1.5	≤ 1.5	≤ 1.5
10	Chlorine Concentration ^{b)}	%-weight, mean ^{d)}	≤ 0.2	≤ 0.6	≤ 1
11	Mercury Concentration (Hg) ^{b)}	mg/MJ, median ^{d)}	≤ 0.02	≤ 0.03	≤ 0.08
		mg/MJ, 80 th percentile ^{d)}	≤ 0.04	≤ 0.06	≤ 0.16
12	Potassium Concentration (in K ₂ O)	%-weight, max.	5	10	15
13	Sodium Concentration (in Na ₂ O)	%-weight, max.	2,5	2,5	2,5
14	Hardgrove Grindability Index (HGI) ^{c)}	HGI, min.	35	35	35
15	Ash Melting Point (IDT)	°C, min.	1200	1180	1180

Source: Data processed

Note: The regulation we use to evaluate the output of RDF results in Bantargebang waste processing is Regulation of the Ministry of Industry of the Republic of Indonesia in 2017 regarding Refused Derived Fuel (RDF) as an alternative fuel in the Cement Industry, because the Cement Factory uses the RDF produced in Bantargebang.

RESULTS AND DISCUSSION

Based on the results of our research, the following RDF product output results were obtained:

Table 7. RDF Result from Fresh Municipal Solid Waste (MSW) RDF Processing Facility

ITEM DESCRIPTION	RESULT	REQUIREMENT(*)	EVALUATION
GROSS CALORIFIC VALUE (KCAL/KG)	7020	3000	COMPLY
MOISTURE (%)	16,4	< 20	COMPLY
SIZE	< 50 MM	< 50 MM	COMPLY

Note: *Requirement as per Regulation of the Ministry of Industry of the Republic of Indonesia in 2017 regarding Refused Derived Fuel (RDF) as an alternative fuel in the Cement Industry

Source: Data processed

Based on the research results in Table 7, for the Fresh Municipal Solid Waste (MSW) RDF Processing Facility, the Gross Calorific Value was obtained at 7020 Kcal / kg, with a Water Content of 16.4% and Size <50 mm. Compared with the requirements as per Regulation of the Ministry of Industry of the Republic of Indonesia in 2017, the results of waste processing into RDF at the Facility meet the requirements.

Table 8. RDF Result from Landfill Mining Waste (LFW) RDF Processing Facility

Item Description	Result	Requirement(*)	Evaluation
Gross Calorific Value (Kcal/Kg)	5246	3000	Comply
Moisture (%)	19,3	< 20	Comply
Size	< 50 mm	< 50 mm	Comply

Note: *Requirement as per Regulation of the Ministry of Industry of the Republic of Indonesia in 2017 regarding Refused Derived Fuel (RDF) as an alternative fuel in the Cement Industry

Source: Data processed

Based on the research results in Table 8, for the Landfill Mining Waste (LFW) RDF Processing Facility, the Gross Calorific Value was obtained at 5246 Kcal / kg, with a Water Content of 19.3% and Size <50 mm. Compared with the requirements as per Regulation of the Ministry of Industry of the Republic of Indonesia in 2017, the results of waste processing into RDF at the Facility meet the requirements.

From the output results of both Facilities above, it can be seen that the lower the Moisture Value obtained, the greater the Gross Calorific Value. This shows that the Gross Calorific Value is inversely proportional to the Moisture Value, so the ability of the equipment to reduce Moisture is very important to obtain good-quality RDF results.

Facilities must be built to support the waste processing process When Building Waste Processing Facilities in Bantargebang. The following figure shows the master plan for waste processing facilities in Bantargebang.

