POTENTIAL OFFTAKER VARIATION OF REFUSE-DERIVED FUEL

Mohammad Ghaffary Al Fairadj

Background

Refuse-derived fuel (RDF) constitutes a fuel derivative sourced from processed domestic and commercial solid waste, wherein contaminants are removed, and its fuel characteristics are augmented. While the prevalent application of RDF in cement plants is well-established, its potential as an off-take commodity extends beyond this sector. This article delineates alternative sectors with substantive prospects for becoming RDF offtaker, with a focus on industries that align with sustainable fuel practices.

Offtaker Option

Industrial manufacturing spans diverse sectors, including paper, textiles, and chemicals, and it exhibits potential as an RDF offtaker. Incorporating RDF as an alternative fuel within these industries holds promise for advancing sustainability objectives and mitigating reliance on conventional fossil fuels.
RDF can serve as an alternative fuel in thermoelectric power plants (Prihandoko et al., 2022). RDF also has a place in electricity generation, like National Electricity Company / Perusahaan Listrik Negara (PLN), as a co-firing agent. It's already done in several power plants in Indonesia. PT Pembangkitan Jawa Bali (PJB) and PT Indonesia Power (IP) have conducted experiments in their power facilities, exploring diverse blends of local resources during their operations. These experiments encompass the use of palm kernel shells, RDF waste pellets, wood pellets, wood chips, and sawdust, with proportions adjusted based on the availability of resources. (Putra Adhiguna, 2021; Dong and Lee, 2009)

The briquette from RDF products also has potential and is already applicable as a firing agent for boilers and several industries. As an example, PT Bakti Bumi in Sidoarjo has taken the additional step of transforming their RDF product into briquettes, which can potentially serve as fuel for industrial fire tube boilers. They can sell their products to UMKM, like the cracker industry, batik industry, and other UMKM sectors that need briquette to fire their boilers (Prawitya Soemadijo et al., 2022)

The combustion of RDF generates steam, propelling turbines to produce electrical energy. This method offers an efficacious means of harnessing energy from solid waste, fostering a sustainable energy production paradigm.

Facilities engaged in waste processing can viably integrate RDF into their operational framework as a substitute for conventional fossil fuels. This diminishes environmental impact and enhances overall efficiency in waste treatment processes. Industries demanding elevated temperatures, such as metallurgy and ceramics, can adopt RDF as a viable fuel source to fulfil their thermal requisites. The utilisation of RDF in these contexts contributes to a reduction in carbon dioxide emissions and fortifies operational sustainability.

RDF emerges as a prospective energy source for installations involved in wastewater treatment processes. This integration presents a sustainable avenue, concurrently minimising environmental ramifications associated with conventional energy sources.

The petrochemical sector, encompassing the oil and gas industries, stands poised to embrace RDF as a strategic offtaker. Particularly relevant is the substitution of conventional fuels with RDF in processes involving heating and refinement, thereby aligning with overarching sustainability objectives. Community-based thermal energy systems and district heating centres represent potential adopters of RDF as a heat source, thereby addressing various energy needs, including space heating.

RDF Characteristic Comparison

It is imperative to acknowledge that the acceptance of RDF as an alternative fuel source is contingent upon regional regulatory frameworks, energy policies, and environmental consciousness. In this context, advocacy initiatives and educational endeavours elucidating the multifaceted advantages of RDF implementation, coupled with advancements in processing and distribution infrastructure, assume pivotal roles in fostering increased adoption across diverse industrial domains.

Based on the unit conversion from kilocalories per kilogram to Megajoules per kilogram, the research findings indicate that the calorific values meet the standards that could be utilised as raw material for Solid Recovered Fuel (SRF). This observation further elucidates the potential applicability of waste and solid refuse, as listed in the table, as a blend of Refuse-Derived Fuel (RDF) and SRF for use as co-firing agents in the previously investigated industries. The successful conversion underscores the feasibility of employing these waste materials in diverse industries, offering a sustainable solution for co-firing in conjunction with conventional fuels. The tabulated data provides valuable insights into the calorific properties of the waste and solid refuse, affirming their potential utility in co-incineration processes across various industrial sectors that were previously explored in the study.

