Status Paper on Utilisation of Refuse Derived Fuel (RDF) in India

Indo-German Environment Partnership

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Foreword

Municipal Solid Waste Management (MSWM) is a global issue to urbanization and is one of the greatest challenges in finding an adequate balance between three major objectives of waste management: (a) creating a healthy living environment (sanitation), (b) restricting the contamination of water, air and soil (environment), and (c) maximizing the re-use and recycling of secondary raw materials (resource efficiency). Rapid urbanization and industrialization exacerbate the problem as they intensify the pressure on cities – on their infrastructure and the immediate environment. Against this backdrop, managing solid waste and providing basic services to the citizens has become a huge challenge for the city administrators.

One of the answers to the question of managing municipal solid waste lies in co-processing of Refuse Derived Fuel – RDF (also known as Alternative Fuel and Raw Material- AFR). RDF can be used as a fuel and raw material substitute in various energy intensive industries. It is increasingly perceived as a suitable option for MSWM in India as it is – if correctly applied – environment-friendly and resource-efficient. However, existing MSW strategies and waste management plans do not yet sufficiently consider co-processing as an environmentally-sound option and as a solution for waste management. So far, public and private sector have made limited efforts to have an overall assessment of the current practises of production and to use RDF derived from MSW.

It has been observed that co-processing of municipal waste can only be successful if the monitoring and compliance instruments are effectively applied and the environmental standards are duly enforced. Also, it is crucial that financial conditions meet the expectations of both sides - the one that owns the waste (for example, the municipalities) and the one that uses the waste in the form of RDF (for example, the cement industry).

This paper aims to undertake a compilation of the current practices of co-processing with a special focus on production and use of RDF. It also provides an overview of the legal and policy framework required for a successful application of co-processing in the context of MSWM. I hope that this paper will contribute to the dialogue that needs to be addressed with regards to MSWM and will stimulate a transparent cooperation between all relevant stakeholders involved.

Dr. Dieter Mutz
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List of Abbreviations

AFR	Alternative Fuel Resource
DPRs	Detailed Project Reports
GCV	Gross Calorific Value
HBEPL	Hanjer Biotech Energies Pvt. Ltd
HDPE	High Density Polyethylene
IGEP	Indo german Environment Partnership Program
LDPE	Low Density Polyethylene
MSW	Municipal Solid Waste
MSWM	Municipal Soldi Waste Management
NAAQ	National Ambient Air Quality Standards
PE	Polyethylene
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
RDF	Refuse Derived Fuel
SLF	Sanitary Landfill
SPM	Suspended Particulate Matter

1. Introduction

High calorific fractions from processed Municipal Solid Waste (MSW) in India are being used both in dedicated Waste-to-Energy plants and as fuel substitutes in industrial processes. However, a detailed assessment on the current modes and scale of these practices across the country has until now not been undertaken. This refers to the technology used to produce RDF, the economics driving the production and utilisation of RDF and the resultant environmental assessment information about these practices.

2. Background:

GIZ-IGEP agreed to undertake a partnership (integrated PPP) with Geocycle (Holcim Group) to explore the possibilities as well as technical, environmental and financial requirements of valorization of MSW, especially for co-processing which is understood in this context as utilising of RDF from MSW as Alternative Fuel and Raw Material (AFR) for cement Kilns.

3. Scope of the paper:

The overall scope of this paper is to undertake a compilation of the current practices of production and use of RDF in existing MSWM facilities in India, as well as to undertake an overview of the legal and policy framework of RDF production and use. This document provides this account using existing data available in-house as well as the reports available in public domain.

The structure of this paper is as listed below:

- Overview of RDF plants in India
- Technology involved in RDF production
- Characteristics of RDF
- Marketability of RDF in India
- Combustion conditions of RDF utilisation
- Environmental aspects during RDF utilisation
- Legal aspects of RDF utilisation

4. Limitations of the report

The data obtained is mainly from secondary sources which could not be verified physically by the authors. Some information's are derived from site visits of MSW processing plants and RDF end user facilities in 2010. These information are used without naming the operator and location as the data are confidential.