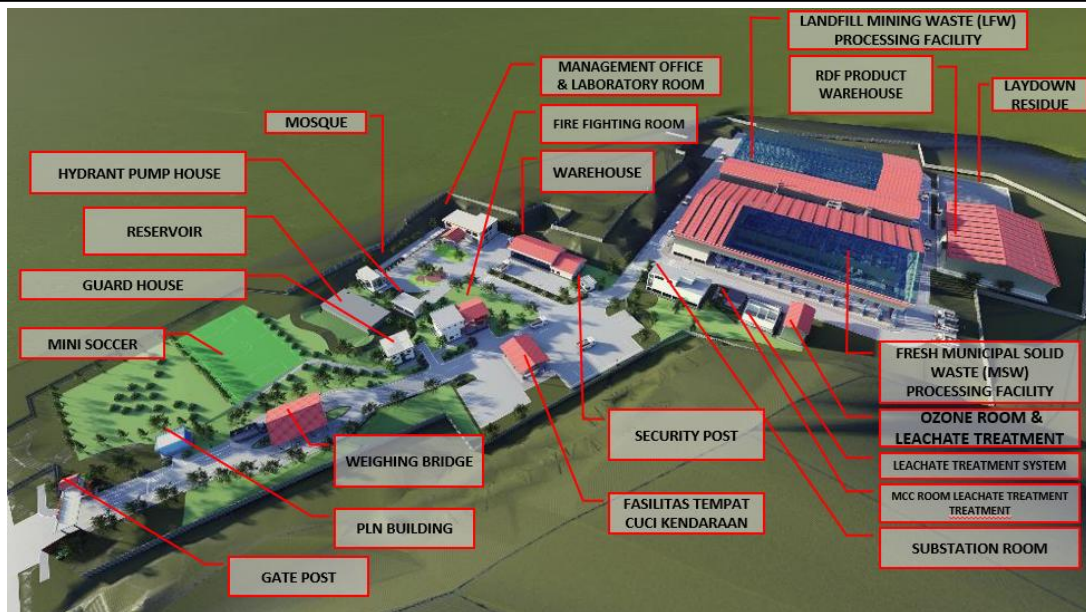


Figure 3. Master Plan Bantargebang RDF Development

Notable concept is to apply different processing skills to organics and non-organics in MSW, and these divided processing routes will be combined in the later processing stage. This intelligent energy-saving method to dehydrate the moisture level is the most challenging task in the Bantar Gebang Project. In the beginning, processing in the Facility, the organics of high moisture content will be separated from other Fresh MSW and dried in the Sun Dry Bay first. Once the moisture level of organics reaches the target level, they will be further dried in a kiln dryer.

Other non-organics will possess the characteristics of simpler dehydration. They will be dried in a “Drying Conveyor.” After the two processing paths are completed, the organics and other combustible non-organics will be mixed to form the final RDF.

The flow of MSW in process, as in Figure 4, and Landfill Mining MSW (LFW) Processing, as in Figure 5, show that the flow of Facility processing will have two major lines for organics and non-organics. Any failure in one line will NOT affect the other line of processing to achieve continuous production with built-in redundancy. In basic, the MSW Sub-plant will have production capacity with a minimum production amount.

Fresh Municipal Solid Waste (MSW) Processing Flow to become RDF can be explained as follows:

Garbage Truck (Fresh Waste) from the City enters the location then the garbage is dumped into the bunker area, Garbage cranes take the garbage and put it into the Inlet Hopper for further taken to the Manual Sorting Area by conveyor Then the garbage is sorted manually by the workforce Then the waste passes through the Magnetic Separator to separate the Ferrous waste (Iron, Steel, etc.) Then the garbage goes to the Shredder (1st) to be chopped and cut into small pieces, then the waste will pass through the Trommel. In this process, waste (organic and non-organic) is sorted based on size. Organic waste will be separated. Garbage with a small size < 50 mm will dry in the sundry bay area (using the sun's heat and air) with the help of the Escalator Module. The garbage is turned over, and the dry one is pushed to the feeder

Conveyor. Furthermore, dried organic waste is taken to the kiln dryer for further drying with hot gas until it reaches the target humidity of 20%, then it produces an RDF product according to requirements for output.

Meanwhile, large-sized waste with a size > 50 mm is followed by separation using In-Combustible Screening. Here, the material separation process is based on specific gravity. Heavy material will be residue, and light material will proceed to the drying process by passing the Drying Conveyor for drying with air until the target humidity is 20%.

Furthermore, the waste will go to the Secondary Shredder to be chopped or cut again to a size < 50 mm, then produce RDF Products according to the output requirements. The Details Flow Diagram can be seen in the image below.