In another study, the RDF product, which takes the form of briquettes, must be tested to obtain standard parameter values required for fuel or co-firing applications. The standard quality of briquettes may vary in each region due to differences in the types of waste materials used as raw ingredients, which also have the potential to be diverse. Therefore, the following are some parameters in briquettes from various locations resulting from the processing of RDF waste:

Tabel 1. Briquette Standard Quality

% Briquettes Parameter	Japan	USA	England	SNI	National Minister of Energy and Mineral Resources Regulation NO 47/2006
Moisture	06-Aug	6	03-Apr	≤8	≤ 15
Ash Content	05-Jul	16	8 – 10	≤ 8	≤10
Volatile Matter	15 - 30	19-28	16,4	≤15	according to raw materials
Fixed Carbon	60 - 80	60	75	≥77	according to raw materials
Calorific value (cal/g)	5000 - 6000	5870	4000-6500	≥5000	4400

(Jundika and Rizkiantika, 2023)

Tabel 2. RDF Characteristic

Parameter	Unit	Commercial Waste	Construction Waste	Domestic Waste
Lower Heating Value (LHV)	MJ/kg	16-20	14-15	13-16
	MWh/t	4,4-5,6	3,8-4,2	3,6-4,4
Annual Energy Content	GWh/Year	530	285-315	360-440
Water content	W-%	Oct-20	15-25	25-35
Ash	W-%	05-Jul	01-May	05-Oct
Sulfur	W-%	<0,1	<0,1	0,-0,2
Chlorine	W-%	<0,1-0,2	<0,1	0,3-1

(Jundika and Rizkiantika, 2023)

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Based on the research, the potential mixing of organic and inorganic waste in controlling its composition will influence the percentage values of parameters in the resulting RDF product. This also affects the quality of RDF that is acceptable to the industry. The importance of RDF characteristics also will influence industrial performance while making their own product from RDF usage as a supporting agent to generate energy as fuel. Here is an example of the proximate analysis of calorific values from previous research:

Table 3. Results of Calorific Value Proximate Analysis

	Sample	Analysis Parameters				
		Ash %	Water %	Volatile Matter %	Fixed Carbon %	Calorific Value (cal/g)
Research Results	95:05:00	13,404	12,205	52,423	21,968	3955,088
	90:10:00	13,765	11,469	53,523	21,216	4102,9
	85:15:00	14,681	11,215	54,465	19,459	4598,017
	80:20:00	14,699	11,984	54,537	18,78	4591,528
	Tanpe Press and adhesive	15,968	10,98	54,447	22,605	4080,237
Previous Research	Yulinah et al, 2017	0,64	12,79	85,14	1,56	8801,04
	Garcia et al, 2021	26	12,79	70,4	3,6	2724,67
	Rithy et al, 2017	7,8	11,16	72,41	9,24	5,725

(Jundika and Rizkiantika, 2023)

RDF Potential for Other Industries

As an alternative source of fuel, the products from RDF (Refuse-Derived Fuel) plants, typically consisting of RDF and SRF (Solid Recovered Fuel), have the potential for use in co-firing and as substitutes for conventional fuels promising applications. However, addressing the challenge involves adjusting parameters to ensure that RDF and SRF products align with the co-firing characteristics required for the industrial sector. For instance, in the research conducted by the Center for Research and Development of Green Industry and Environmental Research and Development Agency in 2017, several classifications of SRF have been utilised as co-incinerators across various industrial sectors, with a comparison of their parameters.

Table 4. Several SRF Standards for Industries

SRF Specifications								
Parameters for classification	Unit	Coal Power Plant	Kalsiner	Grote Burning	Fluidised feed	HOT DISC CEMENT KILN	Main burner Cement kiln	Blast Furnace (Steel Plant)
Net Calorific Value	MJ/kg	Nov-15	Nov-18	Nov-16	Nov-16	14-16	20-25	>25
Particle Size	Mm	<50	<50-80	<300	<20-100	<120	<10-30	<10
Oversize	%	0	<1	<3	<2	*	<1	0
Impurity	%b	<1	0	<3	<1-2	*	<1	0
Chlorine	%b	<1.5	<0.8	<1-0.8	<1-0.8	0,8-0,6	<1-0.8	<1
Ash	%b	<35	<10	*	<20	20-30	<10	<10

*No limitation, depends on site standard

(Pusat Penelitian dan Pengembangan Industri Hijau dan Lingkungan Hidup Badan Penelitian dan Pengembangan Industri, 2017)