5. Overview of RDF plants in India

Table-1: Status of RDF Plants in India

				Processing capacity (TPD)		Status of Power Generation		
No	**Operator**	**Location**	**State**	**MSW plant**	**RDF plant**	**Implementation**	**Operation**	**Since**
1	SELCO	Hyderabad	Andhra Pradesh	No processing only RDF	500	5 MW Power Plant commissioned but now closed as it was not viable	Not in operation	2003, closed in 2005
2	Foundation for Greentech Environmental Systems	Vijayawada	Andhra Pradesh	No processing only RDF	300	5 MW Power Plant commissioned but now closed as it was not viable	Not in operation	2003, closed in 2005
3	Shriram power	Guntur	Andra Pradesh	No processing only RDF	250	RDF only	RDF was supplied to Vijayawada plant	2003, closed in 2007
4	Kochi Municipal corporation	Kochi	Kerala	400	100		Operational	2007
5	Hanjer Biotech Energies Pvt. Ltd. (HBEPL)	Rajkot	Gujarat	300	75		Operational	Jan-05
6	HBEPL	Surat	Gujarat	500	125		Operational	Aug-08
7	HBEPL	Junagarh	Gujarat	150	30		Operational	Jan-09
8	HBEPL	Vadodara	Gujarat	300	75		Operational	Mar-10
9	HBEPL	Bhavnagar	Gujarat	150	75		Operational	Apr-10
10	HBEPL	Surat Expansion	Gujarat	500	120		Operational	Aug-10
11	HBEPL	Ahmedabad	Gujarat	500	120		Operational	
12	Nashik Municipal Corporation	Nashik	Maharashtra	400	100		Operational	

				Processing capacity (TPD)		Status of Power Generation		
No	**Operator**	**Location**	**State**	**MSW plant**	**RDF plant**	**Implementation**	**Operation**	**Since**
13	HBEPL	Jalgoan	Maharashtra	150	30		Operational	Feb-08
14	HBEPL	Pune	Maharashtra	200	50		Operational	Jul-08
15	HBEPL	Vasai	Maharashtra	300	75		Operational	Nov-09
16	HBEPL	Pune Expansion I	Maharashtra	500	120		Operational	May-10
17	HBEPL	Nagpur	Maharashtra	800	200		Operational	Jun-10
18	HBEPL	Pune Expansion II	Maharashtra	500	120		Operational	Jul-10
19	HBEPL	Mira-Bhayandar	Maharashtra	350	80		Operational	Dec-07
20	HBEPL	Shankarpur	West Bengal	500	120		Operational	Jul-10
21	HBEPL	Mangalpur	West Bengal	300	75		Operational	Jul-10
22	HBEPL	Burdwan	West Bengal				Operational	
23	HBEPL	Gwalior	Madhya Pradesh	300	75		Operational	9-Dec
24	HBEPL	Faridabad	Haryana	1000	250		Operational	Aug-10
25	HBEPL	Shimla	Himachal Pradesh	120	30		Under commissioning	
26	HBEPL	Agra	Uttar Pradesh				Operational	
27	A2Z	Kanpur	Uttar Pradesh	1500	300	Planned 15MW power plant	Operational	

As per secondary data collected (2010)

As can be seen in the above table, there are quite a number of waste processing plants in India of which most produce RDF besides other products from municipal solid waste such as compost.

Investment and operation cost for these plants can in most cases only be estimated, as especially for the private plants reliable figures are not available. In general investment costs are in the range of 140 – 370 INR per ton for annual capacities of 45,000 to >500,000 tons of input MSW. The lower costs apply to larger facilities. Operation and maintenance costs are in the range of 120 – 290 INR per ton. Again lower costs apply to larger facilities. As most of the plants use the same installations for the production of the different products, it is difficult to estimate the cost that would apply only to RDF material.

Investment costs are rather low and only the processing of pre-processed material is considered.

The O&M cost seem to be reasonable and also comparable to other countries experiences considering rather low personnel cost and technical construction levels are lower than in most industrialized countries.

