

Guidelines on Usage of Refuse Derived Fuel in Various Industries

July 2018

PREPARED BY

Expert Committee Constituted by Ministry of Housing and Urban Affairs (MoHUA)

CENTRAL PUBLIC HEALTH AND ENVIRONMENTAL ENGINEERING ORGANISATION (CPHEEO)

Ministry of Housing and Urban Affairs
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Executive Summary

To achieve the objectives of a clean India under Swachh Bharat Mission by October 2019 and to ensure the compliance of Solid Waste Management (SWM) Rules 2016, several initiatives have been taken by the Government to ensure scientific processing and disposal of municipal solid waste (MSW). However, MSW management has been the biggest challenge faced by Urban Local Bodies (ULB), not only because of their limited resources and technical capabilities, but because of the characteristics of Indian Waste and old set practices of dumping mixed waste.

Within MSW management, processing of several fractions that are combustible in nature but are not recyclable such as soiled paper, soiled cloth, contaminated plastics, multi-layer, packaging materials, other packaging materials, pieces of leather, rubber, tyre, polystyrene (thermocol), wood etc. has remained a challenge and these fractions unwantedly ends up at landfill sites. These fractions can be processed and converted to refuse derived fuel (RDF) which can be utilised as alternative fuel in various industries in line with the principle of waste to wealth.

To implement the usage of MSW based RDF, an Expert Committee was constituted by Ministry of Housing and Urban Affairs (MoHUA) in October 2017. The overall objective is to recommend the norms and propose regulatory and fiscal incentives for utilisation of RDF in various industries for meeting the objectives of Swachh Bharat Mission.

This report provides an insight of various aspects covering existing policy framework, comparative analysis of potential usage in different industries, global scenarios and Indian best practices. It is found that sound policy framework exists for RDF as SWM Rules 2016 recommends the following:

i. **Clause 15(v)b** under Duties and responsibilities of local authorities and village Panchayats of census towns and urban agglomerates, it is mentioned that *"waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste-based power plants or cement kilns"*

ii. **Clause 21:** Criteria for waste to energy process - (1) Non-recyclable waste having calorific value of 1500 Kcal/kg or more shall not be disposed off on landfills and shall only be utilised for generating energy either through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel. (2) High calorific waste shall be used for co-processing in cement or thermal power plants.

iii. **Clause 18:** Duties of the industrial units located within one hundred km from the refused derived fuel and waste to energy plants based on solid waste state that *"All industrial units using fuel and located within one hundred km from a solid waste based refused derived fuel plant shall make arrangements within six months from the date of notification of these rules to replace at least five percent of their fuel requirement by refused derived fuel so produced."*

The report also identifies estimated quantity of MSW based RDF and maps the cement plants and MSW processing facilities across country.

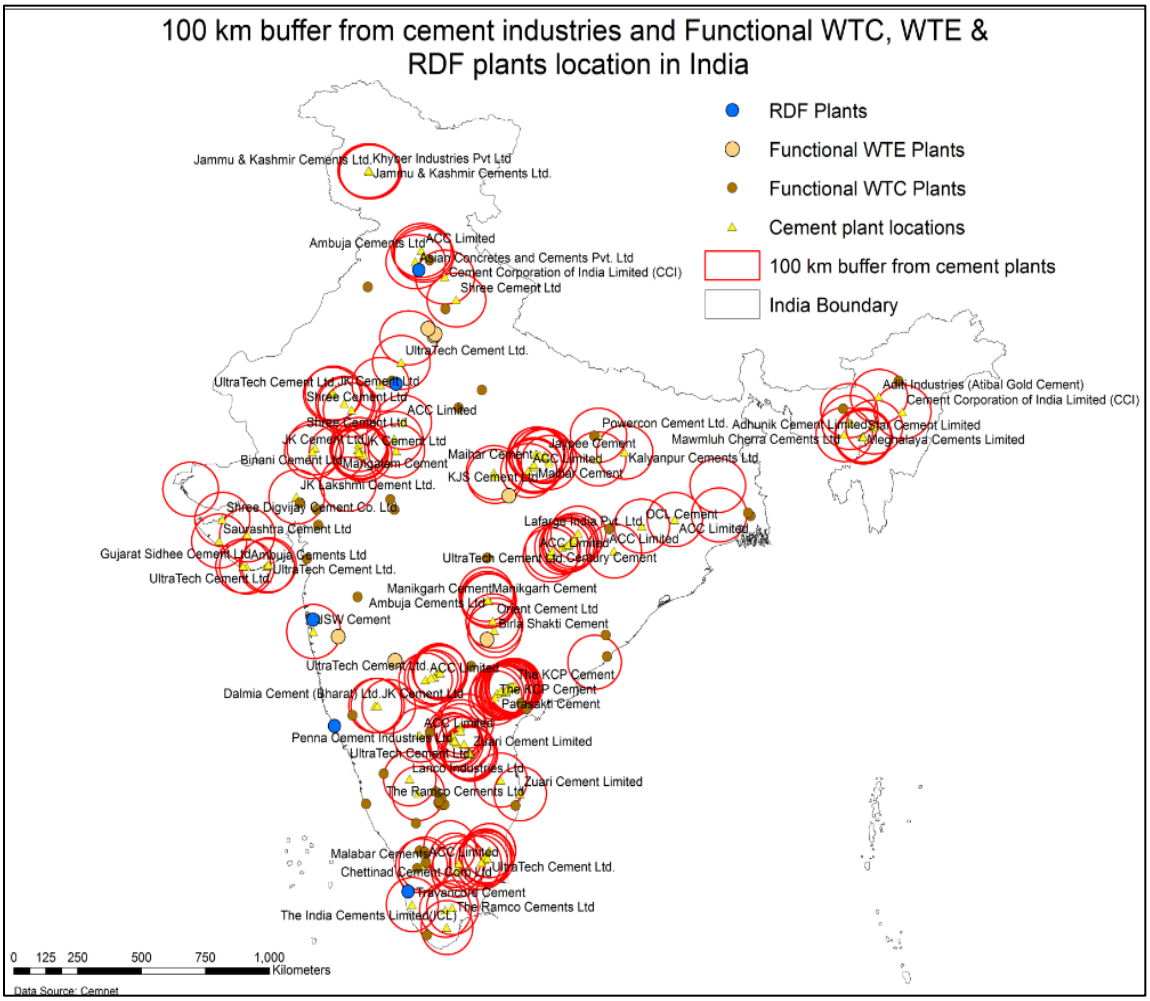


Figure 1. 100 km buffer from cement industries and Functional Waste to Compost, Waste to Energy and RDF plants location in India

The challenges, opportunities and required support for private sector engagement especially from waste management and cement industry have been taken into account through extensive stakeholder engagements.

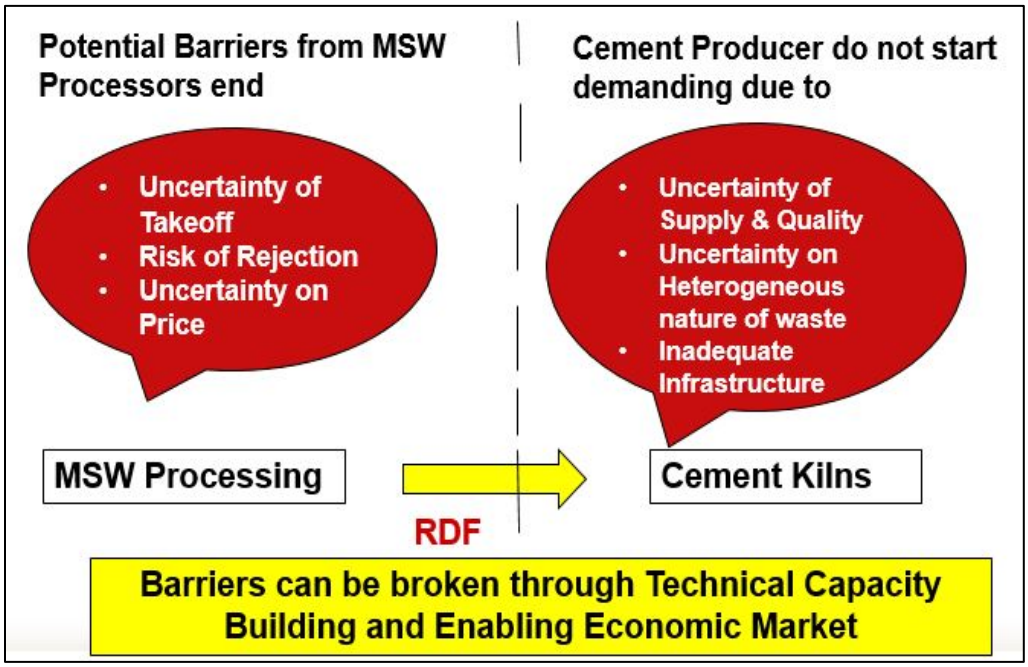


Figure 2. Challenges for RDF Usage in Cement Plants

The waste management hierarchy and resource recovery principles, the safeguards to ensure recycling and positive role of informal waste workers are covered by defining the processes, roles and responsibilities.

To make a viable business model, the financial needs, gaps and instruments for fiscal incentives are defined. To define the roles and responsibilities of key stakeholders, model tender documents along with long term tripartite agreement between urban local bodies, segregated combustible fractions (SCF) / RDF producer and cement plants have been provided and uploaded on the Swachh Bharat Mission (Urban) website.

Finally, the report presents the following norms for SCF and RDF for utilisation in waste to energy plants and cement industry duly confirmed by Cement Manufacturing Association.

S. No	Parameters	SCF	RDF - Grade III	RDF - Grade II	RDF -Grade I
1.	Intended Use	Input material for the Waste to Energy plant or RDF pre-processing facility	For co-processing directly or after processing with other waste materials in cement kiln	For direct co-processing in cement kiln	For direct co-processing in cement kiln
			Grade III	Grade II	Grade I
2	Size	Anything above 400mm has to be mutually agreed between Urban Local Body/ SCF Supplier and Cement Plants.	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively		
3	Ash – maximum permissible	<20 %#	<15 %	<10 %	<10 %
4	Moisture – maximum permissible	<35 %	< 20%	<15 %	<10%
5	Chlorine – maximum permissible	< 1.0 % #	< 1.0 %	< 0.7	< 0.5
6	Sulphur – maximum permissible	<1.5 % #	<1.5 %		
7	* Net Calorific Value (NCV) – in Kcal/kg (Average figure of every individual	> 1500 KCal/kg net	>3000 KCal/kg net	>3750 KCal/kg net	> 4500 KCal/kg net

	consignment)				
8	Any other parameter	SCF – any offensive odour to be controlled. **	RDF – any offensive odour to be controlled.	RDF – any offensive odour to be controlled.	RDF – any offensive odour to be controlled.

Note Before: All figures are vetted by Cement Manufacturing Association (CMA)

 # If blending process is done in cement plants, the deviations in recommitted limit for ash, chlorine and sulphur content can be mutually agreed between urban local body /SCF Supplier and cement plants.

** band width of variations acceptable in NCV can be mutually decided between RDF manufacturer and cement plants.*

*** Since odour is still largely a matter of perception and there is no satisfactory equipment to measure different types of odour, no quantitative figure has been given.*

For initiating the RDF usage in cement industry, the Committee Members agreed that different RDF types have different calorific values, and so the cost of each combustible fraction have to be expressed in INR per 1000 Kcal/kg to be comparable. The commercial acceptability of properly processed RDF was agreed at Rs. 0.4 per 1000 Kcal/kg by the members with reference to the specifications as defined in the report. The acceptable prices of the respective grades of RDF work out to following:

Unit	SCF	RDF Grade III	RDF Grade II	RDF Grade I	Industrial Coal
Kcal/Kg	1500	3000	3750	4500	3000-4200
INR/Ton	600	1200	1500	1800	4500

The mentioned price would be for the <50 mm size material that is suitable for In Line Calciner (ILC). For Separate Line Calciner (SLC), the same will be cheaper and can get negotiated between the RDF operator & the Cement plant. Since nature, quality and acceptability of SCF by cement plants will be very much dependent upon the segregation and quality control at the ULB level and its utilization feasibility also will be plant specific, the commercial terms related to transaction of SCF between cement plant and ULBs can be negotiated between them on case to case basis. However, the most sensitive part of the RDF / SCF cost i.e. transportation up to 100 km will have to be borne by the Cement Plant concerned..

Overall, once RDF of the quality/specifications is made available on dependable basis, within the transport influence zone of 100 km of a cement plant, market forces would take over where the ULB, the RDF processors and cement plants would negotiate an agreeable cost of RDF considering various factors. Therefore, the above indicative price may prove to be indicative over the time and market forces will govern the price determination.

To further increase the utilisation of MSW-based RDF, key recommendations along with responsibilities of different stakeholders are summarised below:

S. No	Recommendations	Responsibility
1.	Modification in SWM Rules 2016 **Existing Clause** in section "Duties of the industrial units located within one hundred km from the RDF and Waste to Energy plants based on solid waste" All industrial units using fuel and located within 100 km from a solid waste-based RDF plant shall make arrangements within six months from the date of notification of these rules to replace at least 5 % of their fuel requirement by RDF so produced. **Modification in Clause** in section **"Duties of the industrial units especially Cement Plants and Waste to Energy Plants for usage of Segregated Combustible Fractions (SCF and/or RDF"** The cement plants located within 400 km from a solid waste-based RDF plant shall make necessary arrangements within six months from the date of amendment of these rules to replace at least 5% of fuel intake (equivalent calorific value/Thermal Substitution Rate) by Municipal Solid Waste based SCF and/or RDF. The transport cost for SCF/RDF up to 100 km from the cement plant shall be borne by cement plant however, beyond 100 km cement plant can transport at its own cost or ULBs as mutually agreed upon by the parties.	MoEF&CC
2.	To ensure processing of segregated combustible fractions (SCF) in existing and proposed MSW plants, ULB shall manage necessary investment either by themselves or through private company selected through competitive bidding process on agreed terms and	MoHUA through State Urban Development

	conditions. The Swachh Bharat Mission funds may also be utilised in setting up such plants.	Departments/ ULBs
3.	Model Tender Documents and tripartite agreement between urban local bodies, SCF/ RDF manufacturer and Cement plants are placed in Annexure I for guidance and uploaded on the Swachh Bharat Mission (Urban) website.	ULBs to lead conclusion of agreement with, SCF/ RDF manufacturer and Cement plants.
4.	To ensure financial viability of usage of MSW based SCF and RDF, the following guiding principles are suggested: (i) The capital cost for setting up SCF/ RDF processing plant shall be managed either entirely/ partly by ULB through Swachh Bharat Mission Funds/ its own funds/ private sector. (ii) SCF/RDF shall be lifted by Cement Plant /Waste to Energy plant on the terms and conditions mutually agreed by the parties on the lines of model agreements in the Report. (iii) The Cement Plant will pay for SCF/ RDF to ULB at mutually agreed Rates on the basis of caloric value of RDF/ SCF and other quality factors on the lines or cost per 1000 Kcal/kg indicated in the report.	State Urban Development Department, ULB and Cement Plants
5.	To reduce the dependence on cement plants, MoHUA may consider supporting applied Research and Development for conversion of RDF to liquid/solid/ gas fuel or other innovative options with potential replication in the form of 2-3 pilot plants. If successful, this will open up additional avenues for RDF utilisation.	MoHUA through SBM or may contact Department of Science and Technology.

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List of Abbreviations

AFR	Alternative Fuels and Raw Materials
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
CMA	Cement Manufacturers Association
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSI	Cement Sustainability Initiative
ETP	Effluent Treatment Plant
MNRE	Ministry of New and Renewable Energy
MoHUA	Ministry of Housing and Urban Affairs
MSW	Municipal Solid Waste
MTPA	Million Tonnes Per Annum
NCV	Net Calorific Value
PCC	Pollution Control Committee
RDF	Refuse Derived Fuel
SCF	Segregated Combustible Fraction
SOP	Standard Operating Procedures
SPCB	State Pollution Control Boards
SWM	Solid Waste Management
SWOT	Strengths, Weaknesses, Opportunities and Threats
TPD	Tonnes per day
SDF	Treatment, Storage and Disposal Facility
TSR	Thermal Substitution Rate
ULB	Urban Local Bodies
WBCSD	World Business Council for Sustainable Development

1. Introduction

To achieve the objectives of a clean India under Swachh Bharat Mission by October 2019 and to ensure the compliance of Solid Waste Management (SWM) Rules, 2016, several initiatives are being taken by the Government to ensure scientific processing and disposal of municipal solid waste (MSW). Various processing technologies like waste to energy and composting are being supported through regulatory and financial incentives in the form of preferential normative tariff for solid waste-based waste to energy plants of INR 7.04/kWh and INR 7.90/KWh for RDF based plants as well output based market development assistance of INR 1,500 per ton of compost.

However, processing of several fractions of MSW that are combustible in nature but are not recyclable – such as soiled paper, soiled cloth, contaminated plastics, multi-layer, packaging materials, other packaging materials, pieces of leather, rubber, tyre, polystyrene (thermocol), wood, etc. has remained a challenge that unnecessarily end up at the landfill site. These fractions can be processed and converted to refuse derived fuel (RDF) which can be utilised as alternative fuel in various industries in line with the principle of waste to wealth.

Various challenges faced in mainstreaming of RDF generation and utilization is presented below:

1.1. Waste Generation

In India, the generation of municipal solid waste (MSW) is growing by 5% annually[1]. Of the 1.2 billion people in India, 377 million live in urban areas and generate approximately 62 million tonnes of MSW annually, which is expected to increase to 165 million tonnes by 2031. The greenhouse gas emissions are expected to grow from 19 million tCO2e to 41 million tCO2e annually in a business as usual (BAU) scenario by 2030. Waste generation rates vary across urban cities from 349 grams per capita per day in smaller cities with a population of below 100,000 to 485 grams per capita per day in bigger cities with a population of more than 5 million[2].

Management of such huge amount of MSW in the country has emerged as a severe problem not only because of the environmental, hygienic and aesthetic concerns but also because of the sheer quantity of waste generated every day that needs to be collected, transported, treated and disposed. Enormous pressure on limited land resources further aggravates the issue.

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[1] According to the Ministry of Finance (2009), the rate of growth of waste generation is 5% while the World Bank estimates that the rate of growth of urban population is 2.38%.
Source: Government of India: Ministry of Finance (2009): Position Paper on the Solid Waste Management Sector in India, New Delhi, http://www.indiaenvironmentportal.org.in/files/ppp_position_paper_solid_waste_mgmt.pdf.

[2] Rajendra Kumar Kaushal, George K. Varghese and Mayuri Chabukdara, "Municipal Solid Waste Management in India – Current State and Future Challenges: A Review", International Journal of Engineering Science & Technology (IJEST), Vol. IV, No. 4, April 2012, pp. 1473-1489.

1.2. Challenges of Processing and Disposal

In India, MSW management falls within the purview of the state and local government. The activities are delegated to Urban Local Bodies through state legislations. MSW management is part of public health and sanitation and is delegated to the Civic Bodies for execution as per the respective Corporation/Municipal/Panchayat Acts. Central government provides rules and advisories for solid waste management. The revised Solid Waste Management Rules (2016) contained directives for all ULBs to establish a proper system of waste management and furnish an annual report to the State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) eventually reaching the Central Pollution Control Board (CPCB).

According to CPCB (2015), processing/treatment and scientific disposal of MSW is the weakest link of SWM as only 22-28% of generated waste is processed and treated. The Planning Commission Task Force Report on Waste to Energy (May 2014) estimated that if the generated MSW continues to be untreated it will require 3, 40,000 cubic metre of landfill space everyday (1240 hectare per year) for a filling height of 10 metre height waste pile. Considering the projected waste generation of 165 million tonnes by 2031, the requirement of land for setting up landfills for 20 years could be as high as 66,000 hectares of precious land, which our country cannot afford to waste. Further, it is observed that in majority of compost plant facilities, combustible portion often lands in landfills with inerts, thereby, consuming more space of landfill apart from wastage of combustible fraction of waste.