Based on the provided data, the net calorific value required by Solid Recovered Fuel (SRF) to efficiently serve as a co-incinerator in these industries can be determined. These values can also serve as a reference for RDF (Refuse-Derived Fuel) plants in designing their product outcomes, whether RDF or SRF, to meet specifications. Furthermore, the research allows us to conclude that the safe calorific value for utilising SRF as a co-incinerator falls within the range of 11-25 Megajoules per kilogram (MJ/kg). These values can be converted to kilocalories per kilogram, which is a standard unit commonly used for determining the calorific value of materials. The conversion factor is 1 MJ/kg equivalent to 239.005736 kcal/kg. With these values, the research related to the calorific value of waste materials intended for RDF or SRF can be determined. The following table of the calorific values studied for the components of the generated waste:

Table 5. Calorific Value of Some Components of Waste

Garbage Components	Calorific Value (Kcal/kg)	Calorific Value (MJ/kg)
Paper	3588	15
Wood	4400	18,4
Textile	5200	21,8
Synthetic Resins	7857	32,9
WWTP sludge	1800	7,5
Rubber and Leather	7200	30,1
Plastic	8000	33,5
Process residual sludge	3000	12,6

(Nurhaliza, 2021)

RDF Potential for Electricity Generation

In the potential usage of RDF in the Electricity generation sector, there is an option to combine it as a co-firing agent. Combining RDF pellets with coal in a percentage of 5% for RDF and 95% for coal will give some parameters optimization, such as moisture content and sulphur content, in order to catch up with boiler fuel categories.reduction targets.

Table 6. Proximate and Ultimate Analysis of Coal and RDF Pellets

Analysis Parameters	Sample Marks		Unit	Basis	Standard Methods
	Coal	Coal 95% + RDF Pellets			
Proximate Analysis					
Moisture in Air Dried	17,13	14,44	%	adb	ASTM D3173
Ash	5,1	7,7	%	adb	ASTM D .3174
Volatile Matter	40,64	41,4	%	adb	ASTM D .3175
Fixed Carbon	37,13	36,46	%	adb	ASTM D .3172
Ultimate Analysis					
Total Sulphur	0,16	0,18	%	adb	ASTM D .4239
Carbon	54,34	54,03	%	adb	ASTM D.5373
Hydrogen	5,49	5,34	%	adb	ASTM D .5373
Nitrogen	0,89	0,93	%	adb	ASTM D .3176
Oxygen	34,02	31,82	%	adb	ASTM D .5374

(Soleh et al., 2019)

From the table above, combining coal with RDF pellets results in lower moisture content and sulphur content even if the moisture content is lower than only coal usage. Ash Fusion temperature testing was carried out to ensure the potential for slagging during the use of RDF pellets. The result of the operating temperature of the boiler above 900°C makes it potentially be used as a coal substitution for boiler fuel, with a low propensity of fouling and slagging.

Conclusion

Initiating the utilisation of products from RDF plants, such as co-firing products in various industries, will enhance economic value linearly, reducing the generation of waste destined for landfills. This potential needs to be continually harnessed through comprehensive studies to address off-taker issues and match the characteristics of RDF and SRF products with supply and demand. If the characteristics of processed waste in the RDF plant system can be determined, and standardised demand from each industry acting as an off-taker has been established, then aligning standards with engineering methods in RDF processing can be adjusted to meet both RDF quality and the desired specifications of the industry. The results of several studies and their applications related to RDF utilisation beyond the cement industry have proven feasible through a more comprehensive approach to the production of products from RDF plants.

To maximise these efforts, optimal collaboration and supervision from each Waste Collection Point (TPS) and TPS 3R (reuse reduce recycle) are also necessary for waste sorting. This aims to make the segregation of targeted waste for RDF more specific. Specific sorting at TPS and TPS 3R ensures optimal RDF performance in landfill areas because the sorted waste is dedicated to RDF, allowing the engineering process to achieve formulated targets effectively.

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Author
Mohammad Ghaffary Al Fairadj
Universitas Indonesia

Supervisor
Baihaqi Muhammad, Abdul Baits Dehana, and Mirmanti Cinahya W
REER Research Officers
Resilience Development Initiative

Resilience Development Initiative

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