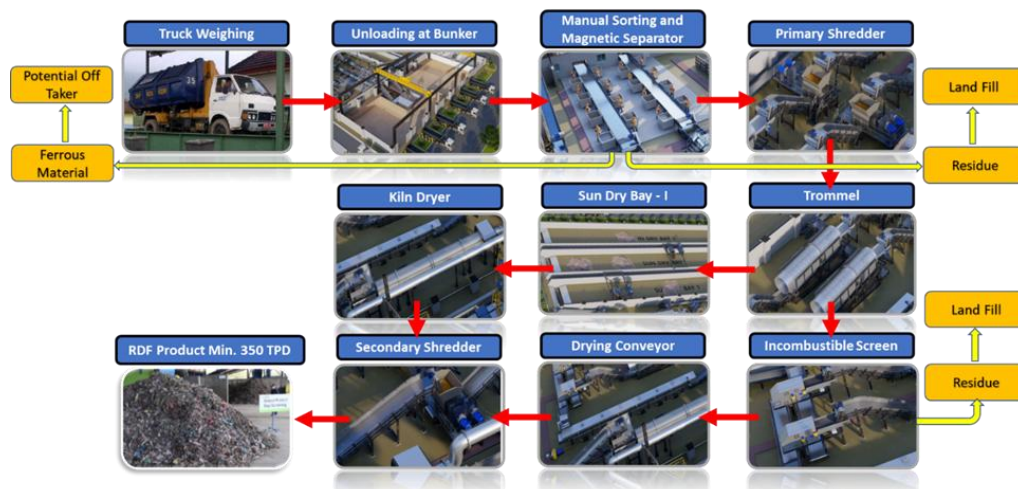


Figure 4. Flow Diagram from MSW to RDF

For the Landfill Mining Waste (LFW) Processing Flow into RDF, as follows

Garbage Truck (Landfill Waste) from the Landfill Mining Waste (LFW) dumping location was taken to the sundry Bay II area and dried with solar heat energy and air. An excavator helped move garbage back and forth for even distribution during the drying process. Dry waste was pushed using a Wheel Loader to the Inlet Hopper Conveyor (Feeder Conveyor).

Furthermore, Waste is moved using a conveyor through a Trommel, which separates material by size. Material with a size of less than 50 mm, such as humus soil, etc., will become residue, while material with a size of > 50 mm will be separated using In-Combustible Screening, and there is a process of separating materials based on specific gravity.

Next, the Garbage Passes the Magnetic Separator process. Heavy materials such as steel and iron will be residue, while light materials such as plastic and cloth will continue to the Next process.

After that, it will continue to the Kiln Dryer. The waste will undergo a drying process with a humidity target of 20%, then the waste will go to the Secondary Shredder and be chopped or cut to a size < 50 mm and then produce RDF products according to the output requirements. The Details Flow Diagram can be seen in the image below.

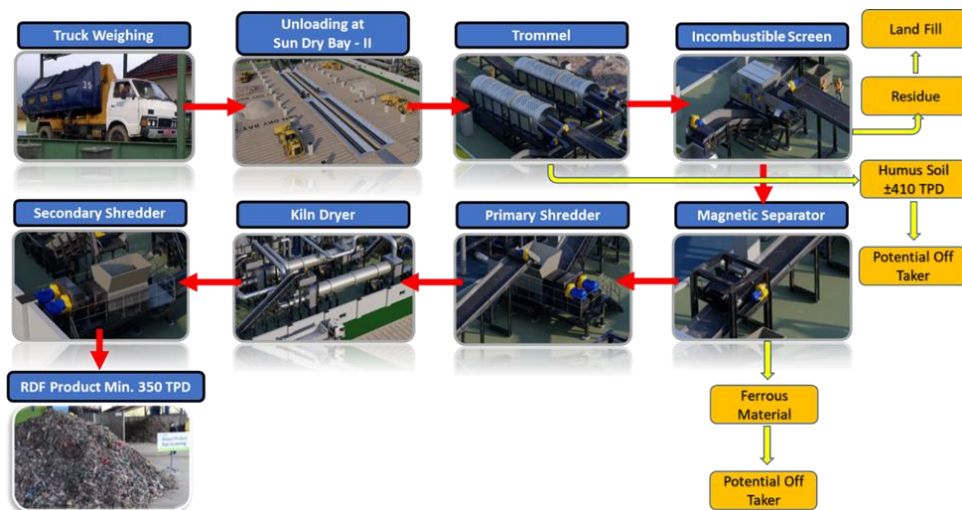


Figure 5. Flow Diagram from LFW to RDF

The “(2)” in Figures 4 and 5 above indicates the number of modules in the Facility that comprise such redundancy.