1.3. Challenges of Processing Combustible Fractions

The Solid Waste Management Rules, (SWM) 2016 suggest various technologies for treatment of MSW considering waste hierarchy principles (see figure 3) and waste characteristics. Though waste composition also varies widely across India, the biodegradable components of waste (including food and garden waste) make the major proportion of waste. The typical characteristics of mixed waste are summarized in figure 4.

It is to be mentioned that in India, the general practice by households is to segregate high worth recyclable materials (like newspapers, plastic bottles, glass, metals etc.) and sell it to *Kabariwalas* (itinerant waste buyers) on direct payment. Recyclables of less value (torn paper, plastic pieces, glass pieces, metal pieces etc.) are mixed with MSW.

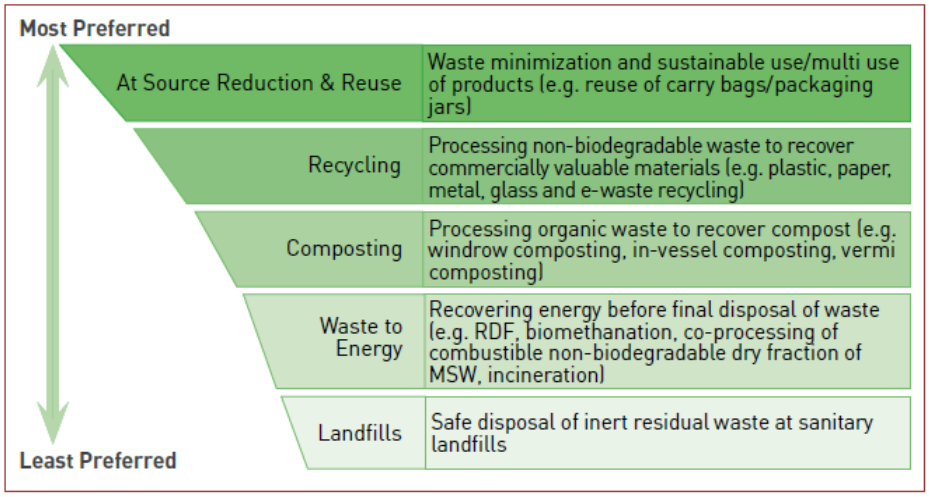


Figure 3: Waste management hierarchy (Source: MoHUA and CPHEEO, 2016)

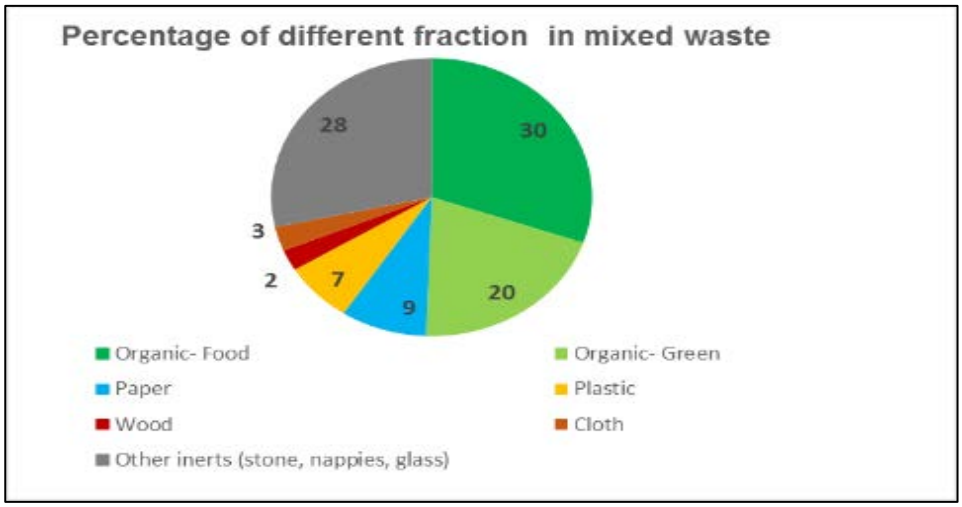


Figure 4: Various fraction in mixed MSW (Source: Indian Waste NAMA Report)

Recycling in India is largely carried out by the informal sector. The informal sector consists of waste pickers, itinerant waste buyers, dealers and recycling units. The recyclables collected by waste pickers are sold to small, medium and large dealers. The dealers sell it directly or through large scale dealers to recycling units. As per an estimate, the informal sector recycles 20% of the recyclable component of MSW collected in India.[3] It has to be mentioned that this number excludes the amount of waste recycled from MSW prior to collection, which is commonly not accounted for and can amount to four times the quantity

[3] Annepu, R. K., 2012, Sustainable solid waste management in India. Columbia University, New York, 2(01).

recycled from officially collected MSW. This implies an estimated overall recycling of 56% of recyclable waste generated.[4] The waste management hierarchy also recognizes material recovery from waste or recycling as one of the most prioritized means of waste handling. After recycling, the technology options can be broadly divided into treatment options for the combustible and the biodegradable fraction.

The biodegradable components of waste have been processed in India for several decades through various composting methods like windrow, vermi and home composting, etc. The segregated organic waste of vegetable and fruit markets and other bulk waste generators are also processed through bio-methanation and other suitable technologies. However, the combustible non-recyclable fraction of waste remains a challenge for processing and often finds its place in landfills along with inerts. This includes, different end of life of products having combustible characteristics like non-recyclable packaging waste, mattresses, soiled textiles, papers, etc. This combustible fraction constitutes around 17-20% of total MSW generated. This material can be further processed to make fuel called refuse derived fuel (RDF) and can be used for co-processing and in waste to energy plants.

The subsequent sections detail out the possible solutions for scientific disposal of this non-recyclable combustible fraction.

[4] Annepu, R. K., 2012, Sustainable solid waste management in India. Columbia University, New York, 2(01).

2. Scope and Objective of the Report

To work towards achieving the objectives of a clean India under Swachh Bharat Mission, Ministry of Housing and Urban Affairs (MoHUA) constituted an Expert Committee in October 2017 to prepare "Norms for Refuse Derived Fuel from Municipal Solid Waste for its utilisation in cement kilns, waste to energy plants and similar other installations" for enhancing the use of MSW based RDF in various industries in compliance with the SWM Rules, 2016.

The role of the Committee is to come up with recommendations for promoting the use of MSW based RDF for co-processing in various industries. The recommendations broadly cover the following:

a) The existing policy framework for use of RDF
b) The strength-weakness-opportunity-threats (SWOT) analysis of co-processing
c) Comparative analysis of use of MSW based RDF in various industries
d) Potential for use of RDF
e) Global perspective on co-processing
f) Standards for RDF
g) Suggest, measures for operationalisation of standards
h) Suggest incentives and guidance for stakeholders

The overall objective is to recommend the norms and propose regulatory and fiscal incentives for utilisation of RDF in various industries for meeting the objectives of Swachh Bharat Mission. The committee also deliberated the factors which might influence the sustainability of co-processing of waste in cement kilns as a business model, considering the issues and challenges in the supply chain framework in India in view of the canonical pillars of sustainability.

PART A: RDF Standards

3. Co-Processing Solid Recovered Fuel (SRF)

Co-firing coal with biomass and/or SRF has increasingly been considered as a way to decrease reliance on coal and its associated impacts. Co-firing can be achieved via three main options: direct co-firing; parallel co-firing; and indirect co-firing. The potential environmental benefits of using SRF and/or biomass as a fuel in industries are improved carbon emissions and reduction in other types of air pollutants owing to their low nitrogen and sulphur contents.

3.1. Global Experiences of Co-processing of Solid Recovered Fuel

Within each member state of the European Union, SRF production and application is more or less established. SRF and RDF are traded like a commodity across borders. Since handling SRF in different sort of furnaces requires a comprehensive regulatory framework, it is not surprising that Western and Central European states are the frontrunners in this regard. Many developed countries have been operating co-processing plants since the 1970s.[5] Due to lack of facilities to absorb the SRF and RDF and concurrent high landfill taxes, countries like UK and Ireland export SRF and RDF to Netherlands and Germany. Currently Germany imports around 1.6 million tonnes, almost 50% thereof from UK. The thermal substitution rate within the cement industry across the globe and leading countries in co-processing can be concluded from Figure 8. Commendable work done in some countries is given below.

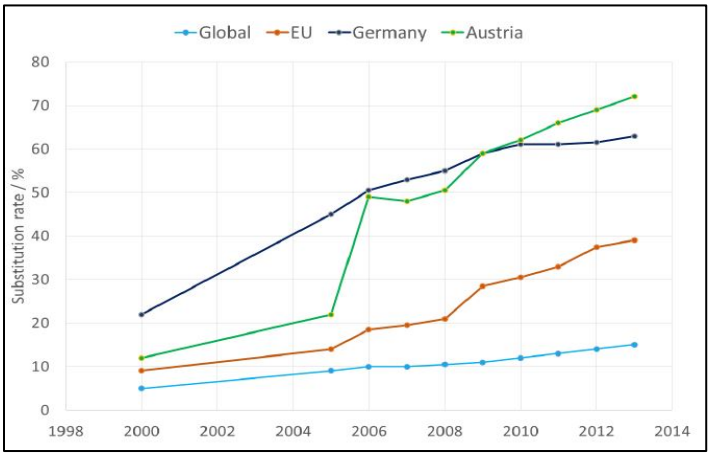


Figure 5: Thermal substitution by alternative fuels in the cement industry[6]

[5] International Best Practices for Pre-Processing and Co-Processing Municipal Solid Waste and Sewage Sludge in the Cement Industry, A Hasanbeigi - 2012 https://china.lbl.gov/sites/all/files/co-processing.pdf, accessed on 10 April 2018

[6] http://www.vivis.de/images/Konferenzen/BAEK/2016/2016_EaA_Sarc.pdf

3.1.1. **Germany**

In Germany until 2005, landfilling was an option available for waste disposal. It was banned in 2005. Before the landfill ban was approved in 1993, almost no SRF was produced in Germany. In the meantime, between 1993 and 2005, the regulatory framework was complemented by a set of recycling regulations and the SRF/RDF production got increasing support. Owing to the lack of treatment and recycling capacity, prices for incineration started soaring. Consequently, other treatment options were promoted and the mechanical biological treatment (MBT) which included the production of SRF (and/or RDF). Driven by commercial considerations, potential SRF off-takers such as power plants, steel mills and cement factories accepted SRF along with asking for supplier's charge which was as high as 30 to 50 €/ton (Rs. 2400-4000 per ton) SRF during peak times. Current user charges for SRF are in the range of -20 to 20 €/ton (minus means that the supplier is paid; (-ve) Rs. 1600) which, of course, is still subject to the location of the supplier and the off-taker, and hence is depending on the market. The German government has approved plans to abandon lignite-based power generation which is another factor in favour of SRF/ RDF. By 2008, Germany had replaced 54% of its conventional fuel used in the cement industry with RDF, and Netherlands had replaced more than 80%.

Some of the German cement plants have reached a 100% substitution rate of fossil fuels already. **It has to be noted though that besides SRF alternative fuels does also include other fuels.**

3.1.2. **Poland**

Like the German framework, the Polish SRF market was also driven by the regulatory framework which was complemented by the EU directives before and after the accession to the European Union which happened in 2004. In Poland, the use of alternative fuel sources for industrial processing experienced a rapid growth in the last two decades making the cement industry (where 20% of MSW gets converted to RDF) the largest contributor to the country's waste reduction targets.[7] This trend can be explained mainly by two key factors:

(i) Increased regulations and taxes on waste management: To conform to relevant European Union directives, Polish waste regulations were steadily enforced since the 1990s (e.g. Waste Framework Directive, Waste Incineration Directive, Landfill Directive). These entailed the multiplication of state taxes on landfilling MSW and a landfilling ban on separately collected combustible waste in 2013 which put

[7] WBCSD, 2014, The Cement Industry – Creating solutions for sage resource-efficient waste management, report.

increased pressure on waste management companies to invest in alternative solutions. At the same time, subsidies from the European Union and domestic funds facilitated the creation of necessary infrastructure, for instance, implementation of waste shredding lines for RDF production.[8]

(ii) Willingness of private sector: Prompted by the new tax regulations, Polish waste management companies extensively invested in co-processing infrastructure. Additionally, the cement industry in Poland actively encouraged waste management companies to develop facilities that treat MSW to produce RDF. In some cases, these investments were shared between cement plants and RDF preparation plants and new partnerships between local entrepreneurs, international companies and investment funds emerged. Long-term contracts between waste management companies and cement industry further ensured planning security which fostered an investment-friendly environment.

The current thermal substitution rate of Poland's cement industry is currently above 60% – with some cement plants using up to 85% alternative fuels – out of which 70-80% is of MSW origin (the remaining alternative fuels are used in tyres and sewage sludge). This rate is far exceeding the global and EU average.[9, 10] The cement industry is the largest consumer of processed waste as a fuel in Poland, with currently 1.5 million tonnes annually – a number which is expected to further increase to 2 million tonnes in coming years. It is projected that the cement industry will absorb around one third of the total expected future RDF processing capacity in Poland.[11] To remain competitive, Polish cement plants are investing in new technologies and innovative solutions to further decrease RDF preparation costs and strengthen the use of less-prepared waste.[12] In 2016, an estimated 1 million tonnes of coal was replaced by RDF in Poland's cement production accounting for an emission reduction of 2.5 million tonnes of CO_2 per year.[13]

The changing regulatory environment exemplifies what may happen in India if rules and regulations on solid waste management are enforced.

8 IFC, 2017, increasing the use of alternative fuels at cement plants: international best practices, report.

9 Ibid.

10 Ecofys, 2016, Market Opportunities for use of alternative fuels in cement plants across the EU: Assessment of drivers and barriers for increased fossil fuel substitution in three EU member states: Greece, Poland and Germany.

11 Ibid.

12 IFC, 2017, increasing the use of alternative fuels at cement plants: international best practices, report.

13 Ecofys, 2016, Market Opportunities for use of alternative fuels in cement plants across the EU: Assessment of drivers and barriers for increased fossil fuel substitution in three EU member states: Greece, Poland and Germany.

3.1.3. **Austria**

Co-incineration of plastic-rich SRF has become an important tool in waste management in Austria. Lafarge Austria first began to use alternative fuels in one of its plant in 1996, since then Austrian cement industry has achieved substitution rates of up to 80 % for fossil fuels. The requirements for legal compliance, guarantee of supply, product quality as well as quality assurance (based on the guidelines CEN/TC 343 – Solid Recovered Fuels) are important preconditions for the use of SRF in the cement industry.

In Austria, the definition of “waste fuels” or “refuse-derived Fuels” (RDF) is given in the legally binding Waste Incineration Ordinance (WIO; BMLFUW, 2010). After adequate and extensive (pre-)treatment in different processing plants and applying strictly defined quality assurance measures, various non-hazardous and/or hazardous waste materials from households, commerce, and industry can be used as RDF in co-incineration plants: sewage sludge, waste wood, high-calorific fractions from mechanical-physical (MP) or mechanical-biological (MB) treatment plant.[14]

3.1.4. **Japan**

Despite its reputation of an advanced nation with respect to its MSW management, the SRF and RDF production in Japan is coming of age recently only. Owing to its land scarcity, Japan relies mostly on thermal treatment of MSW (incineration and gasification, 81% of the almost 43 million tons MSW generated in 2015). In Japan RDF is understood as a refuse derived fuel to which putrescible matter and lime was added while RPF (is a sort of solid recovered fuel made from industrial/commercial plastic, paper, pulp and wood waste. According to available data, only 644,000 tons of RDF and about 1.25 million tons of RPF (refuse derived paper and plastics densified fuel) were produced in 2015. Most of the RPF produced is used for power and heat generation in paper mills (60%) and dye factories (35%).

3.2. Regulatory mechanism on co-processing

As per the SWM Rules, 2016, “co-processing” means use of non-biodegradable and non-recyclable solid waste having calorific value exceeding 1500Kcal as raw material or as a source of energy or both to replace or supplement the natural mineral resources and fossil fuels in industrial processes. Also, the Rules define "Refused Derived Fuel"(RDF) as fuel derived from combustible waste fraction of solid waste like plastic, wood, pulp or organic waste, other than chlorinated materials, in the form of pellets or fluff produced by drying,

14 http://avaw.unileoben.ac.at/media/Modul_11_EBS.pdf

shredding, dehydrating and compacting of solid waste. This material can be utilised for co-processing in various industries like cement and thermal power plants, etc.

A sound policy framework exists in the country as SWM Rules 2016 (Table 1) recommend the following:

Table 1: SWM Rules 2016 on usage of RDF

Reference	Rules/Activities
Criteria for waste to energy process.	(i) Non-recyclable waste having calorific value of 1500 Kcal/kg or more shall not be disposed off on landfills and shall only be utilised for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel. (ii) High calorific wastes shall be used for co-processing in cement or thermal power plants.
Duties of the industrial units located within one hundred km from the RDF and Waste to Energy plants based on solid waste	All industrial units using fuel and located within 100 km from a solid waste-based RDF plant shall make arrangements within six months from the date of notification of these rules to replace at least 5% of their fuel requirement by RDF so produced.
Duties of Central Pollution Control Board	Provide guidance to States or Union Territories on inter-state movement of waste.

The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016[15] are notified by Ministry of Environment, Forest and Climate Change (MoEF&CC) which state that co-processing means the use of waste materials in manufacturing processes for the purpose of energy or resource recovery or both and resultant reduction in the use of conventional fuels or raw materials or both through substitution.

The advantages and limitations of co-processing of MSW based RDF in various industries like cement; thermal power plants and steel industry are detailed in Section 3.4 of this report.

3.3. RDF usage experience across Various Industries

The committee deliberated the RDF usage experience with the industry (Sector) specific experts. Officials from Steel Authority of India Limited (SAIL), National Thermal Power

[15] http://www.moef.gov.in/sites/default/files/Final%20HWM%20Rules%202016%20%28English%29.pdf, accessed on 10 April 2018

Corporation (NTPC), Central Pollution Control Board (CPCB) and Cement Manufacturing Association (CMA) shared valuable inputs on their experiences on the RDF use. The industry wise experiences are documented below:

3.3.1. Thermal Industry

The idea of RDF usage in thermal power plants as a concept first surfaced in the 1970s in USA where electric utilities expressed their interest to use RDF as supplementary fuel in their boilers. However, the usage of RDF in power plants has technical impediments which relate to the boiler efficiency. The important considerations for a thermal power plant are combustion and steam stability. The factors that affect the steam stability of RDF as a fuel are the non-uniform calorific value (which affects the boiler volume and amount of steam produced), high moisture content of RDF, lack of flexible combustion air control and non-uniform feed rate[16]. The power industry till date has conducted a couple of test runs to replace coal. To even achieve a 10% thermal substitution rate in the power sector, there is a requirement of a steady supply of close to 165 Mt of biomass and 12 Mt of RDF[17].

There are very few incidents of usage of waste or alternate fuels in power plants in India. Although the CPCB has attempted a few trials in the past using industrial hazardous wastes such as ETP sludge, spent pot lining, resins and non-hazardous wastes such as tyres within the captive power plants of certain industries, the utilisation rates have hitherto not exceeded the 1% mark[18].

Currently, collaborative research project with Tokyo Institute of Technology has been taken up by National Thermal Power Corporation (NTPC) for converting MSW and Biomass waste to solid fuel compatible for co-firing with high ash Indian coal in thermal power stations. Use of biomass in NTPC has also pioneered trial experiments of co-firing coal and biomass pellets in one of its 210 MW Pulverized coal fired boiler in NTPC Dadri. However, the research and trails are in nascent stage, therefore, with advancement in technology, the options in thermal power plants can be considered suitably in future.