6. Technical aspects of RDF preparation

6.1 Typical Composition of MSW in Municipal Corporations in India

Surveys performed during the last years for preparation of DPRs in Municipal Corporations in India and the information of input material from various private plant operators showed the following general composition of MSW from Indian cities:

Table-2: Composition of MSW

	General waste components	**Mass % Content**
A.	Easily degradable	35-40
B.	Combustibles/long term degradable	15-20
C.	Recyclables/Combustible	15-20
D.	Other materials	20-25
	Grand Total	**100.00**

CPCB- 2000

Table 2 shows the large potential of Indian MSW for reutilization, either as compost or as a potential RDF material. In the end only around 20 % remains to be safely disposed on landfills[1].

[1] In some plants part of the inorganic mineral waste is used for brick manufacturing, thus reducing the rejects to landfills further.

6.2 Processing Technologies

There are a number of different processes for preparing RDF from MSW. However, all the technologies can be summarised into the following generalised process steps:

- Acceptance of segregated (separation at source) or unsegregated waste at the processing plant
- Sorting by different rotating drum or plain sieves into main fractions (biodegradable, combustible, mineral)
- mechanical separation of recyclables like metals
- Size reduction (shredding, chipping and milling)
- Separation and screening of main fractions into products
- Blending
- Drying and pelletising
- Packaging and
- Storage

Besides the legal requirement from the MSW (Management & Handling) Rules 2000, to implement separation at source, private MSW operators usually receive the unsegregated MSW at their plants, when performing processing of total MSW[2]. Furthermore, the plant operators are paid by tonnage and therefore have a better economic performance when receiving mixed waste. Plants that only process RDF need a pre-segregated MSW as input material. They justify this with their efficient sorting technologies and also with the unsatisfying separation at source.

Typically, the waste material is screened to remove the recyclable fraction (e.g. metals), the inert fractions (such as glass) and separate the fine wet putrescible fraction (e.g. food and garden waste) containing high moisture and high ash material before being pulverised. The wet organic materials can then undergo further treatment such as composting or anaerobic digestion, and can be used as a soil conditioner. This process is called the Mechanical Biological Treatment (MBT). In some cases, the putrescible fraction is kept in place to enable the mass of material to be dried through biological treatment (the process of 'dry stabilisation').
The coarse and medium fraction is usually processed as RDF and then packaged and stored. These fractions usually consist of paper, card-board, wood, non-degradable plastic, leather and textiles which are light combustibles and which are processed/ shredded in the process as RDF fluff. Depending on the need of the end user, RDF fluff is further processed in the secondary shredder and densification unit to produce RDF pellets.

The quantity of RDF produced per tonne of MSW varies depending on the type of collection, treatment process and quality requirement. Information collected from the MSW operators in India suggests that the rate of RDF production from MSW is about 30-35% by weight of waste processed. Data from the EU countries suggests that it ranges between 25% to 50% depending on the treatment process and the input material used. In Europe the stabilisation process is more common as the use of mixed waste for production of compost is banned. This leads to an RDF rate of more than 80% of the input quantity.

[2] Substantial amount of recyclable products are sorted out by theinformal sector before entering into the waste stream.

7. Characteristics of RDF

7.1 General Composition and Yield from the Production Process

The combustible fraction, consisting of paper, textile, LDPE, HDPE, diapers, sanitary napkins, rags, leather, rubber, non-recyclable plastic (if separation is not economically viable) and other non-biodegradable fraction of MSW is processed into Refuse Derived Fuel. RDF is thus a dry solid fraction usually with a high calorific value. The composition of RDF from MSW will vary according to the origin of waste material and the sorting/separation process. This will in turn greatly influence the properties of RDF such as calorific value. The important characteristics for RDF as a fuel are the calorific value, water content, ash content, sulphur and chlorine content.

Global trend indicates constantly increasing quantities of dry recyclable in the MSW that are combustible. In most of the cities with more than one million inhabitants the content of paper, jute, broken furniture, tree twigs, textiles, plastic etc is between 20 to 30% by quantity. These wastes have moisture content of < 20% and calorific value of > 2000 Kcal/kg. Overall bulk density of this waste is 200 to 300 kg/m^3. But the contents of the raw material input into RDF is not really documented.