PT Adhi Karya (Persero) Tbk has designed the standard model of an independent dual-path processing facility, or 2 sub-plants (“Facility”) to handle 1,000 tons of MSW and 1,000 tons of LFW per day, respectively. The 2 sub-plants will be represented by independent processing paths, as depicted in Figure 5, which is a schematic. Throughputs from each path would be different due to the different characteristics and composites, like organics and their tailings.

Under the parallel processing concept, single-point failure modes in the processing paths should be avoided. However, the facility investment is optimized to alleviate the redundancy in functionality of the Facility. In failure mode analysis, when the single path of these parallel processing facilities fails for any reason, the independent path of processing will continue producing the RDF deliverables per design capability.

The facility's daily operation is assumed to be 15 hours and two shifts per day, i.e., 7 hours at the first shift, 1 hour of intermission, and 8 hours in the second shift. However, with this working hour plan, the facility will have a daily routine of on and off cycles.

Each path of the Facility is requested to produce the RDF:

- In quantity of 350 MT per day in each separate path
- In calorific value of 3,000 Kcal/Kg
- In moisture level, less than 20%
- In size less than 50mm
- In fluffs

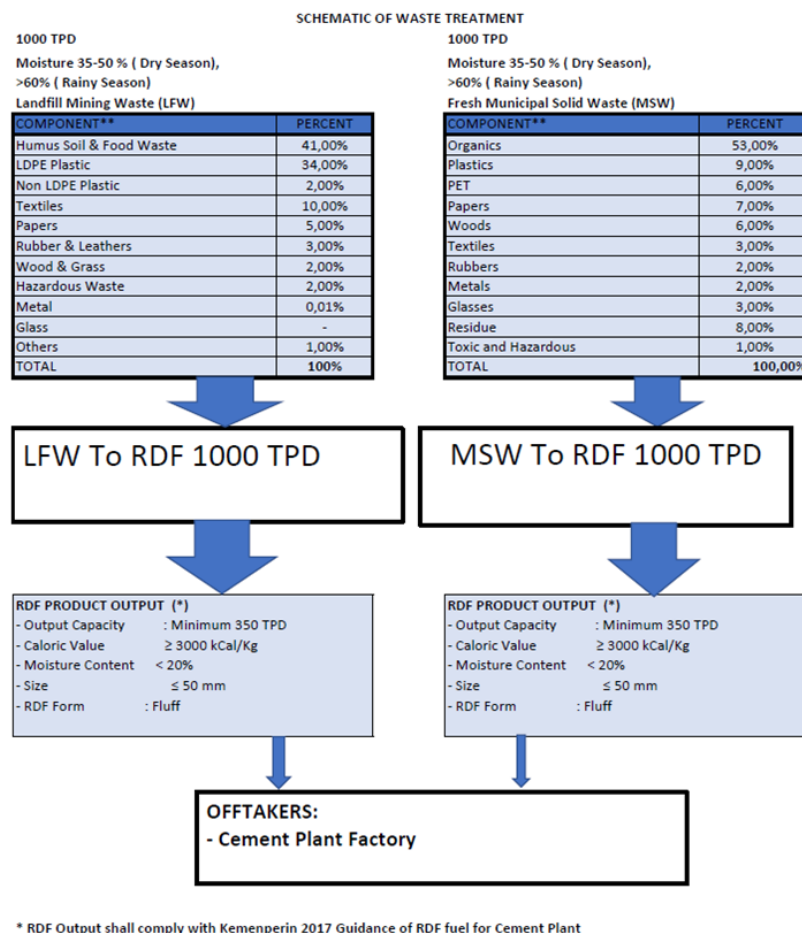


Figure 6. Schematic with Daily RDF Production

Based on the research results, both Fresh Municipal Solid Waste (MSW) and Landfill Mining Waste (LFW) processed at the Bantargebang RDF Facility successfully produced Refuse-Derived Fuel (RDF) that meets the standard requirements set by the Ministry of Industry of the Republic of Indonesia in 2017. The RDF produced from MSW had a calorific value of 7020 Kcal/kg and 16.4% moisture content, while RDF from LFW achieved a calorific value of 5246 Kcal/kg with 19.3% moisture, both within acceptable limits. These findings affirm the high efficiency of the mechanical treatment processes applied at each sub-plant, especially in reducing moisture content, which is inversely related to energy output.

The dual-path processing strategy organics and non-organics separated and processed in parallel offers operational reliability and resilience, minimizing risks from system failures. With a capacity to handle 2,000 tons of waste per day (1,000 MSW + 1,000 LFW), the facility is designed to produce 700 tons of RDF daily with consistent quality. These results confirm that the RDF production system in Bantargebang is technically feasible, strategically scalable, and replicable.

This study demonstrates that the Bantargebang RDF Facility is a viable pilot project for urban waste management. Integrating solar drying, advanced screening, and redundancy-based design provides a replicable model for other cities facing similar waste challenges, reinforcing