The challenges of using RDF as a fuel in Thermal Power Plants are elaborated in Table 2.

[16] Co-processing of municipal solid waste, incinerator residues and sewage sludge: Current treatment and utilisation practices in the cement industry, CPCB, 2015
[17] Co-processing potential in cement, steel and power in India, CPCB, 2015
[18] Co-processing potential in cement, steel and power in India, CPCB, 2015

Table 2. Challenges of using RDF as a fuel in Thermal Power Plants

S. No	Parameter	Performance
(i)	Calorific value	The highly variable nature of size, density, calorific value across regions and seasons of the RDF produced can never ensure that the RDF will be of the same calorific value. Heat release rate of RDF is not consistent compared to the Coal and hence study on the combustion behaviour of RDF while co firing with different blend ratios needs to be done
(ii)	Size	RDF being in fluffy or loose form cannot be mixed with Coal directly as the existing milling system is not designed to pulverize RDF. Separate milling system, conveying system and modification in combustion system shall be required
(iii)	Quality of output	(i) Presence of silica with alkalis creates agglomeration and fouling on heating surfaces (ii) Silica in fly ash causes erosion of heating surfaces (iii) Chloride compounds of RDF cause corrosion of heating surfaces (iv) RDF combustion products contains SO_2 / SO_3 that cause acid dew point corrosion The presence of such corrosive non-metals in the RDF will over a period of time reduce the productivity of the boiler and hence the productivity of the turbine as well.
(iv)	Creation of Slag	Combustion temperature above ash fusion temperature leads to ash fusion and clinker formation on grate. Over a period of time this reduces the productivity of the boiler through deposits and increases the cost of maintenance.
(v)	Policy and finance	(i) Absence of a policy on financials, incentives, technology choice, capacity building and other regulatory issues (ii) Absence of long term Power Purchase Agreements with favourable tariff structure
(vi)	Boiler Metallurgy	The present boiler metallurgy of the PC fired plants is not suitable for the highly corrosive atmosphere generated by burning of high plastics, PVC and alkaline element in RDF. This would result in frequent shutdown of the boiler on account of tube leakages and corrosion related failures.

3.3.2. Iron and Steel Industry

The Indian steel industry currently has very little experience in using RDF as a fuel source. This is generally due to the concerns related to the possible negative impacts on the production process or the product quality. The expert members from SAIL have briefed that MSW derived RDF cannot be used in Iron and Steel industry as the process is autogenous. The usage of RDF as fuel in processes like sinter making or in reheating furnaces was also explored and it is opined that since the present mode of energy supply to sinter and reheating furnaces is gaseous, the solid RDF would not be the appropriate material for those applications.

The challenges of using RDF as a fuel in Iron and Steel industry is further elaborated in Table 3.

Table 3. Challenges of using RDF as a fuel in Iron and Steel industry

S. No	Parameter	Performance
(i)	Calorific Value	The Iron and Steel industry uses Coke as the primary fuel in the furnace. Coke has a calorific value of over 9000 kcal. RDF is not a homogenous fuel base which will lead to a loss of energy in the furnace which has to be compensated through additional use of coal and coke.
(ii)	Quality of Output	RDF when burnt will also release material which are likely to hamper the 'forward reaction rate' of the ore. This will lead to production losses of pure iron from the ore.
(iii)	Input feed	Mode of energy supply to sinter and reheating furnaces is gaseous; the solid RDF would not be the appropriate material for those applications.
(iv)	Creation of Slag	Burning of RDF will also lead to a higher production of slag, which is mostly waste and is difficult to manage for the Iron and Steel industry. This will also reduce the productivity of the ore in the production process
(v)	Policy and finance	The challenges include storage and the cost involved to set up the process to fire RDF in the blast furnace.

3.3.3. Brick kilns

Biomass and /or MSW derived fuel has not been considered in the case of brick kilns as the temperature of the furnace is typically less than 700° - 1100°C and the combustion of RDF at such temperatures will lead to the generation of toxic emissions like dioxins and furans.

3.3.4. Cement Industry

Processing of the combustible fraction of MSW yields Refuse Derived Fuel (RDF) and Cement Industry can play a vital role in utilising RDF as Alternative Fuel in cement kilns. The current thermal substitution rate (TSR) of fossils fuels by alternative fuels such as Industrial waste, biomass and municipal waste, stands at only 3.0 per cent, far below the double-digit rates achieved in developed countries. The MSW based SCF/ RDF use in cement kiln contributes only 0.6% of thermal substitution. Cement Manufacturing Association (CMA) and Cement Sustainability Initiative (CSI) are supporting the Alternative Fuels & Raw Materials (AFR) usage and over last decade, AFR substitution rate has been increased from less than 1 % in 2010 to more than 3% in 2016. The industry aims to achieve 25% of TSR by 2025. In order to achieve India's ambitious Nationally Determined Contributions (NDC), the cement industry needs to achieve a TSR of 20% or more by 2022.

India is the second largest cement producer in the World after China. The carbon footprint of Indian Cement Industry is second only to electricity generation sector. Currently, most cement manufacturers use variety of fuel types like Coal, domestic & imported petroleum coke etc. as high CV fuel in kilns. The net CO_2 emission factor of Pet Coke is highest among all fuels used in cement plants – 105% of coal, 134% of plastic and 1060% of RDF.

There have been close to 75 co-processing trials conducted in various cement plants across the country. As of 2015, co-processing had been implemented by cement companies such as ACC, Ambuja, UltraTech, Shree Cements, Jaypee, Dalmia, Lafarge, India Cements, Bharathi Cement, Heidelberg, Zuari Cement, Madras Cement etc. ACC had achieved a TSR of 2.46% and Ultra-Tech had achieved a TSR of 2.2% in 2014. All the larger cement plants which occupy close to 60% of the market share have currently achieved 2.5% TSR, however, these are not the industry benchmarks. The list of cement plants in different states that have systems in place for utilizing Hazardous Waste and can also accept RDF is given in Table 4. A comprehensive list of Company-wise Cement Plants in India is placed at Annexure X. Case study of use of MSW based RDF in Kymore facility of ACC Cement Plant is also presented below.

Table 4. List of Cement Plants with Approval for AFR (Source: CII)

Company	Plant Location
ACC	Bargarh (Odisha), Chaibasa (Jharkhand), Jamul (Chhattisgarh), Kymore (Madhya Pradesh), Lakheri (Rajasthan), Maddukarai (Tamil Nadu), Wadi (Karnataka), Gagal (Himachal Pradesh)
AMBUJA CEMENT	Kodinar (Gujarat), Rabriyawas (Rajasthan), Darlaghat (Himachal Pradesh)
LAFARGE	Sonadih and Arasmeta (Chhattisgarh)

SHREE CEMENT	Ras and Mewar (Rajasthan)
TRINETARA CEMENT WORKS	Rajasthan
VASAVDATTA	Gulbarga (Karnataka)

Case Study: ACC Cement Plant at Kymore in Madhya Pradesh (MP)

ACC Limited is a pioneer in extending co-processing services under the brand name of Geocycle, which is the global waste management brand of Lafarge-Holcim, the promoter of ACC Limited. Lafarge- Holcim is one of the world leaders in cement manufacturing and has an experience of more than 30 years in waste co- processing. In India, Geocycle has set up 14 co-processing facilities and 6 dedicated pre- processing facilities of handling large volume and varied kinds of waste including MSW based RDF. At Kymore in MP, the plant has a capacity of utilizing 350 TPD of alternative fuel. Currently, the plant is getting segregated combustible fraction of municipal solid waste from Katni, Satna and Jabalpur. The other types of waste include biomass and hazardous waste from Pharma, Automobile, Manufacturing/ Engineering, Refinery, Chemical, Textile & Beverages & other non- hazardous wastes like FMCG. The plant is a modern facility and has best equipment sourced from worldwide, with an elaborate firefighting system in place. A shredding line of 200 m3/hr (90000 TPA) capacity and with proper storage & processing shed is in place. The Geomembrane sheet is provided in the floor of the facility. A firewater retention basin along with separate leachate collection system is also provided to avoid contact of spillage material with soil and water. The plant has laboratory, and sample from each truckload of MSW fraction is tested for moisture, chlorine, ash, calorific value before processing of waste.

The burning of RDF with high chlorine content could be detrimental for the cement clinker. However, the formation of these volatile alkali chlorides can be controlled by the means of a kiln by-pass. The major factors which create slag and cause fouling is the ash composition, slag viscosity, the SiO_2/Al_2O_3 ratio and acid/base ratio. Therefore, the particle size of the RDF used becomes an important consideration, as large particles of glass may generate nuclei that encourage slag forming reactions. Since the part of non-combustible particles in RDF will be different from that of coal, it will have a different impact on fouling and slagging.

The corrosion of metal surfaces is also a concern when RDF is combusted in the boiler. This is due to the high temperature liquid corrosion due to alkali sulphates, a reducing

atmosphere within the boiler may create corrosive agents like CO and H2S due to partial combustion.[19]

The emission norms for co-processing of waste / RDF in cement plants are notified by Ministry of Environment Forest and Climate Change in May 2015. The copy of same is provided as Annexure II.

Co-processing in cement kiln achieves effective utilization of the material and energy value present in the wastes, thereby conserving the natural resources by reducing the use of virgin material. Table 4 below illustrates the benefits of using RDF as an alternate fuel in cement industries.

Table 5. Benefits of using RDF in Cement Industries

Indicators	Benefit
RDF Specifications	Cement plans usually require RDF to be shred to size less than 50 mm which is not a technological challenge. Particle sizes less than 50 mm usually disintegrate completely with 4-5 seconds in an oxygen rich atmosphere as is present in a cement kiln.
Feeding of RDF	The installation of alternate fuel feeding mechanism enables RDF to be fed into the cement kiln without any difficulty. Usually, cement factories build a separate entry point for AFR which can include pharma waste, FMCG waste, packaging waste, lubricants, etc. The same feeding mechanism can be used for RDF.
Impact on Product	Very high temperatures of approximately 1400ºC and a residence time of 4-5 seconds in an oxygen rich atmosphere ensure complete combustion of RDF without affecting the productivity. The fuel has a calorific value of around 3000 Kcal which can generate enough thermal energy required in the processes in these plants, reducing the use of non-renewable fossil fuels like coal.
Environmental Impact	RDF usage replaces fossil fuels with materials which would have been landfilled leading to emissions. Furthermore, improper landfilling would have allowed leachate to run into ground water and become a major source of pollution. Furthermore, the use of equipment to check stack emissions can lead to a reduction of dioxins and furans from being emitted in the atmosphere.

[19] Co-processing of municipal solid waste, incinerator residues and sewage sludge: Current treatment and utilization practices in the cement industry, CPCB, 2015

Residual Disposal	Acidic gases generated in the combustion process are neutralised by the alkaline raw material in the cement kiln and are incorporated into the cement clinker. The interaction of the raw material and the flue gases in the clinker ensures that the non-combustible part of the residue is held back in the process and is incorporated in the clinker in an almost irreversible manner. No additional waste is generated in the process

3.3.5. **Waste-to-Energy (Incineration)**

Waste-to-energy (W to E) or energy-from-waste is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste. Energy recovery in the form of electricity, heat and fuel from waste using different technologies is possible through a variety of processes, including incineration, gasification, pyrolysis and anaerobic digestion. These processes are often grouped under “W to E technologies”.

Two groups of technologies could be used for processing different fractions of wastes:

(i) Bio-chemical waste to energy technologies: can be categorized into biomethanation and fermentation. As this technology provides solution for organic waste only, the same can’t be considered for using RDF.

(ii) Thermo-chemical waste to energy technologies: MSW thermal technologies are processes that create energy in the form of electricity, fuel or heat from thermo-chemical processes such as, gasification, pyrolysis incineration or mass burning of municipal solid wastes. MSW, after limited or full pre-processing is used in most of these thermal technologies. These are also referred to as waste to energy or transformation facilities. Incineration, which is a well-established process, has limited efficiency from the thermodynamics point of view but could improve up to some extent if it is preceded by conversion of combustible fraction of MSW to “RDF” (refuse derived fuel) since Indian wastes in raw form are not suitable for incineration. Due to reduction in fuel particle size and removal of non-combustible material, RDF fuels are more homogeneous and easier to burn than the gross MSW. The RDF burning technology includes spreader stroker fired boiler, suspension fired boilers, fluidized bed units, and cyclone furnace units.

The waste to energy plants across country can also utilize RDF derived from MSW Plants. During the Expert Committee Meeting deliberations, it was stated that in waste to energy plants even RDF of 1100 Kcal can be utilized however optimum energy recovery is at

1600 k/ cal. The modern combustors continue to perform with MSW composition with 30% ash/inert and up to 40% moisture on sustainable basis.

A typical analysis of acceptable RDF contains Carbon C: 13.66%, Hydrogen H: 1.94%, Oxygen O: 8.90%, Nitrogen N: 0.45%, Sulfur S: 0.12%, Chlorine Cl: 0.14%, Ash /Inert: 31.00%, Water/Moisture: 43.78%. The resultant net calorific value with the above analysis produces 1100 Kcal/kg.

The list of operational and under construction waste to energy plants is given as Annexure III.

3.4. Comparative feasibility of RDF use in various industries

The SWM Rules, 2016 suggest the possible usage of RDF in various industries. While the usage of RDF may translate into potential cost savings and reduce fossil fuel consumption, certain safeguards are necessary to ensure its optimum usage. A comparative analysis of cement kilns, thermal power plants, iron and steel manufacturing units, and brick kilns (not recommended by SWM Rules, 2016, only considered for analysis purpose) is detailed in the previous section.

The use of RDF as an alternate fuel has been established primarily because of its calorific value which can be extracted to generate energy. There is, however, a need to assess the viability of using RDF in the select industries with respect to specific factors. These factors investigate whether the business and environment can optimally benefit from co-processing waste as RDF. The factors considered are:

(i) RDF Quality Specifications: Technological changes required to make RDF suitable for usage (e.g. shredding it to the required size).

(ii) Feeding Mechanism: Difficulty in feeding RDF into the Kiln/Boiler/Furnace.

(iii) Impact on Final Output: Impact on quality and quantity of final product like cement, steel, power generation, etc.

(iv) Environmental Impact: Impact on emissions due to usage of RDF

(v) Residue Disposal: Final rejects to be disposed off after RDF usage

Table 6 below presents a comparative analysis of specific industries which have been identified for potential co-processing option of waste as RDF.

Table 6: Comparative Analysis of MSW based RDF usage

Criteria for ease of implementation	Cement Plants	Thermal Power	Iron and Steel	Brick Kilns (Not recommended in SWM Rules, 2016 compared for analysis purpose only)
RDF size Specifications	RDF size is acceptable(<50mm)	Additional shredding required (<2 mm)	RDF cannot be used as fuel for steelmaking as the process is autogenous. The usage of RDF as fuel in other processes like sinter making or in reheating furnaces was also explored by Steel Authority of India (SAIL) and it was opined that since the present mode of energy supply to sinter and reheating furnaces is gaseous, solid RDF would not be appropriate for those applications also.	RDF size is acceptable
Impact on Final Output	Negligible impact on final product	RDF contaminants like Silica and Chlorides corrode the heating surface, thereby affecting the	Burning RDF affects forward reaction rate which leads to lower production of pure iron from the ore	No impact on final product

Criteria for ease of implementation	Cement Plants	Thermal Power	Iron and Steel	Brick Kilns (Not recommended in SWM Rules, 2016 compared for analysis purpose only)
		boiler		
Feeding Mechanism	Alternate feeding mechanism in place for feeding AFR	Alternate feeding mechanism needs to be installed	Alternate feeding mechanism needs to be installed	Alternate feeding mechanism not needed
Environmental Impact	None if proper safeguards are in place; additionally it leads to net reduction in GHG emissions	Toxic emissions like dioxins and furans	Toxic emissions like dioxins and furans	Toxic emissions like dioxins and furans
Residue Disposal	None, as it becomes part of the clinker	Higher generation of fly ash and clinker formation on grate	Higher generation of slag, which is a difficult to manage waste	Ash and non-combustible part of RDF need to be disposed

A comparative analysis of the factors to understand the viability of RDF across select industries leads to the conclusion that currently cement is the best suited industry to adopt RDF as an alternate fuel source along with fossil fuels.

4. SWOT Analysis for RDF usage in India

An analysis on the strengths, weaknesses, opportunities and possible threats is presented in this section for RDF usage in India.

Strengths

4.1. Availability of RDF for co-processing

The urban areas comprise of 31.16% (2011) of the population and considering an average of 0.55 kg/person/day of waste generation, around 1.7 Lacs TPD is generated (estimates as per CPCB, 2015). Based on detailed mapping of cities within 200 km radius of cement plants around 143,379 TPD MSW is generated. Therefore, approx. 28,676 tonnes per day of RDF will be available for co-processing in the cement plant.

However, considering that 88.4 MW of W-t-E is already operational while another 415 MW is under tendering/construction and considering collection efficiency ranges from 60-90% in different cities and some cities are small or are remote from cement plants, setting up of RDF production plant is not promoted as Segregated combustible fractions are preferred to use in incineration plants. Thus, only 40% i.e. around 0.68 Lacs TPD of MSW is assumed to be available for RDF Processing and thus only 13,600 tonnes per day of RDF can be utilized for co-processing in cement kilns.[20]

4.2. Enabling Policy Framework

The key enabling existing polices and initiatives for promoting use of MSW based RDF are summarized in table 7.

Table 7. List of Enabling Policy Framework for Co-processing

Policy / Programme	Enabling Policies
Swachh Bharat Mission	Government of India has launched Swachh Bharat Mission on 2nd October 2014, with the objectives of modern and scientific Municipal Solid Waste Management among other by providing an infrastructure to manage the waste littering, collection, transportation, treatment and disposal effectively. Grants are made available for processing and disposal of MSW and therefore can be utilized for setting up RDF facilities.
Solid Waste Management Rules 2016	Recommend that high calorific wastes shall be used for co-processing in cement or thermal power plants or waste to energy plants and all industrial units using fuel and located within 100 km from a solid waste-based

[20] Waste NAMA Report

	RDF plant shall make arrangements within six months from the date of notification of the rules to replace at least 5% of their fuel requirement by RDF so produced.
Draft guidelines on "Preprocessing and Co-processing of Hazardous and Other Waste in Cement Plants as per H&OW(M&TBM) Rules 2016	To promote Co-processing, Central Pollution Control Board has drafted guidelines for preprocessing and co-processing of waste which also includes use of MSW based RDF with enabling conditions by regulators for trans boundary movement of RDF and defining emission standards.
Preferential Tariff for Waste to Energy Plants and Grants by Ministry of New and Renewable Energy (MNRE)	A preferential tariff for Waste to Energy plants was issued by Central Electricity Regulatory Authority (CERC) of INR 7.04 per unit for MSW and NR 7.90 for RDF[21] based projects. In addition, a grant of INR 20 million per MW is provided for setting up waste to energy plants [22]by MNRE.

4.3. Mapping of RDF availability across India

4.3.1. Waste Management Industry

The private sector engaged in waste management industry plays an important role in meeting Swachh Bharat Mission goals. The projects are implemented in public private partnership model. Other than direct participation of waste management, industry, is investing corporate social responsibility funds in waste management sector. The list of RDF plants and compost plants around cement industry can be accessed from below link:

Link to the Functional Waste Management Plants –

https://drive.google.com/open?id=1SREhXRUgwu7beKTBmpYUbkeayQc&usp=sharing

Link to the Proposed Waste Management Plants –

https://drive.google.com/open?id=1R5eZaflQLlMAwZaG4G52aBF-d0w&usp=sharing

Please use the options on the left-hand side of Google maps to add layers using select.

The figure below depicts the spatial distribution of 100 and 200 km buffer from cement industry, functional waste to energy, waste to compost and RDF plant in India (Figure 6).