7.2 Physical Characteristics of RDF Material

Regarding the physical characteristics of the RDF material produced by private waste processing plants, some data exists from private companies (HBEPL, GRASIM Industries, etc.) which is however partly confidential. The detailed compositions are not published, but as per standards following comments can be made on the composition:

- Hanjer Biotech HBEPL states that the RDF material produced in their plants is usually devoid of PVC, material which is picked up by the recyclers.
- At some plants plastics, such as PE or PP can be separated by mechanized equipment to be used as secondary raw material.

End users of the material are small and medium enterprises with a demand of process energy (e. g. textile and paper factories).

Table 3: Properties of RDF derived from municipal waste

	GRASIM Industries (Jaipur)		HBEPL
Parameters	Before treatment	After treatment	
Feed (tph)	42	13	
Calorific value (kcal/kg)	1500	3000-3500	3200 – 3900
Moisture content (%)	20-40 (max)	10-20	20 – 25
Bulk density (t/m3)	0.5	0.2	0.2 – 0-3
Feed size (mm)	1000 (max)	0-50	50
Ash (%)			13 – 15
Dust (%)			< 0.3
Plastic (%)			4 – 6

As per secondary data collected (2010)

7.3 Chemical Characteristics

A study by Dr. Pawan Sikka from Department of Science & Technology, Government of India on RDF pelletization shows results of RDF pellets from a pilot plant at Mumbai with the following results:

Table-4: Results of Study on physical/chemical conditions of RDF pellets

Moisture:	3.0% - 8.00%
Mineral matter:	15.00% - 25.00%
Carbon:	35.00% - 40.0%
Hydrogen:	5.00% - 8.00%
Nitrogen:	1.00% - 1.50%
Sulphur:	0.20% - 0.50%
Oxygen:	25.00% - 30.00%
Size:	dia 8/20/30 mm, length 8-40 mm
Calorific value:	4000 Kcal / Kg (minimum)
Bulk density:	0.7 MT per cu.m.
Density:	1.3 gm per cc. (minimum)
Ash content :	< 15%

Dr. Pawan Sikka (Department of Science & Technology)

Some of the above results do not correspond with the findings displayed above and have to be considered with care (moisture, oxygen, density).In order to have a rough idea and compare with the studies in EU, the chemical composition of RDF from domestic source is given:

Table-5: Quality of RDF from household

RDF source	Calorific value) Kcal/kg	Ash residue (% w)	Chlorine content (% w)	Water content (% w)
Household waste	2866- 3822	15-20	0.5-1	10-35

Source: Data reported for Finland in the WRc Ref: CO5087_4, July 2010

8. Marketability of the RDF in India

The RDF in India is usually sold by the MSWM operators to industrial units as alternate fuels to coal and fire wood. The usual customers of RDF are textile units, dyeing units, industrial boilers, hot air generators etc. The consumers of RDF use them to produce thermal energy and are situated in rather close proximity to the production of RDF.

Difficulties in marketing RDF originate from bad or not stable qualities of the product (limitations are due to odour/foul smell and variation in GCV of the RDF). Since a couple of years, private MSW companies are establishing plants that follow a stringent process. These companies intend to establish RDF as an alternative fuel to coal especially and experience an emerging market due to stable quality and price advantages.

According to information from the MSW plant operators the current market prices of RDF are in the range of Rs 2700 to Rs 3000 per ton. The RDF sold in current retail market has a GCV from 3200 - 3800 kcal/kg. As the normally used coal is of rather low quality (GCV only around 50% of the RDF) the lower cost of the coal (1500 – 1800 Rs/ton) is more than compensated by the better quality of the RDF. This makes it financially attractive for the end users.

9. Legal aspects of RDF utilisation

The MSW Handling Rules 2000 are the only legal document describing guidelines for incineration of MSW. They only describe standards for flue gas after incineration. Binding documents for definition of permissible input materials or the utilisation of RDF do not exist. Table 6 below shows a comparison of the existing MSW (M&H) Rules, 2000 with the standards existing in Germany/Europe for incineration of MSW.