the importance of sustainable, energy-efficient waste-to-fuel strategies in addressing urban environmental burdens.

CONCLUSION

Research Results, Fresh Municipal Solid Waste (MSW) RDF Processing Facility produces RDF with a Gross Calorific Value of 7020 Kcal / kg, Water Content of 16.4%, and Size <50 mm. Compared with the requirements as per Regulation of the Ministry of Industry of the Republic of Indonesia in 2017, the results of waste processing into RDF at the Facility meet the requirements. Research Results, Landfill Mining Waste (LFW) RDF Processing Facility produces RDF with a Gross Calorific Value of 5246 Kcal/kg, Water Content of 19.3%, and Size <50 mm. Compared with the requirements according to the Regulation of the Minister of Industry of the Republic of Indonesia in 2017, the results of waste processing into RDF at the Facility meet the required requirements. The lower the Moisture Value obtained, the greater the Gross Calorific Value. This shows that the Gross Calorific Value is inversely proportional to the Moisture Value, so the ability of the equipment to reduce Moisture is very important to obtain good quality RDF results. The waste processing facility to become RDF in Bantargebang is worthy of being used as a model for waste processing in other cities.

REFERENCES

- Adhi-Jakon. 2021. "Proposal for the Design of Landfill Mining Waste Treatment Facility and RDF Plant (Design and Build)."
- Aliaghaei, Fatemeh, Maryam Pazoki, Forough Farsad, dan Iman Tajfar. 2020. "Evaluating of refuse derived fuel (RDF) production from municipal solid waste (case study: Qazvin Province)." *Environmental Energy and Economic Research* 4 (2): 97–109.
- Bernat, Katarzyna, Agnieszka Cydzik-Kwiatkowska, Magdalena Zielińska, Irena Wojnowska-Baryła, dan Justyna Wersocka. 2019. "Valorisation of the selectively collected organic fractions of municipal solid waste in anaerobic digestion." *Biochemical Engineering Journal* 148:87–96.
- Damanhuri, Dian Marya Novita; Enri. 2010. "Heating Value Based On Composition And Characteristics Of Municipal Solid Waste In Indonesia In Waste To Energy Concept." *Jurnal Teknik Lingkungan*.
- Governor Regulation. 2019. "Governor Regulation Number 142 of 2019 concerning the Obligation to Use Environmentally Friendly Shopping Bags in Shopping Centers, Supermarkets and Traditional Markets."
- Haushofer, Jakob. 2018. "Towards a climate-resilient Jakarta: An analysis of the resilience thinking behind Jakarta's current public policy approach to climate-related hazards." In . ÖFSE-Forum.
- Ismangoen, Moh Hadiano, Muhammad Achirul Nanda, Leopold Oscar Nelwan, I Wayan Budiastara, dan Kudang Boro Seminar. 2022. "Estimation of energy generation from municipal solid waste in the Jabodetabek Metropolitan Area, Indonesia." *International Journal of Environment and Waste Management* 30 (4): 453–71.
- Maulana, A., D. Rahmalina, L. O. M. Firman, B. M. Suyitno, E. Mahandika, D., dan Suwandi.