[21] Central Electricity Regulatory Commission (2015) http://www.cercind.gov.in/2015/regulation/SOR115.pdf

[22] MNRE, (2017), Details of Programme On Energy from Urban, Industrial and Agricultural Wastes/Residues Beyond 12th Plan Period (2012-17), http://mnre.gov.in/file-manager/offgrid-wastetoenergy/programme_energy-urban-industrial-agriculture-wastes-2012-17.pdf

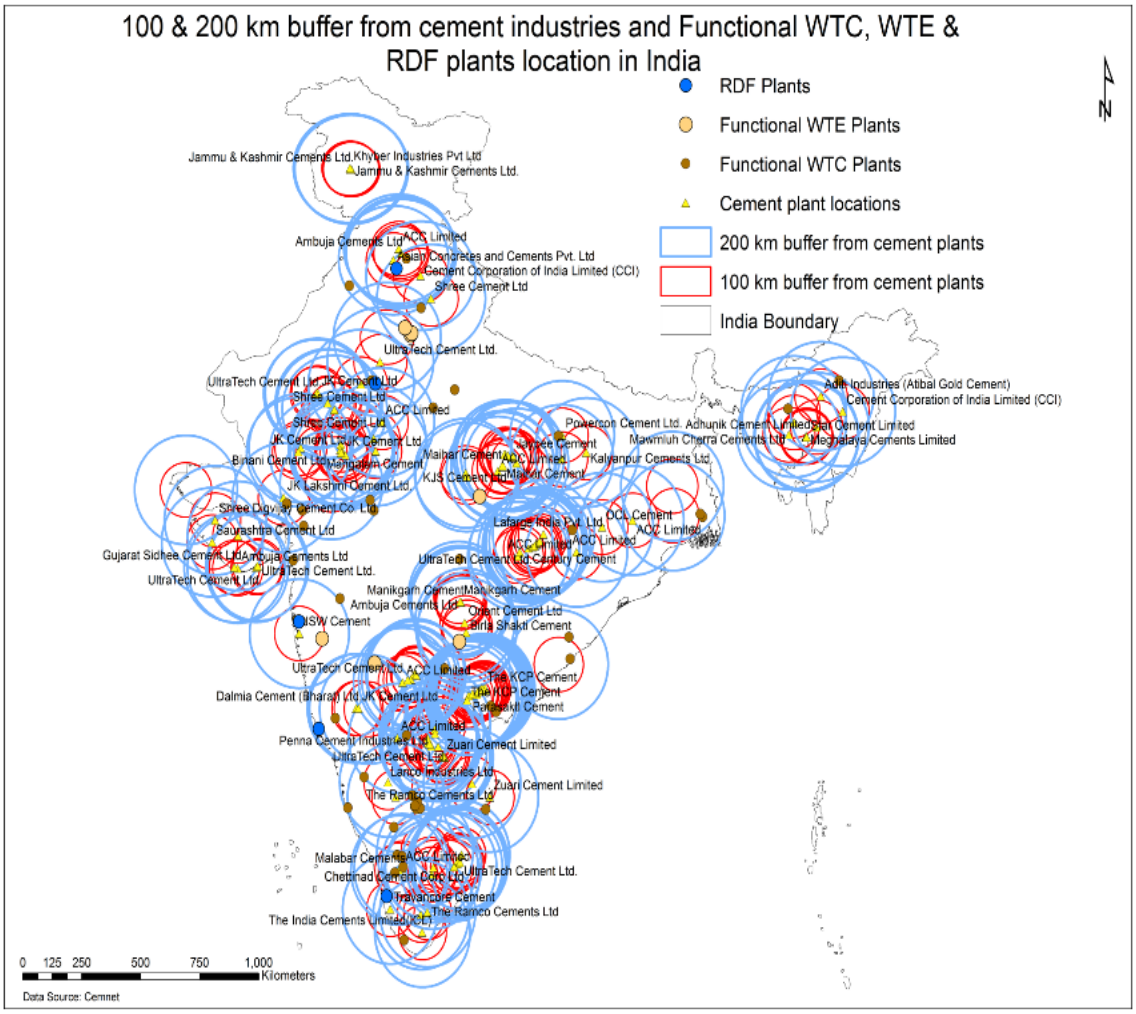


Figure 6. Spatial distribution of 100 and 200 km buffer from cement industry, functional waste to energy, waste to compost and RDF plant in India

4.3.2. **Cement Industry**

As per a recent study,[23] India is the world's second largest producer of cement after China, with a production capacity of 366 million tonnes in 2014. To produce 250 million tonnes cement in 2013 the industry consumed approximately 300 million tonnes of virgin raw materials, 24 million tonnes of coal, 20 billion kWh of electricity and emitted nearly 175 $MtCO_2$[24]. The top 20 cement companies account for almost 70% of total cement production.

[23] Government of India: Ministry of Environment & Forests: Central Pollution Control Board (2015b) www.cpcb.nic.in

[24] Government of India: Ministry of Environment & Forests: Central Pollution Control Board (2015b) www.cpcb.nic.in, page 3

The cement demand in India comes mainly from housing, infrastructure, construction and the industrial sector. Between 2000 and 2010, the cement industry grew at an average rate of 10% per year. The sector is expected to continue to grow due to recent government initiatives (e.g. the development of 100 smart cities).

Coal is the main fuel used for cement production in India. Over 30% of the coal used is imported. Fossil fuels and raw materials used by cement plants can be in principle replaced to a large extent by Alternative Fuel and Raw materials (AFR) such as RDF and biomass. To reduce energy costs and CO_2 emissions, the global cement industry is gradually increasing the use of AFR. In 2014, the Thermal Substitution Rate (TSR) – which is the rate at which the calorific value of fossil fuel is replaced by the calorific value of AFR - reached 19% of the global average fuel mix in the cement sector. Within the EU (28 states) the TSR amounts to a total of 40%, with 26% from waste and 14% from biomass. However, the use of AFR in the Indian cement sector is still very low. The average TSR in the cement sector in India is estimated to be 4%.[25] The weighted average TSR of 5 major cement companies in India is an estimated 2.5%. The aim is to reach a TSR of 25% by 2050[26]. Initiatives of co-processing trials and investment of over INR 386.7 million for installations demonstrate that the Indian cement industry is beginning to develop capacity and competence for enhancing TSR levels.

With extensive national and global expertise, the Indian cement industry is technically ready to adopt higher rates of AFR use.[27] The Indian cement sector is highly organised and major cement companies are members of the World Business Council for Sustainable Development (WBCSD) and the corresponding Cement Sustainability Initiative (CSI) which published the "CSI Technology Roadmap: Low-Carbon Technology for the Indian Cement Industry"[28]. A study on GIS mapping of cement plants and waste to energy plants is undertaken by GIZ along with TERI. The below links showing details of operational waste processing facilities and cement plants.

Link to the Functional Waste Management Plants –

https://drive.google.com/open?id=1SREhXRUgwu7beKTBmpYUbkeayQc&usp=sharing

(i) Link to the Proposed Waste Management Plants –

https://drive.google.com/open?id=1R5eZaflQLlMAwZaG4G52aBF-d0w&usp=sharing

Please use the options on the left-hand side of Google maps to add layers using ***select***.

[25] Helge and Saha (2017)
[26] IEA, WBCSD - Technology Roadmap (2012), page 19
[27] IEA, WBCSD - Technology Roadmap (2012), page 17
http://www.iea.org/publications/freepublications/publication/2012_cement_in_india_roadmap.pdf
[28]IEA, WBCSD - Technology Roadmap (2012)
http://www.iea.org/publications/freepublications/publication/2012_cement_in_india_roadmap.pdf

4.4. Identification of Challenges

In spite of enough demand and supply of RDF by vibrant private sector in waste management and cement industry and existence of enabling policy framework of SWM Rules 2016, current on ground situation is not very promising due to several challenges as depicted through Figure 7 below.

The use of MSW based RDF in cement and waste to energy plants involves active engagement of the following stakeholders' groups;

i. the Urban Local Bodies (ULBs),
ii. the waste management companies/ the RDF plant operators
iii. the cement companies, and
iv. the informal sector (mainly waste pickers).

The barriers which prevent these groups from supporting RDF production and co-processing of RDF in cement and waste to energy plants are elaborated in subsequent sections.

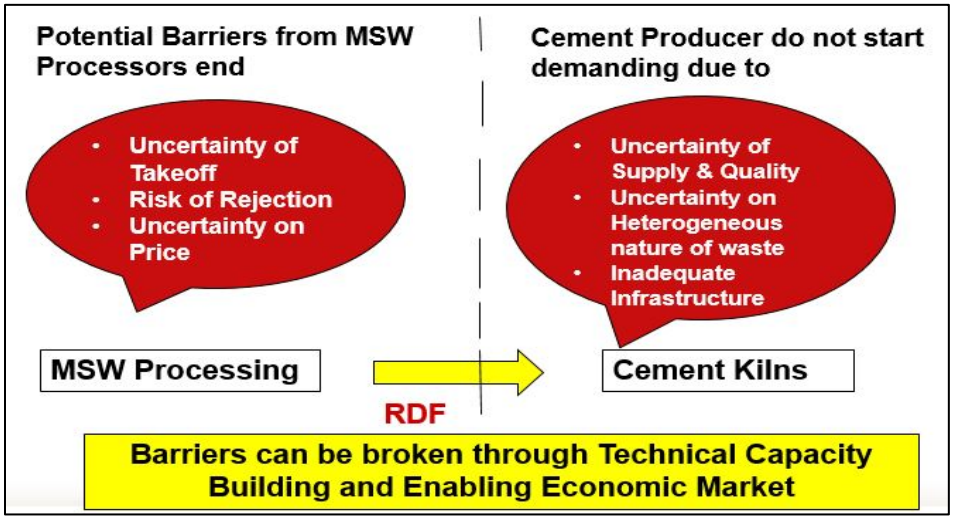


Figure 7. Challenges for RDF Usage in Cement Plants

<u>Weaknesses</u>

4.5. Lack of Established Business Model

It is to be noted that segregated combustible fraction of MSW cannot be directly utilised for co-processing in cement kilns (see section 6 for details on process of RDF production). To make it a fuel, pre-processing of MSW is required and cement plants also need to have the necessary infrastructure of required capacity such as, storage & handling facility, feeding mechanism etc. to use this fuel. In the entire process a capital investment and operation and maintenance cost (including transportation of RDF to cement plants) needs

to be borne by both. However, currently, ULBs do not collect enough waste fees[29] to pay adequate tipping fees[30] to the RDF production plants to enable them to produce quality RDF at a price that is competitive with fossil fuels, e.g. coal. Creating a viable business model for RDF production and use in the cement sector thus requires closing the gap between RDF production costs and its sales price to cement producers. The key barriers related to this aspect are summarised as following:

a) **Lack of competitive prices for RDF production (compared to coal):** Due to several global demand, supply and market factors the price of fossil fuels, particularly coal, is not high enough to incentivise cement plants to purchase RDF as an option to save cost. Due to the uniform nature of coal the willingness to pay for coal is higher than that for RDF. Due to low coal prices, it is challenging to recover even the cost of production and transport of RDF to cement plants. Therefore, this is a major barrier to the promotion of co-processing in cement kilns.

b) **Lack of incentive for cement industry to invest in co-processing technology:** The cement industry needs to invest to enable use of RDF in cement kilns as an alternate fuel. To recover the investment, they either need RDF at a very low cost or some form of financial incentive. As there is no incentive available for cement plants to retrofit their facilities to enable co-processing of RDF, there are very few cement plants willing to invest in the current situation.

c) **Lack of trust in RDF quality by cement plants:** The key objective of cement plants is to produce cement at the required quality and not to be part of an MSW management system. As such, cement plants will not engage in RDF co-processing as long as they are afraid of low RDF quality that may impact the production process or the quality of the cement produced. There are particular concerns of cement plants regarding high chlorine contents in RDF and inconsistent calorific values due to which they have to use this material by adding other alternative fuel like biomass by incurring additional cost.

4.6. Lack of Financial Incentives

a) **Lack of governmental support programmes to promote RDF:** Present policies of the Government of India have provided support for waste to energy technologies through a feed-in-tariff of INR 7.04 per KWh, i.e. approximately INR

[29] Waste fee/User fee = waste management fee = fee charged by the public or private service provider (e.g. ULB) to the waste producers

[30] Tipping fee = fee charged by the operator of a waste processing facility (e.g. sanitary landfill, treatment plant or RDF production plant) for a given quantity of waste to be processed

1350 per tonne of RDF[31]and for compost through market development assistance of INR 1500 per tons of compost sale. However, there is no assistance for promoting RDF co-processing in cement kilns. Thus, this RDF processing option is at a disadvantage compared to composting or W-t-E.

b) Lack of transitional financial support to close the gap between RDF production costs and acceptable sales price to cement companies: Reducing the costs for RDF processing and co-processing to less than the cost of coal can lead to the emergence of a self-sustaining market for RDF co-processing in cement kilns. In order to achieve this, significant capacity with the technology and value chain for RDF production is required on all sides. While most stakeholders are interested in removing the MSW from their vicinity, the willingness to pay for safe disposal is often limited. In some cases, financing is made available for setting up MSW management projects but there is no funding available for covering operational costs as people are not willing to pay user or waste disposal fees or in other cases ULBs are not doing enough to collect sufficient user fees. Even when financing is available, the setting up of waste management facilities faces resistance due to the Not in my Backyard (NIMBY) syndrome[32].

4.7. Capacity Gaps

a) Lack of awareness and financial resources in ULBs and public: The ULBs - which are the primary stakeholders responsible for MSW management suffer from lack of financial resources, institutional capacities; limited knowledge on selection of proper technology for MSW management, lack of public participation in SWM etc.[33]. In general, awareness regarding composting and waste to energy has increased significantly resulting in favourable policy and public response, yet, the limited awareness regarding the potential for RDF co-processing in cement kilns remains to be addressed.

b) Lack of long term agreements: In absence of awareness about co-processing, standards of RDF and viable business model, no long-term agreements between urban local bodies, waste processing companies and cement plants exist. There is need to draft model long term agreements on the lines as similar to sale to

[31] The output based market development assistance per tonne of RDF is calculated taking into account that waste to energy plants have Plant Load Factor (PLF) of around 80%.
[32] Narain, S. (2016) http://www.downtoearth.org.in/reviews/not-in-my-backyard-solid-waste-mgmt-in-indian-cities-54040
[33] Government of India: Ministry of Urban Development: Central Public Health and Environmental Engineering Organization (CPHEEO) (2013) http://moud.gov.in/pdf/57f1f0a614e7aAdvisory%20on%20Improving%20Municipal%20Solid%20Waste%20Management%20Services08.pdf

electricity to Discoms through power purchase agreement for waste to energy projects and sale of compost agreements.

c) **Awareness on use of MSW based RDF at cement plants:** At cement plants level, need for creating awareness among workers for use of MSW based RDF in cement plant is required as in a few plants, resistance by plant workers and nearby population to the use this RDF exists.

d) **Need of integration of informal sector:** In India, informal sector plays an important role in MSW management and their livelihoods largely depend on sale of recyclables. Due to limited source segregation lots of combustible fraction like paper, plastic etc. are soiled and cannot be used for recycling. Such components can be utilised for making RDF and informal sector can earn some revenue by picking up such material.

5. RDF Standards for Co-processing

Standardization is the development of specifications for key product features against which product quality can be compared and controlled. Quality management, of which Standardization is a part, when properly implemented plays an important role in marketing a product by creating confidence in suppliers, end-users, and regulators. This is particularly true for Waste Derived Fuels like RDF which are processed from heterogeneous MSW and are thus prone to wide compositional fluctuations. According to the European Committee on Standardization (CEN) [34,35] in [36] , the central body creating standards in Europe – creating standards increases public trust, provides access to permits; results in cost savings for co-incineration plants by reducing the need for compliance monitoring; facilitates trans-border movements; and aids communication with equipment manufacturers. In the following sections, an overview on selection of parameters, existing global standards and Indian guidelines are provided to arrive at minimum quality criteria for a RDF standard, as proposed.

5.1. Existing Global Standards

The number of quality criteria and standards available for waste derived fuels in the market today differ substantially. The standards application may span from small regions to nations; be legally binding or constitute trade provisional agreements; rely upon waste input origin or final product quality; or refer to all or specific end-users.[37]

Due to the extent of trading activities, particularly in the European Commission, SRF suppliers were interested to harmonise the quality of SRF. In 2003, the European Committee for Standardisation (CEN), established a technical committee, the CEN/TC 343, which developed “European Standard EN 15359 Solid recovered fuels – Specification and Classes”. While this report’s objective is the development of standards of MSW-derived RDF for cement production, only a few standards/quality parameters exist for it. Moreover, in some countries, the waste processed from MSW to be used as fuel might not be called as RDF. Hence, a broad comparison for standards for RDF is done without specific end-user criteria. Comparison of various parameters across countries is presented in figure 8-10.

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[34] European Committee for Standardisation. Solid recovered fuels (PD CEN/TR 14745:2003). Ministry of Urban Development, 2003.
[35] European Committee for Standardisation. Solid recovered fuels— Specifications and classes (DD CEN/TS 15359:2006), 2006.
[36] CA Velis, Philip J Longhurst, Gillian H Drew, Richard Smith, and Simon JT Pollard. Production and quality assurance of solid recovered fuels using mechanical—biological treatment (MBT) of waste: a comprehensive assessment. Critical Reviews in Environmental Science and Technology, 40(12):979–1105, 2010.
[37] CA Velis, Philip J Longhurst, Gillian H Drew, Richard Smith, and Simon JT Pollard. Production and quality assurance of solid recovered fuels using mechanical—biological treatment (MBT) of waste: a comprehensive assessment. Critical Reviews in Environmental Science and Technology, 40(12):979–1105, 2010.