Table-6: Standards for Air Emissions for Incinerators

Contaminant	**Directive 2000/76/EC**	**17.BimSchV**[2]	**MSW Rules 2000**
Org. Subst. (C-total.)		10	
CO		50	
HCl	10	10	50
HF	1	1	
SO_2	50[3]	50	100
NO_x	500/800	200	450
SPM	30	10	150
Dioxines & Furans	0.1 ng TE	0.1 ng TE	
Cd + TI	0.05	0.05	
Hg	0.05	0.03	
Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	0.5	0.5	
TOC	10[3]		
Minimum temperature		850 centigrade	
Retention time		More than 2 seconds	
Reference value for flue gas oxygen content		11% by volume	
Reference value for flue gas oxygen content for waste pyrolysis/ gasification/ waste oil		3% by volume	

1. Directive 2000/76/EC of the European Parliment and Council of 4 December 2000 on incineration of waste
2. 17. German Federal Immission Protection Ordinance, (BMU,2009)

The table 6 shows that the Indian guidelines are not complying with modern international standards. Confidential interviews with end users of the RDF material showed that they were satisfied with the material but were lacking broader knowledge on the senstive issues of incineration of fuel derived from waste. The incinerators are of rather simple design and lack efficient cleaning procedures. Random assessment of sample analysis protocols showed that not all parameters according to the MSW Rules were fulfilled (e.g. SPM).

Toxic contaminants created by incineration of waste like dioxines are not analysed at all. The Indian waste can of course currently not be compared with waste from industrialized countries, like Germany. It can be assumed that the chlorine contents are much less from the origin due to a generally lower income situation and thus less use of chlorine containing goods such as PVC. Moreover, the informal waste pickers select PVC very thoroughly out of the collected waste. Nevertheless, emissions of highly toxic compounds such as dioxins and furans cannot be completely ruled out. As the incineration conditions for many small RDF users are still on a rather low technical level, a detailed assessment of the emissions from RDF utilisation in small and medium facilities where co-combustion is being practised is recommended.

The legal situation can be summarized as follows:

- RDF projects work within the framework of MSW Rules 2000.
- RDF based power projects come under the purview of Electricity Act 2003.
- RDF facilities are also governed by the umbrella acts like Air Act, Water Act and Environment Protection Act. These facilities also have to obtain the consent of Establishment and Consent for Operation licenses from the State Pollution Control Boards.
- The emission standards are specified by the State Pollution Control Board as per the NAAQ 2009
- RDF projects require Environmental Impact Assessment (EIA) and Clearence.
- The industrial units utilising RDF as fuel also have to adhere to the laws applicable, which are Air, Water and Environment Protection Acts. Compliance with the emission standards of stack have to be monitored once in a year and submitted to the State Pollution Control Board. The cement kilns using RDF also come under the purview of all the above acts and in addition other special notifications like Hazardous Waste Rules.

There are no specific guidelines or Rules for RDF in India. However, in Europe, there is a separate directive for RDF.

10. Conclusions:

The total waste quantity in India is about 600,000 tons per day (6.0 lakhs MT/d). Assuming that 20% can be utilised as RDF, this translates to 120,000 tons per day (1.2 Lakh MTD) of RDF fuel. This can theoretically effect a substitution of 240,000 tons (2.4 lakh MT) of coal every day, assuming a 50% lower GCV of coal compared to RDF. A power potential of 15,000 MW exists if all the RDF can be utilised in India but this will account for approximately 2-4 % of the total energy demand of the country.

According to statements from MSW operators the quality of RDF in India is different from EU and other western countries and therefore the emissions at the end users are well within the permissible values. There are however no comprehensive analyses available on actual and potential emissions of combustion of RDF in India to substantial this claim. This is an important issue, as probably the majority of the boilers and incinerators have very low incineration temperatures and insufficient flue gas cleaning equipment.

The legal requirements for incineration of RDF (or waste in general) in India are rather low and only consist of few parameters. To avoid potential generation of hazardous chemical byproducts from the incineration process and emission of the other toxic compounds, the following activities are recommended:

- A thorough analysis of the quality of RDF product including contents of chlorines and other potentially harmful waste components

- A quality control and monitoring guideline for MSW as input for RDF production and utilisation of the end product

- Standards for utilisation of RDF as end product to generate electricity with description of incineration process requirements and flue gas cleaning as well as ash disposal/utilisation requirements.

- A monitoring program for the utilisation of RDF for electricity generation and/or fuel substitution.

- The Financial Sustainability of RDF plants also needs to be assessed as the capital costs are fairly high for setting up an RDF uinit.

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