2021. "Analisis kinerja refuse derived fuel (RDF) dari sampah organik dan non organik dengan pendekatan simulasi software." *Jurnal Teknologi* 13 (1): 109–114. <https://doi.org/10.24853/jurtek.13.1.109-114>.
- Maulana, Gathut Imam Gunadi; Taufik Nur Isman; Ridwan Alawi; Alvian Hadinata Tambunan; Prawoto; Eka. 2023. "Study of the Potential of Refuse Derived Fuel (RDF) at the Cipayung Final Disposal Site (TPA) to Meet Industrial Quality Standards and Environmentally Friendly."
- Maulidayanti, M., M. H. Robbani, W. Wiharja, E. Hambali, D. E M. Setyaningsih, dan Yuliani. 2024. "Evaluasi produksi refuse-derived fuel (RDF) dari sampah perkotaan (studi kasus: RDF Plant di Kabupaten Cilacap)." *Jurnal Teknologi Lingkungan* 25 (2): 179–189. <https://doi.org/10.55981/jtl.2024.1008>.
- Ministry of Industry of the Republic of Indonesia. 2017. "Refused Derived Fuel (RDF) as an alternative fuel in the cement industry."
- Mulyani, Reni, dan Amalia Nur Milla. 2024. "Environmental Love Movement Through Environmental Poster Training, Waste Sorting Training and Organic Liquid Fertilizer Making." *International Journal Of Community Service* 4 (3): 222–25.
- Prihandoko, Diananto, Chandra Wahyu Purnomo, Primanda Kiky Widyaputra, dan Nasirudin. 2022. "Application of Refuse-Derived Fuel (RDF) Plant in Piyungan Landfill Municipal Solid Waste Management." *ASEAN Journal of Chemical Engineering* 22 (2): 296–305.
- Prihartanto, Prihartanto, Yulinah Trihadiningrum, Muhammad Abdul Kholiq, Arseto Yekti Bagastyo, dan IDAA Warmadewanthi. 2023. "Characterization of landfill-mined materials as a waste-to-energy source at integrated solid waste treatment facilities of Jakarta Province, Indonesia." *Journal of Material Cycles and Waste Management* 25 (6): 3872–84.
- Rahotharn, Udorn, Maneerat Khemkhao, dan Prangtip Rittichote Kaewpengkrow. 2023. "Solid waste management by RDF production from landfilled waste to renewable fuel of Nonthaburi." *International Journal of Renewable Energy Development* 12 (5): 968.
- Rini, Willia Novita Eka, dan Fajrina Hidayati. 2022. "Factors Related to Community Waste Management in Kota Baru District Jambi City in 2022." In .
- Sharma, Bhavisha, Barkha Vaish, Monika, Umesh Kumar Singh, Pooja Singh, dan Rajeev Pratap Singh. 2019. "Recycling of organic wastes in agriculture: an environmental perspective." *International journal of environmental research* 13:409–29.
- "SNI 8966:2021 Regarding Solid Fuel for Power Generation." 2021.
- Suroto; Mulyati R., A.; Sukmawani. 2021. "Analisis karakteristik refuse derived fuel (RDF) dari fraksi ringan sampah kota dengan variasi ukuran." *Jurnal Teknik Lingkungan* 22 (1): 1–8. <https://doi.org/10.35793/jtl.v22i1.109>.
- Suryawan, I Wayan Koko, I Made Wahyu Wijaya, Novi Kartika Sari, Iva Yenis Septiariva, dan Nurulbaiti Listyendah Zahra. 2021. "Potential of energy municipal solid waste (MSW) to become refuse derived fuel (RDF) in Bali Province, Indonesia." *Jurnal Bahan Alam Terbarukan* 10 (1): 9–15.