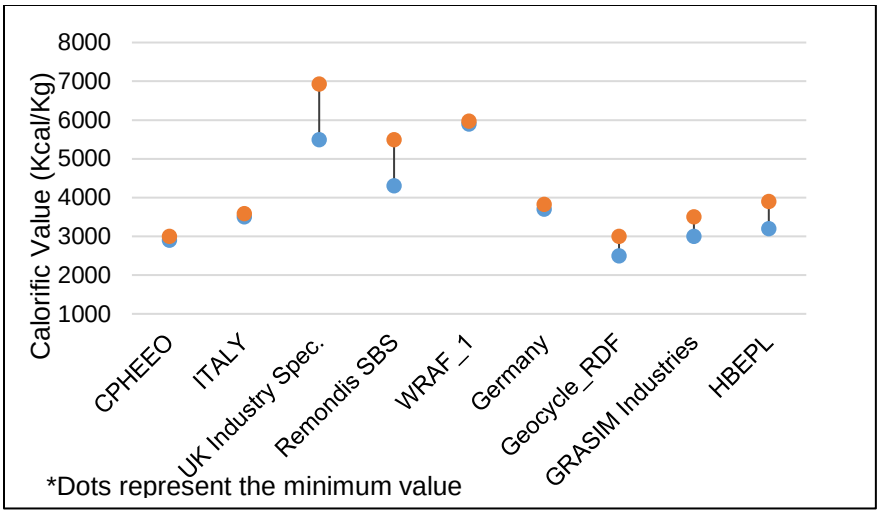


Figure 8: Comparison of Net Calorific Value across different standards

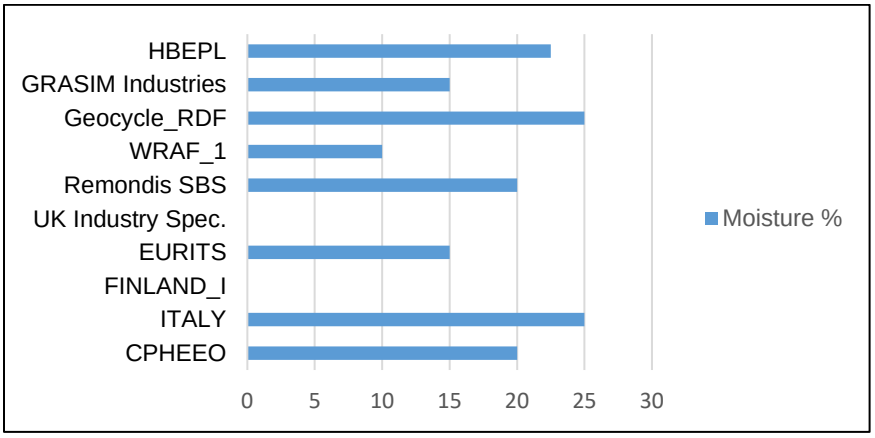


Figure 9: Comparison of moisture (in %) across different standards

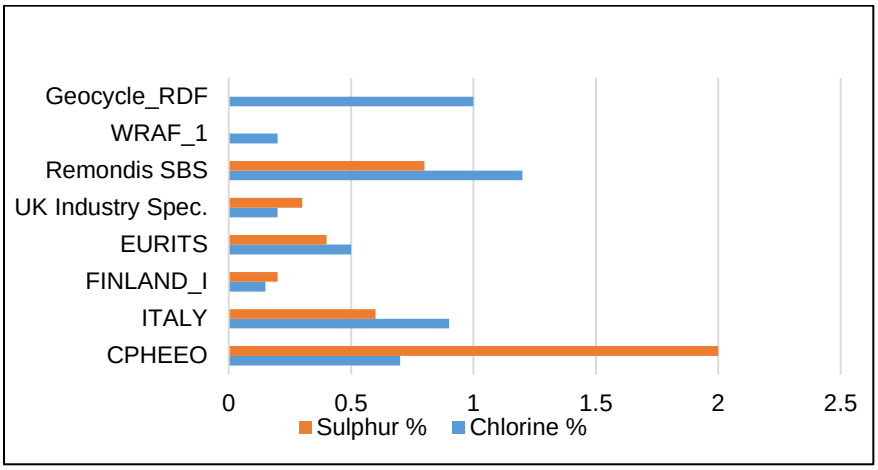


Figure 10: Comparison of Sulphur and Chlorine across different standards.

American Society for Testing and Materials (ASTM)[38] International has developed a classification scale based on seven RDF categories into which different RDF types are grouped and presented below.

ASTM Classification	**Description**
RDF 1	MSW used as RDF in as discarded form
RDF 2	MSW processed to a course particle size with or without ferrous metal separation
RDF 3	MSW processed to a particle size such that 95% by weight passes through a 50 mm square mesh screen and from which most of the glass, metals and other organics have been removed
RDF 4	MSW processed to a powdered form 95% by weight of which passes through 10 mesh screen and from which most metals, glass and other organics have been removed
RDF 5	MSW that has been processed and densified (compressed) into the form of pellets, slugs, cubettes or briquettes
RDF 6	MSW that is processed into a liquid fuel
RDF 7	MSW that has been processed into gaseous fuel

The ASTM classification is based on solid, liquid and gaseous forms, but for Indian scenario, the grading of RDF as per end user requirements

5.2. Existing guidelines in India

The Central Public Health and Environmental Engineering Organisation (CPHEEO) Municipal Solid Waste Management Manual, PART II (page 316) provides a quantification of some desirable characteristics of RDF for co-processing in cement plants. However, it is quite general and does not provide details on the methodology to be used. The parameters include particle size, calorific value, moisture, chlorine, and Sulphur content (See Figure 11).

[38] ASTM International is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

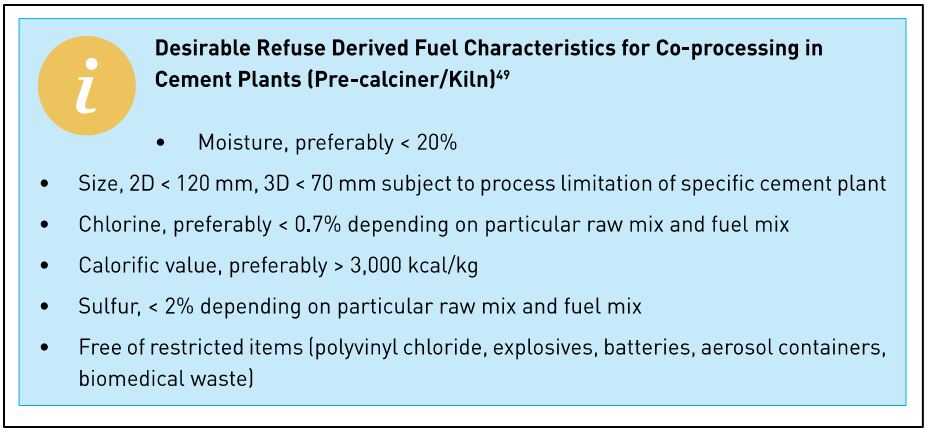


Figure 11: Desirable characteristics of RDF for co-processing in cement kilns as per MSW Manual, 2016 (Source: MSWM Manual CPHEEO; 2016)

Another draft guideline by Central Pollution Control Board (CPCB)[39] emphasizes the importance of a waste characterization process within the waste treatment process. Therefore, the guidelines mandate all pre-processing and co-processing facilities using hazardous and other waste in cement plants to perform a fingerprint analysis on every waste stream as given in 5.3.

5.3. Need for Standards for RDF in India

The committee deliberated and considered the following factors pertinent to evolve the standards for RDF

a) Waste heterogeneity: Indian MSW is highly heterogeneous (with non-existent segregation at source), and the RDF thus generated not only varies widely in quality but is often inferior quality. On the other hand, cement producers need RDF of consistent quality and quantity to ensure that cement quality, plant output, and compliance to regulations are not affected.

b) Different requirements and capacities of cement plants: RDF of one quality required by a cement plant may not be suitable for another plant; every cement plant has specific requirements and therefore standards will help to categorize the requirements.

[39] Central Pollution Control Board. Draft guidelines for pre-processing and co-processing of hazardous and other wastes in cement plants as per H&OW (M&TBM) rules 2016. Technical report, Ministry of Environment and Forests, Govt. of India, 2017.

c) Business Prospects: The standards will be helpful to enter into long-term agreements between cement and RDF plants.

d) Compliance to SWM Rules 2016: Standards will enable the implementation of SWM Rules 2016, by defining the characteristics/qualities of RDF, so that cement producers cannot claim that the product of the nearby RDF plants is not standard RDF.

e) Market Development: For a waste stream to be certified as RDF (after appropriate processing) would help the RDF plant better market their product and would increase the confidence of cement manufacturers in using RDF.

5.4. Parameters to be standardised

The most important parameter when using RDF as a substitute fuel in cement industry or waste to energy plants is the Net Calorific Value (NCV).[40, 41 in 42] Other important parameters listed in relevant literature include Chlorine (C), Sulphur (S), moisture, and ash content.[43] [44]

A technical report by the Central Pollution Control Board (CPCB)[45] on draft guidelines for pre- and co-processing of hazardous and other wastes in cement plant lists the following parameters for mandatory fingerprint analyses of waste streams in cement plants:

a. NCV
b. Moisture content
c. Chlorine and Sulphur content
d. Ash content
e. Chemical compatibility
f. Heavy metal analysis, Reactive Sulphide, Reactive Cyanide or Halide (analysis if suspected)

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[40] Hyderabad Waste to Energy Project. Municipal Corporation of Hyderabad. URL: http://local-renewables.iclei.org/fileadmin/user_upload/Local_Renewables/Mr_Rajiv_Babu__small.pdf. Accessed 27 August 2017.

[41] J Van Tubergen, Th Glorius, and E Waeyenbergh. Classification of solid recovered fuels. European Recovered Fuel Organisation, 2005.

[42] CA Velis, Philip J Longhurst, Gillian H Drew, Richard Smith, and Simon JT Pollard. Production and quality assurance of solid recovered fuels using mechanical—biological treatment (MBT) of waste: a comprehensive assessment. Critical Reviews in Environmental Science and Technology, 40(12):979–1105, 2010.

[43] Cement Sustainability Initiative. Guidelines for the selection and use of fuels and raw materials in the cement manufacturing process. World Business Council for Sustainable Development, 38, 2005.

[44] J Van Tubergen, Th Glorius, and E Waeyenbergh. Classification of solid recovered fuels. European Recovered Fuel Organisation, 2005.

[45] Central Pollution Control Board. Draft guidelines for pre-processing and co-processing of hazardous and other wastes in cement plants as per H&OW (M&TBM) rules 2016. Technical report, Ministry of Environment and Forests, Govt. of India, 2017.

Most of trace contaminants in the RDF, i.e., heavy metals become part of the clinker matrix, and studies have shown that their leaching is extremely small during the operational lifespan of cement plants46. Other compounds like dioxins and furans, formed during combustion have been shown to be much less than W-t-E plants.[47, 48]

In the Indian setup, an example of RDF co-processing trial by Vikram Cements (with permission from Madhya Pradesh Pollution Control Board) showed that concentration of common pollutants like Particulate Matter, NOx, carbon monoxide, HCl, and S didn't significantly change (±1 %) when RDF was used for co-combustion compared to without RDF[49]. Other trials done by CPCB, using hazardous material as co-fuels in cement plants have shown that with the existing pollution abatement technologies, concentration of all toxins was within permissible levels[50],[51]. Based on this evaluation reporting of heavy metals is not considered necessary for certification as RDF. The trails mentioned above were however performed using small thermal substitution rates (TSR) and considering the unsegregated and heterogeneous nature of Indian MSW, a higher TSR may necessitate the need for monitoring of leaching products from the clinker.

Based on these considerations and in line with the report by CPCB, the parameters (1) size (mm, longest side of the material), (2) NCV (kcal/kg), (3) Moisture content (%), (4) Ash content (%), (5) Chlorine content (%) and (6) Sulphur content (%) will be standardized as minimum quality criteria for RDF.

5.5. RDF Standards

The characteristics (composition, physical and chemical properties) of MSW stream differs across cities in India. Although MSW-based RDF plants have some control over the quality of RDF produced, producing high quality RDF with high NCV, low moisture and Cl content, may not be possible due to cost considerations (expensive equipment) or nature of Indian MSW. Keeping the same in view, following values are the minimum criteria that should be fulfilled for the product to be certified as RDF, as decided by the Expert Committee (Table 8).

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[46] CA Velis, Philip J Longhurst, Gillian H Drew, Richard Smith, and Simon JT Pollard. Production and quality assurance of solid recovered fuels using mechanical—biological treatment (MBT) of waste: a comprehensive assessment. Critical Reviews in Environmental Science and Technology, 40(12):979–1105, 2010.

[47] Central Pollution Control Board. Guidelines on co-processing in cement/power/steel industry. Technical report, Ministry of Environment and Forests, Govt. of India, 2010.

[48] Ankur Tiwary, Garima Sharma, and PK Gupta. Quantification of the reduced environmental impacts with use of co-processing in cement kilns in India. Environmental Research, Engineering and Management, 69(3):5–16, 2014.

[49] P V Kiran Ananth. Bulletin: Pre-processing MSW. Technical report, Confederation of Indian Industry- Sohrabhji Godrej Green Business Centre, 2011.

[50] J Van Tubergen, Th Glorius, and E Waeyenbergh. Classification of solid recovered fuels. European Recovered Fuel Organisation, 2005.

[51] Ankur Tiwary, Garima Sharma, and PK Gupta. Quantification of the reduced environmental impacts with use of co-processing in cement kilns in India. Environmental Research, Engineering and Management, 69(3):5–16, 2014.

Table 8. Proposed Standards for SCF and RDF

S. No	Parameters	SCF	RDF - Grade III	RDF - Grade II	RDF -Grade I
1.	Intended Use	Input material for the Waste to Energy plant or RDF pre-processing facility	For co-processing directly or after processing with other waste materials in cement kiln	For direct co-processing in cement kiln	For direct co-processing in cement kiln
			Grade III	Grade II	Grade I
2	Size	Anything above 400mm has to be mutually agreed between Urban Local Body/ SCF Supplier and Cement Plants.	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively		
3	Ash – maximum permissible	<20 %#	<15 %	<10 %	<10 %
4	Moisture – maximum permissible	<35 %	< 20%	<15 %	<10%
5	Chlorine – maximum permissible	< 1.0 % #	< 1.0 %	< 0.7	< 0.5
6	Sulphur – maximum permissible	<1.5 % #	<1.5 %		
7	* Net Calorific Value (NCV) – in Kcal/kg (Average figure of every individual	> 1500 KCal/kg net	>3000 KCal/kg net	>3750 KCal/kg net	> 4500 KCal/kg net

	consignment)				
8	Any other parameter	SCF – any offensive odour to be controlled. **	RDF – any offensive odour to be controlled.	RDF – any offensive odour to be controlled.	RDF – any offensive odour to be controlled.

Note Before: All figures are vetted by Cement Manufacturing Association (CMA)

 # If blending process is done in cement plants, the deviations in recommitted limit for ash, chlorine and sulphur content can be mutually agreed between urban local body /SCF Supplier and cement plants.

** band width of variations acceptable in NCV can be mutually decided between RDF manufacturer and cement plants.*

*** Since odour is still largely a matter of perception and there is no satisfactory equipment to measure different types of odour, no quantitative figure has been given.*

Part B: Preparation and Usage of RDF

6. RDF- Functional Elements

6.1. Constituents of Waste for RDF

MSW consists of various different fractions and to manage them effectively, different technological processes are required. As per SWM Rules 2016, depending on waste characteristics and waste hierarchy, the potential treatment options are summarized below in Figure 12.

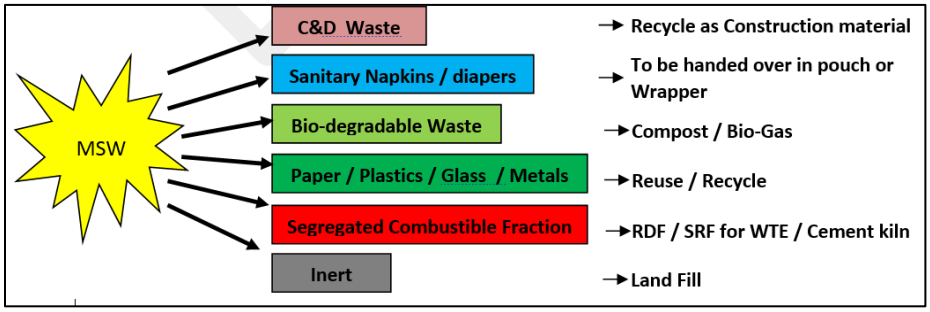


Figure 12 Source segregation fractions mandated by SWM Rules, 2016

The segregated combustible fraction includes recyclables of less value (torn paper, plastic pieces, glass pieces, metal pieces etc.) mixed with it. Also, a percentage of **garden waste, soiled paper, cardboard, textile, thin film plastic, multi-layered packaging and other such materials not suitable for recycling due to technical and financial reasons** and ends up at dumpsites and water bodies which can be converted into RDF.

As per the CPCB guidelines [52] the following waste should NOT be used for co-processing:

(i) Biomedical waste
(ii) Asbestos containing waste.
(iii) Electronic scrap.
(iv) Entire batteries.
(v) Explosives.
(vi) Corrosives.
(vii) Mineral acid wastes.
(viii) Radioactive Wastes.
(ix) Unsorted municipal garbage

6.2. Collection and Handling of waste for RDF

The urban local bodies are responsible for ensuring source segregation, collection, transportation, processing and disposal of MSW under SWM Rules 2016. Under Swachh

[52] Central Pollution Control Board. Draft guidelines for pre-processing and co-processing of hazardous and other wastes in cement plants as per H&OW (M&TBM) rules 2016. Technical report, Ministry of Environment and Forests, Govt. of India, 2017.

Bharat Mission, door to door waste collection system has been initiated by ULBs. While making RDF, it should be ensured by ULBs that the existing system of recycling largely carried out by informal sector, consisting of waste pickers, itinerant waste buyers, dealers and recycling units are not negatively affected. The waste management hierarchy also recognizes material recovery from waste in the form of recycling as one of the most prioritized manners of waste handling and ULBs shall ensure following safeguards for recycling.

a. During door to door waste collection and transportation, the collected recyclables fractions shall be diverted to recycling units by integrating waste workers.
b. Separate transportation of wet and dry fractions of MSW as per SWM 2016, so that after separating recyclables, the leftover segregated combustible fraction can be processed for making RDF.
c. Separate transportation of rejects from decentralized waste management facilities.
d. At the processing plant site also, during manual and mechanical separation, the recyclable material should be sent to recycling units.

The leftover segregated combustible fraction shall be preprocessed or stored by ULBs / Waste Management Company.

6.3. Storage

The ULBs shall made arrangement for safe storage of segregated combustible fraction of waste for conversion to RDF. ULBs own RDF Plants shall have, separate storage facility for RDF. In smaller ULBs, depending on the frequency of transportation of material to nearest RDF Plant or waste to energy facility, storage facilities for waste fractions shall be provided. As per the guidelines of CPHEEO Manual, adequate arrangement for firefighting approved by the competent authority shall also be installed.

6.4. Transportation

The safe and regular transportation of RDF or segregated combustible waste fractions to nearest waste to energy or cement plants (as the case may be) shall be done by ULBs or Private operator or by the cement plant (as varies from case to case). To ensure same, long term agreements have to be signed by the parties. As per the agreement, the RDF or segregated combustible waste fractions can be sent in the form of fluff, bales or pellets. To optimize transportation cost, reverse haulage options may be explored by the parties. The weighment record of material transported and received by waste to energy plant or cement plant shall be maintained at both sites.

The RDF co-processing in cement plants involves three key steps involving collecting and supplying MSW to RDF plants for RDF production followed by use of RDF in cement kilns. The figure 13 below presents flow of MSW to RDF plants and then supply of RDF to cement kilns.

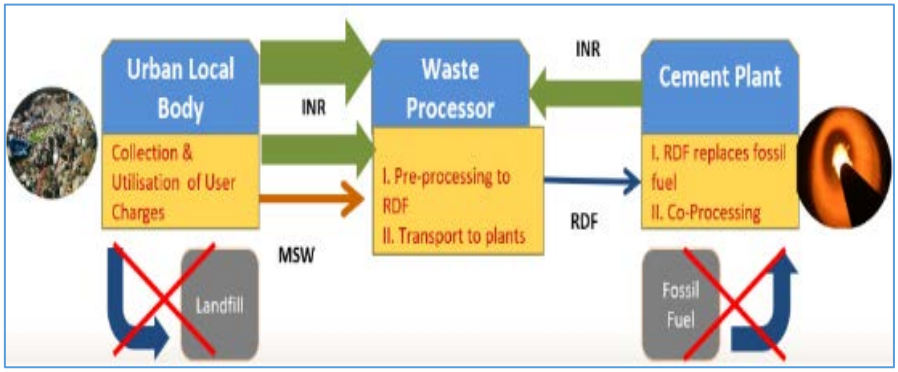


Figure 13. Flowchart of MSW to RDF plant to RDF co-processing in cement kilns

The RDF from other ULBs can also be sent to waste to energy plants in similar way.

7. RDF Preparation & Quality Check Mechanism

The key processes involved in RDF production are summarized below in table 9 and Fig. 14.

7.1. Steps for RDF Preparation

For producing RDF, it is desired that source segregation is rigorously implemented and collection and transportation of the dry fraction of the MSW is carried out separately. The dry fraction is first processed to remove the recyclable materials. The left-over material, which is segregated combustible fraction, is then processed through a dedicated facility having screening, shredding, air density separation, blending, etc. to produce the desired quality SCF/RDF. The schematic representation of process is given in fig. 14

Table 9. Standard components of RDF plant

S.No	Standard components of RDF plant
1.	**MSW receiving, sampling, hand sorting and bag-opening area:** The MSW arriving in trucks or compactors is unloaded for collection of samples, hand sorting of large components and transported to the bag opening machines.
2.	A **twin shaft primary shredder** is designed to shred MSW to less than 100 mm
3.	A **rotary trommel** is then used for separating the fine sand and silt from the MSW before it can be sent for further processing. The material tumbles in the rotary screen as it moves ahead across the length of the screen and the fine silt and sand gets removed through the holes provided in the screen. The rest of the material is discharged onto the belt conveyor which carries the material for further processing. After the trommel, a belt for hand sorting (separation of recyclables) should be placed.
4.	An **air density separator and dryer** consists of a rectangular column designed to separate out light fractions from heavy inert. The material is introduced at the top section and air blast is given at its bottom. Both incoming and outgoing materials pass through their respective airlock valves. It is a three stage process. High pressure air blast de-agglomerates the incoming materials and the very light fraction is sucked up. Furthermore, the air blast from the bottom of the column moves the medium sized fraction of the material up in the air. The bottom fraction consists of heavy material that falls through the airlock and gets discharged. Hot air can also be injected in the system to lower the moisture content of material.
5.	A **twin shaft secondary shredder** is designed to shred the material to less than

	50 mm. Further components include again a main drive motor, a reduction gear box, other integral components and a starter panel.
6.	The **fine shredder** is designed to reduce the size of the RDF fluff after it has passed through the secondary shredder.
7.	Finally, a **pellet press (optional)** is designed to produce fuel pellets with a 16 – 25 mm diameter by extrusion. Ground and conditioned material is fed to the pellet press by gravity feed. A roller presses the material through die holes and extrudes the material. The size of pellets can be adjusted by a knife provided below the die press. The pellets are cooled on a cooling conveyor and sent for storage.
8.	Testing of RDF and Transportation to cement plants/ waste to energy plants

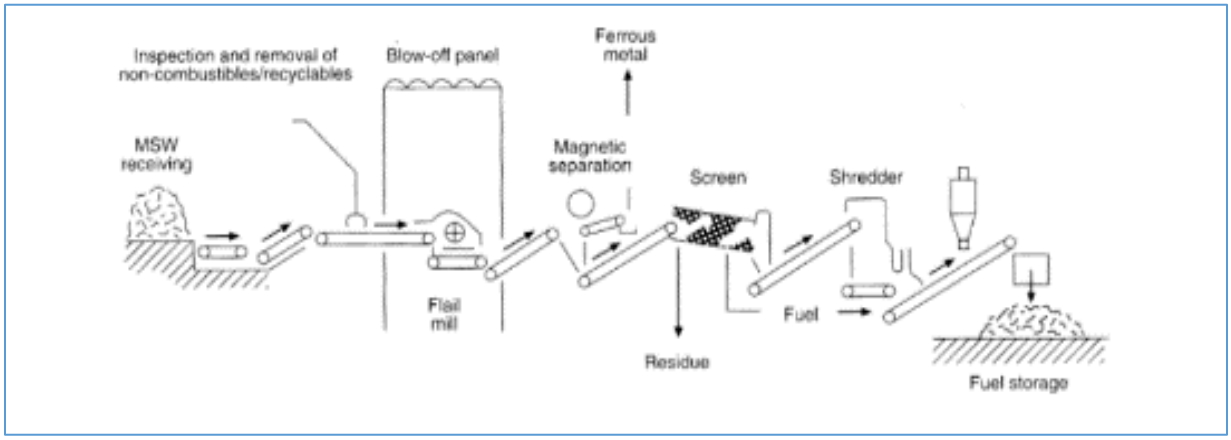


Figure 14: Schematic overview of RDF manufacturing process[53]

7.2. Steps for quality check of RDF at co-processing facility

According to the Guidelines of the CPCB[54], (Section 3.0) for Treatment, Storage & Disposal Facilities (TSDFs), Stand-alone Pre-processing Facilities and Cement plants shall undertake pre-processing and co-processing of wastes as per the Standard Operating Procedures (SOPs).

Section 5.5 of the CPCB guidelines lists steps on how waste categorisation should be carried out 'before pre-processing and ultimately co-processing into the cement kilns'. It is

[53] Murdoch University (2009) http://www.see.murdoch.edu.au/resources/info/Tech/waste/
[54] Draft guidelines for pre-processing and co-processing of hazardous and other wastes in cement plants as per H&OW (M&TBM) rules 2016. Technical report, Ministry of Environment and Forests, Govt. of India, 2017. http://www.cpcb.nic.in/final_report_27.01.17.pdf

assumed that this is valid at both input and output stages of a pre-processing facility as well as at the receiving end, i.e., the cement plant. The following steps shall be undertaken:

(i) Upon receipt of the waste, it shall be weighed and property logged.

(ii) It shall then undergo a visual inspection to confirm the physical appearance.

(iii) A representative sample of the waste shall be collected and sent to the onsite laboratory for finger print analysis. The finger-print analysis should be done for each consignment of waste received for pre-processing or co-processing, i.e., at both the input (raw feed) of the RDF plants and the output (RDF) of the plant.

(iv) The following should be part of the analysis:
- Moisture content
- Ash content
- Chloride and Sulphur content
- Net Calorific Value (NCV)
- Any other specific parameter, which may be decided on merit of each case keeping the clinker production process in focus.
- Heavy metal analysis, Reactive Sulphide, Reactive Cyanide or Halide analysis, if present.

7.3. Methodology

The recommendations do not specify the exact methodology to be followed for waste categorisation but mention:

“Starting from sampling like collection of a representative sample, its storage in suitable container, avoiding any adulteration during transportation to lab, sample preparation in lab, performing test as per BIS for different quality parameters and carefully observing, recording and comparing the results”.

The Bureau of Indian Standards (BIS) has no standard for selection of representative waste sample and transportation to the lab. However, IS 9234 provides method for sample preparation and a few standards exist for measurement of some required values, namely particle size, moisture content, calorific value.

7.4. Concerned Standards

The BIS standards are presented in table 10 below.

Table 10- BIS Standards

Stage	Standard
Glossary of terms relating to solid wastes	IS 9569
Methods for preparation of solid waste sample for chemical and microbiological analysis	IS 9234
Physical Analysis and Determination of Moisture in Solid Wastes (Excluding Industrial Solid wastes)	IS 9235
Methods of Analysis of Solid Wastes (Excluding Industrial Solid Wastes)	IS 10158

In the absence of standards for other parameters, namely ash, chlorine, and sulphur content (specifically for solid waste), either the BIS can make these standards (especially for solid waste/RDF), or an international set of standards be used, especially designed for RDF, e.g., ASTM (American Section of the International Association for Testing Materials):

Table 11 ASTM Standards

Stage	Standard
Test Method for Collecting Gross Samples and Determining the Fuel Quality of RDF	ASTM D5115 - 90(1996) Standard
Standard Practice for Preparing Refuse-Derived Fuel (RDF) Laboratory Samples for Analysis	ASTM E829 – 16
Test Method for Thermal Characteristics of Refuse-Derived Fuel Macro samples,	ASTM E955-88(2009)e1 Standard
Test Method for Residual Moisture in Refuse-Derived Fuel Analysis Samples	ASTM E790-15 Standard
Test Method for Determination of Forms of Chlorine in Refuse-Derived Fuel	ASTM E776-16 Standard
Test Methods for Total Sulfur in the Analysis Sample of Refuse-Derived Fuel	ASTM E775-15 Standard

The Geocycle facility in India routinely pre-processes segregated combustible fraction and feeds the processed RDF to its own cement plants. The methodology for doing finger print analysis and standards followed by them are as under:

(i) *Sample selection for laboratory analysis*

a) Method of coning and quartering**:** This method is used to reduce the sample size of a material. It involves pouring the sample into a cone and then flattening it out in a cake. The cake is then divided into four quarters and two quarters on the opposite side are discarded. The other two quarters are grouped together and the process is repeated until an appropriate size sample remains. Table 12 presents the BS EN British Standards used.

Table 12. BS EN British Standards

Stage	Standard
Methods for sampling	BS EN 15442:2011
Methods of preparation of laboratory sample	BS EN 15443:2011
Methods for the preparation of the test sample from the laboratory sample	BS EN 15413:2011

b) The resulting sample is then dried in an oven followed by shredding to a very fine size of <1 mm or <2 mm.

(ii) *Frequency of sampling*

The finger print analysis is carried out either on consignment (i.e., each truck) or shift (once or multiple times per shift), or daily average basis (many times during the day and averaged). The frequency depends on the expected variability of the consignments [21].

(iii) Parameters measured and standards used:

For finger print analysis, the parameters are measured as per BS EN Print Analysis Standards (Table 13).

Table 13. BS EN Print Analysis Standards

Parameter	Standard used
Particle Size	BS EN 15415-1:2011
Net Calorific Value	BS EN 15400:2011
Ash content	BS EN 15403:2011
Moisture content	BS EN 15414-3:2011
Chlorine content	BS EN 15408:2011

7.5. Testing Infrastructure

Most cement plants are equipped with a laboratory to carryout finger print analysis on conventional fuels (like pet-coke). A typical laboratory contains the following setup as defined in table 14.

Table 14 Laboratory Infrastructure Details

Sr. No.	Parameter	Equipment details	Number
1	Moisture content	Oven	2
2	Ash content	Furnace	1
3	Chloride	Autotitrator	1
4	Calorific value	Bomb calorimeter	1
6	Auxiliaries	Analytical balance	1
7	Auxiliaries	Distilled water system	1
8	Auxiliaries	Sieves (different sizes)	1
9	Auxiliaries	Top loading balance	1
10	Auxiliaries (optional)	Cutting mill with cyclone system	1
11	Auxiliaries	Hot plate	1
12	Auxiliaries	Sampling tools (Scoops, shovel, trays made of S.S.)	1
13	Auxiliaries	Glassware (Beakers, volumetric flasks etc.)	1
14	Auxiliaries	Pure Oxygen cylinder with regulator	1
Source: Geocycle			

A similar laboratory setup will need to be installed by the RDF producers to ensure that quality product is supplied to cement plants and a mechanism to be put in place to maintain the record of quality of RDF supplied.

8. Role of Stakeholders

This section of the report deals with the role of various stakeholders involved in rollout of RDF co-oprocessing.

8.1. RDF Producers- ULBs & Private Operators

To promote the use of RDF the following should be undertaken by ULBs:

(i) In most urban local bodies, waste management services are implemented by contracts or in public private partnership model. Therefore, at the stage of tender, if cement plants or waste to energy plants are available within a reasonable distance (100/200kms) utilization of RDF in these facilities needs to be mentioned in contract documents.

(ii) To ensure implementation of source segregation and collection and transportation of segregated MSW for resource recovery so that only non-recyclable combustible fraction needs to be sent for co-processing.

(iii) Long term tripartite agreements for the supply of RDF could be signed by ULBs, RDF Producers and cement plants (like signed for compost).

(iv) Recovery of user charges for operation and maintenance (including transportation) cost for RDF plants through tipping fees for RDF producers and to access Swachh Bharat grant/ funds for setting up RDF facilities.

The RDF producers will be responsible for making RDF as per standards defined in section 5 and agreed by end user (cement or waste to energy plant). The process of RDF preparation is covered in section 6.1. The representation of same in block diagram is given below in figure 15:

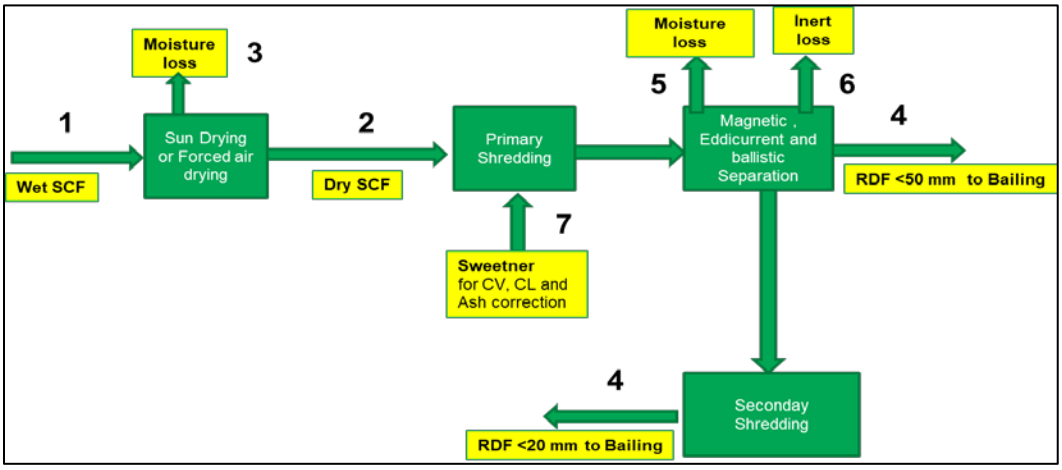


Figure 15 Process block diagram for manufacturing RDF from SCF

In case RDF producers have an integrated waste management contract from urban local bodies, implementation of source segregation and collection and transportation of segregated waste has to be ensured for maximum resource recovery.

8.2. RDF Users– Cement plants and waste to energy plants

The RDF users shall clearly define the RDF specification (as per the standards defined in section 5) and can enter into long term agreement with RDF suppliers.

The cement plant using RDF requires additional equipment which will depend on a number of factors such as:

(i) type and number of RDFs that are to be used
(ii) the final envisaged TSR at the cement plant
(iii) the design of the existing facilities at the cement plants
(iv) the design of the kiln (kiln type) with regard to the details of the RDF feed, combustion and lining of calciner

While several existing components within the cement plant can be used (e.g. the weighbridge for the incoming trucks, assumed to be already available), other components need to be constructed in addition to the existing components at a cement plant. An overview of the equipment required is presented below.

a) **Receiving facilities (including sampling station and laboratory):** The cement plants need to have sufficient data on the received RDF to ensure undisturbed operation of clinker production. Accordingly, facilities are required to take samples of the RDF from the incoming trucks and to analyse the referred parameters of the RDF (e.g. NCV, heavy metals, etc.).

b) **RDF pre-processing**: It is assumed that the RDF is produced and supplied to the cement plant at high quality avoiding any treatment requirement at the cement plant. Nevertheless, suitable pre-processing especially with regard to mixing or homogenisation may require related equipment to be installed at the cement plant. In addition, mobile technical equipment such as wheel led / front-end loaders may be required.

c) **RDF storage:** Continued supply of fuels is a key condition to be maintained at the cement plant. Accordingly, storage facilities for RDF need to be constructed at the cement plant duly considering the fire hazard associated with RDF storage.

d) **RDF dosing, feeding and burning system:** This includes for example a weight belt feeder. In addition, the detailed location of RDF burning (feed points) within the clinker production process (e.g. main firing, kiln inlet firing, secondary firing or pre-calciner firing) determines the requirement for installation of the related feeding

and burning system. Usually it is a mix of several feed points (options are shown in figure below). Compliance with air pollution regulations might result in the need to install further components and equipment.

The facilities and equipment described above shall generally include measures to minimise impacts from odour and to prevent health risks for the workers and the neighbourhood. In addition, power supply and firefighting facilities are required.

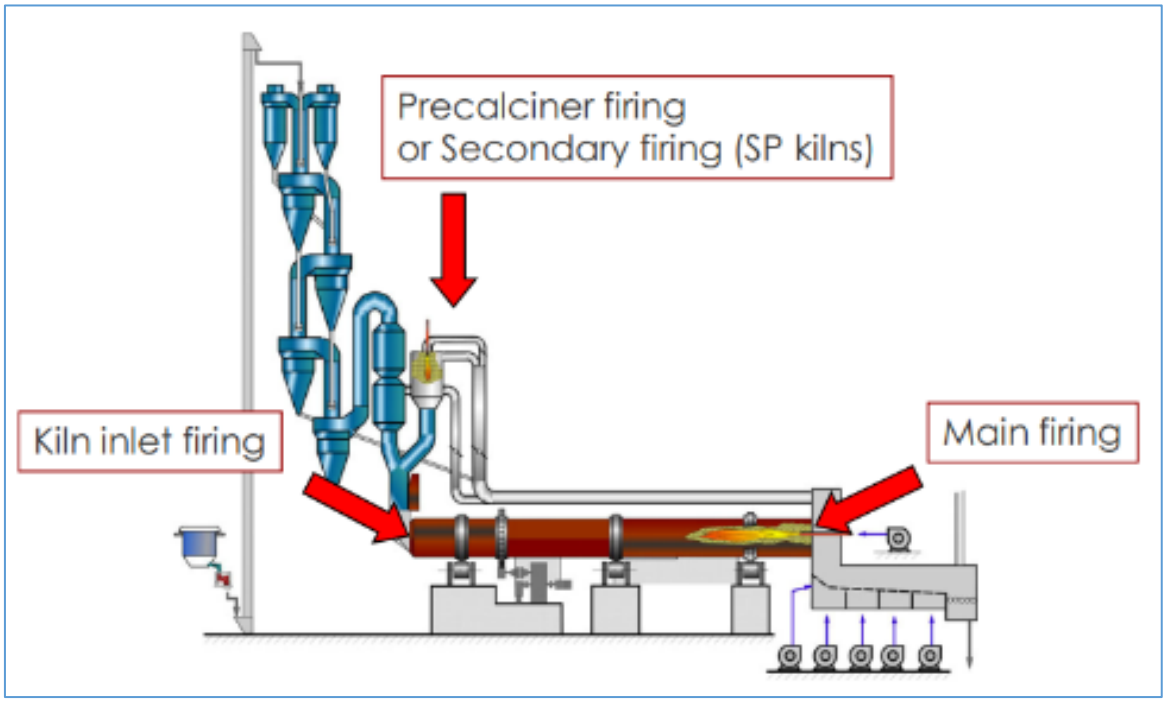


Figure 16: Options for fuel feed points at cement kiln[55]

8.3. Regulators

As per Central Pollution Control Board (CPCB) guidelines, a waste type (i.e. RDF) that was tested and approved in one cement plant can be used for regular co-processing in another cement plant and state pollution control boards (SPCBs) can provide approval based on the CPCB guidelines. The SPCB should ensure that emissions are monitored and reported by cement plants as per the guidelines. Emissions limits proposed for India and their comparison with limits in other countries are presented in Table 15 below:

[55] GIZ/Holcim (2011)

Table 15: Emission limits for cement kilns co-processing in India[56]

Parameter [a]	EU limit	US (Load Based)	South Africa	India [b]
Total Dust	30	0.005 kg/t of clinker [c]	30	50 (or 0.125 kg/t of clinker)
HCl	10		10	10
HF	1		1	1
NO_x for existing plants	800	0.75kg/t of clinker	800	800
NO_x for new plants	500			600
Cd + Tl	0.05		0.05	0.05
Hg	0.05		0.05	0.05
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0.5		0.5	0.5
Dioxins and furans (ng I-TEQ/Nm3)	0.1 [d]		0.1 [d]	0.1
SO2	50 [e]	0.2kg/t of clinker	50 [e]	100 [f]
TOC	10 [e]		10 [e]	
CO	National values			

[a] Daily average values for continuous measurements (mg/Nm3)

[b] Limits proposed to come into force from 01.08.2015 (IIP, 2014); Emissions limits of EU, US and South Africa taken from Hasanbeigi et al., 2012

[c] Emissions on a 30-operating day rolling average

[d] Dioxins and furans must be measured at least twice a year, and at least every 3 months for the first 12 months of a plant's operation

[e] Exceptions may be authorized by component authority if TOC and SO2 do not result from the incineration of waste

[f] Relaxable up to 400 by SPCBs in special cases, CPCB proposed 100 (for <0.5% sulphur in raw materials), 1000 (for >0.5% sulphur in raw materials)

For waste to energy plants also, environmental compliances need to be monitored as per requirement by SPCB. The official communication in this reference is attached as Annexure II. It should be ensured that RDF derived from MSW shouldn't be used without emission control system.

[56] CPCB (2015), page 23

Part C: Financial Analysis and Rollout Models

9. Financial Analysis and Funding Support

For making the operational and financial models successful, this report also suggested the pricing of various grades of RDF in comparison with coal.

9.1 Comparison with Coal

Coal still makes up around 90% of the energy input in cement plants around the world, despite the environmental concerns. It takes 200 - 450kg of coal to produce 1 tonne of cement. The cement industry consumes around 4% of global coal production, about 330 million tonnes per year. Under the Alternative Fuel and Resources (AFR) concepts, there are ample ways to substitute coal in cement manufacturing without adding to emissions and saving on natural resources by using waste of equivalent energy.

The drive for AFR has been the EU legislation which along with economic factors enabled the European cement producers to achieve an average alternative fuel substitution rate of around 35%. If the entire global cement sector achieves this substitution rate on average by 2050, it would significantly reduce the amount of coal (and other fossil fuels) required. In light of this, it is estimated that 25% is a reasonable estimate for a global alternative fuel substitution rate by 2050. However, the rapidly-expanding infrastructure projects around the world, particularly in developing countries where coal is the main fuel, coal usage for cement is likely to continue in the absence of any strict regulation.

In India, coal is the predominant fuel (10 MTPA) used for cement production but shortages in coal supplies are making imports necessary. Both quality and availability have seen variations, while price increases have been noted. The price of coal varies depending upon the region of the country, mainly because of transportation costs. The prices of thermal and industrial coal vary from INR 1900- 4500/MT. Continuous supply of coal is also a concern and many cement and power plants have been forced to halt operations at times due to lack of coal. This situation provides impetus for a regular and sustainable use of RDF in cement industry, as a substitution rate of even 5% will result in RDF utilization of about 0.5 MTPA, which is 3% of total RDF potential out of municipal solid waste. The table below presents the comparison in the Coal vs RDF.

Table 16. Comparison between Coal and RDF

Fuel/Factor	Coal	RDF
Calorific Value (Kcal/Kg)	3000-6000	2500-4500
Equivalent Ton in calorific value	1	1.15
Cost per Ton in Rs. (Avg.)	2100-4500	1100-1800
Sulphur content (weight %)	0.4	0.2-0.5
Moisture content (weight %)	3-9	10

Ash content (weight %)	4.2	<15
NOx content (weight %)	1.2	1-1.5
Carbon (weight %)	31.4	35-40
Oxygen (weight %)	7.4	25-30
Hydrogen (weight %)	4.3	5-8

9.2 Preparatory Requirements in Cement Plants for use of RDF

Cement manufacturing companies have different approaches for management of cost for use of alternative fuels. Some companies have company-wide initiatives to invest in upgrades to kilns or to materials handling equipment to initiate use of alternative fuels, and also promote pilot projects in which different cement plants of the company conduct studies of different alternative fuels. In addition to the cost of modifications to the kiln or materials handling system, the cost of performance testing is also incurred to establish use of alternative fuels in cement production. Performance testing is generally required by state air quality regulations, to determine that the cement kiln operation with AFR is in compliance with its air emissions permit conditions.

There are various aspects to the overall cost of alternative fuels, including the capital costs and operating costs of:

- Kiln and equipment upgrades;
- Performance testing;
- Alternative Fuel conditioning (preprocessing);
- Engineered fuel production;
- Material transportation;
- Continuous Emissions Monitoring Systems (CEMS);
- Sampling and testing of materials; and
- Material acquisition.

Several cement manufacturing companies have already conducted experiments in their cement kilns for utilizing wastes and other hazardous wastes as alternate fuels and have demonstrated success. The CPCB was also a partner in some demonstration studies to establish the compliance to emissions. Thus, it only remains that the AFR system is established in the cement manufacture in India, for which suitable economic pricing has to be derived.

9.3 Pricing of RDF

As discussed in earlier section of the report, the usage of municipal solid waste derived RDF in cement kilns would entail additional cost towards its processing, transportation, the feeding mechanism and its modifications, monitoring of emissions and the quality of cement output. These costs in RDF usage need to be properly apportioned, as per

requirement in comparison with the corresponding costs for coal vis-à-vis the calorific values. The data regarding the coal substitution by RDF and the cost needs to be generated on case to case basis at each location of the cement plant and the source of MSW – RDF.

For initiating the RDF usage in cement industry, the Committee Members agree that different RDF types have different calorific values, and so the cost of each combustible has to be expressed in INR per Kcal/kg to be comparable. The commercial acceptability of properly processed RDF was agreed at Rs. 0.4 per 1000 Kcal/kg by the members with reference to the specifications as defined in the report. The acceptable prices of the respective grades of RDF work out to following:

Unit	SCF	RDF Grade III	RDF Grade II	RDF Grade I	Industrial Coal
Kcal/Kg	1500	3000	3750	4500	3000-4200
INR/Ton	600	1200	1500	1800	4500

The mentioned price would be for the <50 mm size material that is suitable for In Line Calciner (ILC) and delivered at the cement plant gate. For Separate Line Calciner (SLC), the same will be cheaper and can get negotiated between the RDF operator & the Cement plant. Since nature, quality and acceptability of SCF by cement plants will be very much dependent upon the segregation and quality control at the ULB level and its utilization feasibility also will be plant specific, the commercial terms related to transaction of SCF between cement plant and ULBs can be negotiated between them on case to case basis. However, the most sensitive part of the RDF / SCF cost i.e. transportation will have to be borne by the Urban Local Body concerned, in charge of the function of scientific management of municipal solid waste.

Overall, once RDF of the quality/specifications is made available on dependable basis, within the transport influence zone of a cement plant, market forces would take over whereby the ULB, the RDF processors and cement plant would negotiate an agreeable cost of RDF considering various factors. The SWM and other applicable Rules will act as enablers for such AFR regime.

9.4 Indicative Cost- Capital and Operation & Maintenance

The detailed analysis clearly shows that there is huge potential of utilization of RDF in cement plants and waste to energy plants, but due to lack of standards and viable business models the practice is not implemented at scale in the country. The standards are recommended in section 6 and financing needs, gaps and instruments for fiscal incentives are detailed in subsequent sections. The indicative capital investment (Capex)

and operation and maintenance (O&M) cost for setting up 100, 200 and 300 Tonne Per Day (TPD) given by RDF processors / producers are summarized below.

Table 17: Indicative Capital and Operation and Maintenance Cost of RDF Plants of various sizes

Parameters (INR)	Size in TPD		
	Upto100	100-200	200-300
CAPEX (Source 1)		240,000,000	
CAPEX (Source 2) 25 mm	153,000,000	341,910,000	447,690,000
CAPEX (Source 2) 50 mm	125,400,000	215,580,000	295,250,000
OPEX (Source 1) <20 mm		1750	
OPEX (Source 1) <50 mm		1400	
OPEX (Source 2) 25 mm	1390	1870	1851
OPEX (Source 2) 50 mm	1150	1200	1280
Transportation Cost for 100 Km per tonne (@Rs 3 per Km)*	300	300	300

** The cost of transportation decreases with increase in distance and reverse haulage options.*

The capital costs and operation and maintenance costs for co-processing of RDF includes following:

(i) Capital costs for setting up RDF Plants
(ii) Capital cost for storage and feeding mechanism (retrofitting) of RDF at cement plants,
(iii) Operational costs for RDF production
(iv) Transportation of RDF to cement plants/ waste to energy plant
(v) Operational cost for using RDF at cement plants / waste to energy plant

The indicative capital and O&M cost is presented in Table 18 and Table 19. The entire cost working is based on theoretical knowledge & discussion with various experts and is subject to change from time to time.

Table 18. Tentative Capital Cost for setting up to 100 TPD plant

S.No.	Items	Cost (Rs. Lakhs)
1	Air Shifter (1 nos.)	25
2*	Shredder Metso (14tph @ 50mm X1 nos.)	390
3*	Screen, Ecostar make for segregation & recycling 1 no. @12 tph	145
4*	Baling Machine (1 X 15tph)	102
5	Magnetic band (1 no.)	3

6	Conveyors (50 mtrs length approx)	13
7	Weigh Bridge-60T	11
8	Electricals	
a	600 KVA transformer	10
b	1 nos. of 365 KVA DG	22
c	Panel & cables	10
d	VCB	4
e	Earthings	5
f	Lighting of shed & boundary wall	15
9	Civil (Covers Boundary wall, office block, rain water harvesting, bore well, soaking pit, road, toilet etc.)	172
10	Covered Shed (2000 sqm)	200
11	Office furniture & computer	2.5
12	Lab equipment	10
13	Fire fighting	30
14	Reject collection Bins- 6 nos.	3
15	Electrical Connection charges (govt. department)	10
16	Vehicle (JCB 1 nos. & Tractor 1 no.)	35
	Total	1217.5
	Contingency @3%	36.5
	Grand Total	1254.0
	Rounded Off	12.55 Cr

(Source: M/s IL&FS Environmental Infrastructure & Services Ltd.)

Table 19 Tentative Operation and Maintenance Cost for setting up to 100 TPD plant per tonne (100 TPD X 50 mm Shredded RDF Duly Baled Line)

S.No.	Activity/ Equipment	100 TPD Shredding Line		
		Unit	Cost (Rs.)	Remarks
1	Shredder consumables	per ton	110	Refer Metso mail
2	Others mechanical equipment consumable & maintenance	per ton	50	-

3	Power consumption for 8 hours (387.5 kwhr @ Rs.11 per kwhr) (Load factor = 0.8)	per ton	273	Air Shifter=20 kW Shredder=250kw Screen= 7.5kw Baling mc= 60 kW Conveyors= 20kw Lighting = 10kw Others = 20 kw **Total = 387.5 kw** (Assumed 80% load factor) (*(387.5 X 80% X 8 X 11)/100 = 272.8)
4	6 man-days @ Rs.600 per day for shredders & screen operation & manual sorting over the conveyors	per ton	36	-
5	Mechanical Handling (Man Power + JCB+ Tractor)			-
a	Vehicles charges for 8 hours@ Rs. 625 per hour	per ton	50	-
b	4 man-days @ Rs.600 per day	per ton	24	-
6	Staff & Technicians			-
a	Assistant manager (1 no. @ 5lakh per annum)	per ton	14	-
b	Accountant (1 no. @ 3lakh per annum)	per ton	9	-
c	Supervisor (1 no. @ 3lakh per annum)	per ton	9	-
d	Security (3 nos. @ 10244 per month)	per ton	11	-
e	Weigh bridge operator (1 no. @ 18000 per month)	per ton	6	-
f	Store man (1 no. @ 18000 per month)	per ton	6	
g	Electrician (1 no. @ 18000 per month)	per ton	6	
7	Interest (15%) & Depreciation on Capex on Rs. 1255 Lakh	per ton	547*	
	Total (Rs. Per ton)		1151	

*Depending on cost sharing in form of grant, the cost of operation will reduce appropriately.

During deliberation the industry expert informed that the CAPEX for setting up MSW to RDF processing plants considering that **segregated dry waste is provided to the facilities** varies from INR 984,167 per TPD to 1,709,550 per TPD, the significant range is due to various factors like size of the RDF, cost of imported or domestically manufactured equipment etc. The average of all CAPEX values shared is around INR 13,21,31 per TPD.

If for simplification the TPD CAPEX is divided by 10 years and 300 days of operation, then the cost of CAPEX per tonne of RDF is around INR 440 while for the lowest CAPEX value it is around INR 330.

The OPEX ranges from INR 1150 per tonne to INR 1870 per tonne with higher OPEX for less than 20 mm sized RDF and low OPEX for 50 mm sized RDF. The average value for all OPEX values provided is INR 1486. The transport cost is around INR 3 per tonne per km and for a transport distance of around 100 Kms will add INR 300 to the total cost. However, the cost of transportation decreases with increase in distance. For e.g. dry segregated & bailed SCF from Goa, is transported to distance of 600 Kms in 10-wheeler truck which carries approximately 13-14 Tones per trip. The transportation of RDF of grade I, II or III also being of similar bulk density therefore can be transported in similar way. The cost of transportation varies from INR 2.8 to 3.2 per Kms.

9.5 Financing Gaps

The cost of RDF production in India is much higher than the price cement plants are willing to pay. The transport is a major concern while arriving at the RDF cost. Transport is a major contributor to this financing gap, therefore, depending on the distance between the cement plants and the RDF plants (that could be from 100 km to 1000 km) the financing needs will vary. Further the cost per tonne per km also tends to vary as trucks transporting cement or other products to cities can carry RDF on their way back or long-term contracts can enable negotiating prices lower than existing market rate of INR 3 per km per tonne. The transportation cost makes lot of difference whether truck return is empty or he has load on both sides. In general, the pay load of SCF / RDF vis-a-vis materials which have Bulk Density ≥ SCF / RDF, depending upon the configuration in which it is loaded varies from 0.25 to as high as 0.6 or even 0.7.

Thus there is no fix formula which can define freight of carrying the said commodity. Even most of the transporters are reluctant to carry SCF / RDF due to its inherent properties like foul smell, moisture etc. For the purpose of the report various capacities of truck and prevailing rates are given below:

Table 20. RDF transportation cost

Transportation distance (Km)	Transportation Cost (Rs./ Km/tonne)
0-30	10 to 12
30-120	7 to 10
120-250	4 to 7
250-600	3 to 4
600 -1300	2.8 to 3.2

Table 21. RDF transporting capacity of trucks

*Truck Type (*No. of Wheels)	*RDF Quantum in Truck (Tonnes)*
10	13 to 15
12	18 to 21
14	21 to 23

Table 22: Indicative Cost of Transportation based on low interest rate

	Distance in km										
INR/ tonne/ km:	20	50	100	150	200	300	400	500	700	900	1000
0.5	671	701	751	801	851	951	1051	1151	1351	1551	1651
1	691	751	851	951	1051	1251	1451	1651	2051	2451	2651
1.5	711	801	951	1101	1251	1551	1851	2151	2751	3351	3651
2	731	851	1051	1251	1451	1851	2251	2651	3451	4251	4651
2.5	751	901	1151	1401	1651	2151	2651	3151	4151	5151	5651
3	771	951	1251	1531	1851	2451	3051	3651	4851	6051	6651

9.6 Fiscal Incentives for Promoting Usage of RDF

To promote use of RDF or segregated combustible fraction of MSW, capital investments in following are required.

i. Storage facilities for ULBs where preprocessing / RDF plant is not set up at site.
ii. Transportation vehicles (in case transportation is not out sourced)
iii. RDF Plant

The above-mentioned capital investments can be supported by the Government through **Swachh Bharat Mission Funds, 15th Finance Commission, State/ULB** funds as given below**.**

9.7 Financing Instruments

The financial requirements in form of capital investment for setting up RDF Plants and by providing output-based market development assistance (OMDA), various options of domestic and international financing opportunities are summarized below.

9.7.1 Central Government Sources

The funding support can be extended from the following schemes of the central government:

a) Swachh Bharat Mission – Urban (Grant/ VGF)

Till 2nd October' 2019 the Swachh Bharat Mission is expected to allocate INR 7,366 crore on MSW management. SBM funds are to be invested in waste management activities, with an upper limit of 35% of total capital cost, which can be combined with other sources of financing. Output based assistance can be funded during mission period, considering that total value of the support does not exceed 35% of the capital cost in value. Urban local bodies can access the funds for setting up RDF plants.

b) Smart Cities Mission (SCM) (Grant)

Each of 100 selected smart cities is entitled to INR 500 crore from the central government over four years, with state and city governments expected to contribute another INR 500 crore. Two fifths of the central government funding will be provided upfront in the first year, after which yearly instalments will be disbursed in consecutive years if certain conditions are met. The mapping of cement plants shows that more than 50% of Smart Cities are within 200kms range and therefore SCM funds can be utilised for setting up RDF Plants.

9.7.2 State Government Sources

Goa cess on packaging (Grant) - A case

The State of Goa has introduced a cess of 0.5% of sale price or INR 200 per item sold whichever is less, on the value of goods sold. With this revenue a subsidy of INR1500 per tonne of MSW processed is granted to a 100 TPD MSW to RDF production plant.

9.7.3 Urban Local Body Sources

User charges (Operation and Maintenance cost)

MoHUA has drafted the bye laws for levying User Charges on SWM services under SBM in September 2016. Currently, the charges are commonly applied by Indian municipalities,

albeit at very low levels out of which a minimal amount is spent on treating MSW. The user charges can be used to pay tipping fees to RDF producer for processing of RDF. The Geocycle suggested approach to improve viability of MSW treatment given below:

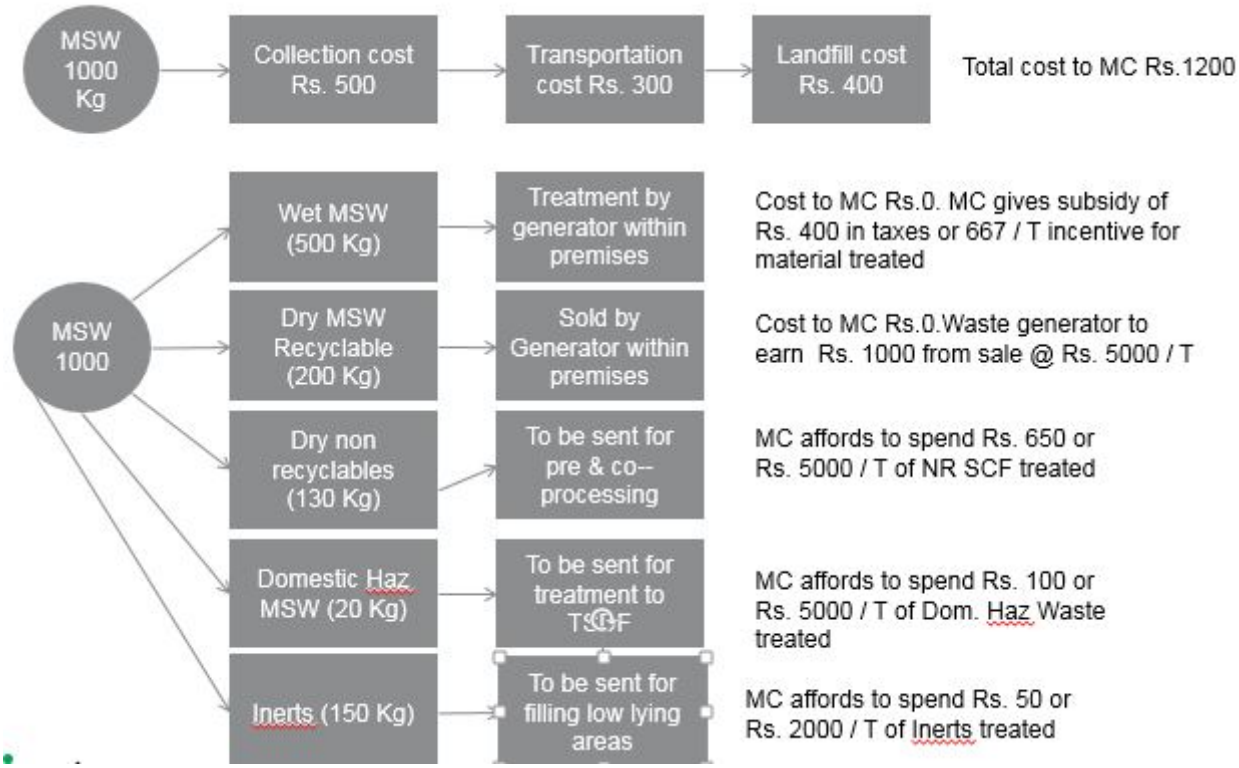


Figure 17: Potential Cost and Revenue model for Urban Local Bodies

9.7.4 Other Sources

a) Corporate Social Responsibility (CSR) funding (Grant)

Under the Companies Act 2013, Indian companies with an annual turnover exceeding INR 1000 crore or a profit exceeding 5 crores have to spend at least 2% of the average net profit in three consecutive years on CSR activities. The total volume of such funding is estimated to reach INR 20,000 crore (PwC and CII 2013). In Varanasi CSR funding from NTPC enabled reopening of an idling compost plant. A campaign to tap CSR funding for RDF plants could unlock significant funding.

b) International Support Mechanisms

In addition to domestic sources funding from International Support Mechanisms (Grants and Loans) can also be explored. This includes, market mechanism like Clean Development Mechanism (CDM), Multilateral climate finance through Green Climate Fund (GCF), NAMA facility etc.

10. Rollout models and bid parameters

To expeditiously achieve the objectives of Swachh Bharat Mission, the standards recommended at 5.5 need to be supported with working operational and financial models. Such three models are suggested below to facilitate ULBs/ Cement Plants to enter into suitable agreement and start using RDF as coal replacement in suitable proportions

10.1. Operationalization Models

Suitable models as suggested in subsequent paragraphs can be adopted for preparation and operationalization of MSW based RDF by ULBs. Based on existing scenario in the country, three types of plants can process MSW to RDF with or without retrofitting requirements as defined in table 23.

Table 23: Types of RDF Plants and Retrofitting Requirements

S.No	RDF plant type	Retrofitting Requirements
1	Newly constructed RDF plants	No retrofitting required since they will be installed with suitable technology to produce RDF as per cement plants requirements.
2	Already operating composting plants, or composting plants under development, that would be upgraded by adding RDF production line	There will be a need for installing shredders, air-density separators, and trommels and in some cases palletisation units to ensure that the RDF produced is suitable for use in cement plants.
3	Non-operating RDF plants, or RDF plants that currently operate at low output or produce RDF of insufficient quality, that would be retrofitted for production of cement grade RDF at full capacity	Depending on the configuration and state of the plant, there will be a need for upgrading or retrofitting.

10.1.1. Model 1: Standalone RDF unit for an ULB

The ULBs with 5 Lac population generates approximately 200-250 tonnes waste daily. Estimated generation of segregated combustible fractions (SCF) is up-to 40-50 tonnes in such ULBs. A new RDF plant can be set up adjoin the existing waste to compost processing facility. The RDF processing plant can also be set up alongside the material recovery facility or dry waste collection centre, where the quantity of non-*recyclable* fraction of dry waste is substantial and uneconomical to transport subsequently to another location for processing of RDF. In case of smaller capacities material recovery facilities, the SCF component can be transported to nearby RDF plant for economical processing of RDF. Various options for operationalization are given below:

i. Addition/amendment to the existing contract/concession agreement with the waste processing facility operator for setting up the RDF plant: The RDF unit can be set up within the compost plant premises by existing contractor with rights to use SCF generated out of compost plant/ combustible portion of segregated waste collected by ULB or its agency. To achieve financial viability of the project, ULB can provide one time grant assistance admissible under SBM i.e. 35% of central grant of project as well as any additional fund requirement from its own resources. Agency operating the plant can also contribute in capex/ opex as per agreement between agency and ULB. A copy of draft agreement is attached at Annexure I. ULB will also facilitate an agreement for purchase of RDF between agency and nearby cement plants, ensuring 100% purchase of RDF by cement plants.

ii. **New contract/concession agreement with an Agency for setting up the RDF plant:** A separate operator or agency can also be engaged through transparent bidding process for setting up separate RDF manufacturing unit within or outside the premises of compost plant, on the cost sharing basis mentioned in para above. A model agreement document is placed at Annexure I.

iii. **Setting up the RDF plant at Material Recovery Facility:** In the case of setting up RDF unit alongside the material recovery facility (MRF), an amendment to the existing contract of the MRF operator will be required. If the ULB had not set up Material Recovery Facility or dry waste collection center, an agency or operator can be engage through transparent bidding for setting up and to operate the proposed facility. This will provide impetus to source segregation, mainstreaming of informal sector and processing of RDF.

In all the three scenario mentioned above, the sale of RDF and recyclables will help to sustain its operation.

10.1.2. **Model 2: RDF unit for a cluster of Cities/Towns**

The ULBs with population less than 5 Lac produce smaller quantities of SCF from its waste to compost facility. Installation of individual RDF units and its sustainable O&M is a challenges for smaller cities. In this model, it is suggested that a cluster of ULBs facilitated by state government, may set up a RDF unit. Depending on the situation this model can be used even for ULBs having population more than 5 Lacs. This purchase-transport model can be exercised as suggested under:

i. A lead ULB takes the initiative for setting up the plant in consortium with other ULBs by pooling up their SBM contribution towards central share. State/ ULB/ Private operator may also put the balance share of project cost and O&M is done by private party. Revenue for operation and maintenance may be generated through sale of RDF to cement plant. The responsibility of SCF transportation to the clustered RDF unit vest with participating ULBs/ its agencies.

ii. ULBs in partnership with the private sector can set the RDF in various financing options: BOT, DBOFT etc. The private agency may charge tipping fee for SCF processing and may also generate revenue through sale of RDF to cement plants.

In all scenarios mentioned above, the sale of RDF and also recyclables will help operator to sustain plant's operation. However, in case the recyclables are not reaching to the RDF plant, because of various reasons including availability of MRF facility/ separate agency for collection and transportation of waste, the private agency may charge tipping fee for SCF processing to sustain plant operation as mentioned above.

Illustrative calculations showing Financial Sustainability for above two models:

The financial viability for different scenarios with or without government financial assistance and/or with or without right on recyclables to plant operator are worked out for a 100 TPD capacity RDF plant in Annexures IV to VII. The financial viability of the RDF facility is worked out in form of Internal Rate of Return (IRR) of the facility over a 10 years period. Here, it may be noted that Internal Rate of Return (IRR) is the interest rate at which the net present value of all the cash flows i.e. receipt and expenses from a project/ investment over the designed life of plant equal to zero. Internal rate of return is often used to evaluate the attractiveness viability of a project / investment with and without subsidy. IRR calculation for different scenarios mentioned above is as under:

(i) RDF Plant with or without Government Grant and without Recyclables

The IRR worked out for this scenario (Annexure IV) shows IRR of (-ve) 33% without Government grant and (-ve) 26% with Government grant for the given assumptions of revenue & operational expenses per annum.

(ii) RDF Plant with or without Government Grant and with 10% Recyclables

The IRR worked out for 5 year payback period scenario (Annexure V) shows IRR of (-ve) 4% without Government grant and (+ve) 23% with Government grant for the given assumptions of Revenue mix & operational expenses per annum. However, in 10 year period payback scenario IRR of (+ve) 12% is achievable without Government grant and (+ve) 33% with Government grant.

(iii) RDF Plant with or without Government Grant and with 20% Recyclables

The IRR worked out for 5 year payback period scenario (Annexure VI) shows IRR of (+ve) 22% without Government grant and (+ve) 64% with Government grant for the given assumptions of Revenue mix & operational expenses per annum. However, in 10 year period scenario shows IRR of (+ve) 33% without Government grant and (+ve) 69% with Government grant.

(iv) RDF Plant with or without Government Grant and with 30% Recyclables

The IRR worked out for 5 year payback period scenario (Annexure VII) shows IRR of (+ve) 43% without Government grant and (+ve) 101% with Government grant for the given assumptions of Revenue mix & operational expenses per annum. However, in 10 year period scenario shows IRR of (+ve) 51% without Government grant and (+ve) 104% with Government grant. The Table below summarizes the financial sustainability of the standalone and cluster based modes.

Table 24. Financial Sustainability for Standalone/ Cluster Models- IRR Calculations

IRR Scenario	With or Without Recyclables	5 Years	10 Years
IRR Without Grant	No Recyclables	-	(-) 33%
	10% Recyclables	(-) 4%	12%
	20% Recyclables	22%	33%
	30% Recyclables	43%	51%
IRR With Grant	No Recyclables	-	(-) 26%
	10% Recyclables	23%	33%
	20% Recyclables	64%	69%
	30% Recyclables	101%	104%

10.1.3. Requirements for take-off by Cement Companies under the standalone and cluster approach models

The Cement companies based on the proposed standard may takeoff the RDF material of the desired grade from the RDF manufacturer on agreed cost from the ***standalone and cluster approach based RDF units***. The responsibility of transporting RDF material lies with cement. The cement companies which intend to use the RDF need to invest in setting up RDF feeding mechanism. Substantially, the cost for setting up auxiliary feeding mechanism will be recovered from the savings from thermal substitution of coal. Calculation with set of assumptions for additional revenue required per cement bag to ensure a payback of additional investment for installation of co processing facility to use RDF as fuel in Cement clinkers within a period of 4 years are presented in Annexure VIII. The additional revenue requirement per bag works out to Rs. 0.41. The Internal Rate of Return (IRR) of the facility over a period of 10 years from the date of commencement of commercial production is 9% without subsidy and 29% with subsidy. The payback period is 7.5 years with an average RDF cost of Rs.1200/-per MT at an average calorific value of 3000Kcal/kg. However, if the RDF price is brought down to Rs.1000 then the payback period would reduce to 5 years.

10.1.4. Model 3: Cement Industry Model

Cement companies in India has also taken the initiative for co-processing of Municipal waste in cement kiln and have established in-house processing facility for the SCF and utilizing it in the cement kiln. It may not be prudent to again set up similar facility by ULB and instead it would be better to utilize their facility by SCF to them. On the lines of draft agreement part of this report, the financial arrangement for lifting and transporting desirable quality of SCF by cement plant may be arrived by transparent means. The report also lists the ULBs in close vicinity of the cement plant at Annexure IX.

10.2. Bid Parameters

For implementation of the above models, it is prudent to say that technically and financially competent companies (private sector) is involved in the partnership with ULBs/ States. The Qualifying Criteria for RDF manufacturers for setting up 300 TPD Municipal Solid Waste based Refuse Derived Fuel in Cement Plants is summarized below:

A. Technical Capacity: For demonstrating technical capacity and experience (the "Technical Capacity"), the Bidder has to comply with the following conditions:

a. Should have at least three years of experience (in last 3 years) of handling collection, storage and transportation of municipal solid waste (MSW) or refuse derive fuel

(RDF) on Public Private Partnership (PPP) projects on BOT, BOLT, BOO, BOOT, DBOOT or Contract Basis or any other similar basis, of following capacity:

(i) One project of 300 TPD, or

(ii) Two projects of 150TPD, or

(iii) Three projects of 100 TPD.

In case, Bidder wishes to form a Consortium, both the Consortium members should individually have technical experience of handling MSW or RDF of at least 50 MT per project for a period of two years.

Consortium formed to qualify only for financial criteria will not be eligible.

Note: The entity claiming above experiences should have held, in the company owing the Eligible Project, a minimum of 26% (twenty six percent) equity during the entire period for which technical experience is being claimed by providing the certificate from Statutory Auditor.

B. Financial Capacity:

a. Turnover: Bidder shall, over the past 3 (Three) financial years preceding the Bid Due Date, has an average annual turnover from operations of similar projects as listed in technical capacity of at least Rs. 25 cr. (Rupees Twenty-Five Crore) and

b. Net Worth: The Bidder shall have a minimum Net worth of Rs. 10 cr. (Rupees Ten Crore) at the close of the preceding financial year.

In case of a Consortium, the combined Technical Capacity and Financial Capacity of both Consortium Members shall be considered.

Supporting Documentation

Bidder to enclose all of the following documents in support of bid:

(i) Certificate(s) from its concerned client(s) in support of above work undertaken clearly stating quantities collected and transported/per day, during the past 3 years in respect of the projects whose experience is claimed.

(ii) In case a particular work/ contract has been jointly executed by the Bidder (as part of a consortium), it should further support its claim for the share in work done for that particular work/ contract by producing a certificate from the client.

(iii) Certificate(s) from its Statutory Auditors specifying Turnover of the Bidder, as at the close of the preceding financial year, and also specifying the methodology adopted for calculating such Turnover conforming to the provisions of this Clause.

(iv) Copy of the latest Service Tax Return filed.

Note: For the purposes qualification, turnover (the "Turnover") shall mean the sum of annual revenues from operations of the projects listed in technical capacity criteria, including tipping fee and user charges collected and appropriated during the financial year. This shall not include capital grants/capital subsidies and income from sources other than projects specified under this Clause.

(v) Certificate(s) from its Statutory Auditors specifying the net worth of the Bidder, as at the close of the preceding financial year, and also specifying that the methodology adopted for calculating such net worth. For the purposes of Qualification, net worth (the "Net Worth") shall mean the sum of subscribed and paid up equity and reserves from which shall be deducted the sum of revaluation reserves, miscellaneous expenditure not written off and reserves not available for distribution to equity shareholders.

PART D: Conclusions and Recommendations

11. Conclusions and Recommendations

Solid Recovered Fuel/ RDF is traded like a commodity across borders in developed countries especially Europe. Many developed countries have been operating co-processing plants since the 1970. Due to lack of facilities to absorb the SRF and RDF and concurrent high landfill taxes, countries like UK and Ireland export SRF and RDF to

Netherlands and Germany. Some of the countries like Germany, Netherlands, Poland and Austria has done commendable work as mentioned below:

- Currently Germany imports around 1.6 million tonnes, almost 50% thereof from UK.
- Netherlands had replaced more than 80% of fossil fuel by RDF.
- The current thermal substitution rate of Poland's cement industry is currently above 60% – with some cement plants using up to 85% alternative fuels – out of which 70-80% is of MSW origin.
- Lafarge Austria first began to use alternative fuels in one of its plant in 1996, since then Austrian cement industry has achieved substitution rates of up to 80 % for fossil fuels.

India has to go a long way in promoting Thermal substitution of fossil fuel by Alternative Fuel & Raw Material (AFR) such as RDF and Bio-mass etc. Against the global average of 19% of replacement by AFR, the European Union have achieved Thermal Substitution rate at about 40% (26% from waste + 14 % by Bio-mass). However, in India, the average TSR in cement industry is estimated at 4%. Recently, the cement industry has shown confidence to achieve 25% TSR by 2025.

In majority of compost plant facilities operated across the country combustible portion often lands in landfills with inerts, thereby, consuming more space of landfill. This material can be further processed to be used for co-processing and in waste to energy plants. This report provides an insight of various aspects covering existing policy framework, comparative analysis of potential usage in different industries, global scenarios and Indian best practices. It is found that sound policy framework exists for RDF as SWM Rules 2016. The report summarizes that usage of RDF in cement kiln is a win – win situation for ULBs as well as for cement industry. The existing barriers and challenges in RDF preparation and usage can be mitigated through capacity building and providing financial incentives to ULBs. The utilisation of RDF is not recommended in Thermal and Iron & Steel industry due to various reasons cited in the report.

To provide impetus standards and operational and financial modelling is presented in the report. The following norms for SCF and RDF for utilisation in waste to energy plants and cement industry duly confirmed by Cement Manufacturing Association and well accepted by all other stakeholders. The standards are as given below.

S. No	Parameters	SCF	RDF - Grade III	RDF - Grade II	RDF -Grade I
1.	Intended Use	Input material for the Waste to	For co-processing	For direct co-processing in	For direct co-processing in

		Energy plant or RDF pre-processing facility	directly or after processing with other waste materials in cement plant	cement plant	cement plant
			Grade III	Grade II	Grade I
2	Size	Anything above 400mm has to be mutually agreed between Urban Local Body/ SCF Supplier and Cement Plants.	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively
3	Ash – maximum permissible	<20 %#	<15 %	<10 %	<10 %
4	Moisture – maximum permissible	<35 %	< 20%	<15 %	<10%
5	Chlorine – maximum permissible	< 1.0 % #	< 1.0 %	< 0.7	< 0.5
6	Sulphur – maximum permissible	<1.5 % #	<1.5 %	<1.5 %	<1.5 %
7	* Net Calorific Value (NCV) – in Kcal/kg (Average figure of every individual consignment	> 1500 KCal/kg net	>3000 KCal/kg net	>3750 KCal/kg net	> 4500 KCal/kg net

	)				
8	Any other parameter	SCF – any offensive odour to be controlled. **	RDF – any offensive odour to be controlled.	RDF – any offensive odour to be controlled.	RDF – any offensive odour to be controlled.

Note Before: All figures are vetted by Cement Manufacturing Association (CMA)

 # If blending process is done by cement plants, the deviations in recommitted limit for ash, chlorine and sulphur content can be mutually agreed between urban local body /SCF Supplier and cement plants.

** band width of variations acceptable in NCV can be mutually decided between RDF manufacturer and cement plants.*

*** Since odour is still largely a matter of perception and there is no satisfactory equipment to measure different types of odour, no quantitative figure has been given.*

To expeditiously achieve the objectives of Swachh Bharat Mission, the standards need to be supported with working operational and financial models. Accordingly in the report, three roll out models along with model tender document and model agreement between ULB/ Cement plant/ RDF plant operator is incorporated as below:

- Model 1: Standalone RDF unit for an ULB
- Model 2: RDF unit on Cluster Approach
- Takeoff by Cement Companies under the standalone and cluster approach models
- Model 3: Cement Industry Model
- Model tender document for ULB
- Model Agreement between ULB, Cement Plant and Plant operator

The financial viability for different scenarios with or without government financial assistance and/or with or without right on recyclables to plant operator are worked out for a 100 TPD capacity RDF plant in the report. The financial viability assessment concludes that for achieving the financial sustainability in any of the suggested operational models (Stand alone or clustered), it is recommended to give the right to recyclables to the processing agency/ ULB operating the RDF plant. Without the recyclables, the financial sustainability cannot be achieved even 50% grant (subsidy) is provided to the project. The Table below summarizes the financial sustainability of the standalone and cluster based models:

IRR Scenario	**With or Without Recyclables**	**5 Years**	**10 Years**
IRR Without Grant	*No Recyclables*	-	(-) 33%

	10% Recyclables	(-) 4%	12%
	20% Recyclables	22%	33%
	30% Recyclables	43%	51%
IRR With Grant	*No Recyclables*	-	(-) 26%
	10% Recyclables	23%	33%
	20% Recyclables	64%	69%
	30% Recyclables	101%	104%

The report also provided insights on the payback period for the cement industry investing in the auxiliary feeding mechanism (100 tpd capacity) by way of thermal substitution. It is estimated that the Payback Periods for setting up auxiliary feeding mechanism (100 TPD RDF) in cement plant is 7.25 Years for Rs. 5.5 Cr investment. To achieve a payback period of 4 years, the cement company producing 1 million MT of cement annually need to enhance its per bag cement cost by Rs. 0.41.

In addition to above committee has given the following recommendations on non-technological innovations to promote RDF usage on an affordable, sustainable and scalable basis. The recommendations are listed below:

S. No	Recommendations	Responsibility
1.	Modification in SWM Rules 2016 **Existing Clause** in section "Duties of the industrial units located within one hundred km from the RDF and Waste to Energy plants based on solid waste" All industrial units using fuel and located within 100 km from a solid waste-based RDF plant shall make arrangements within six months from the date of notification of these rules to replace at least 5 % of their fuel requirement by RDF so produced. **Modification in Clause** in section **"Duties of the industrial units especially Cement Plants and Waste to Energy Plants for usage of Segregated Combustible Fractions (SCF and/or RDF"** The cement plants located within 400 km from a solid waste-based RDF plant shall make necessary arrangements within six	MoEF&CC

	months from the date of amendment of these rules to replace at least 5% of fuel intake (equivalent calorific value/Thermal Substitution Rate) by Municipal Solid Waste based SCF and/or RDF. The transport cost for SCF/RDF up to 100 km from the cement plant shall be borne by cement plant however, beyond 100 km cement plant can transport at its own cost or ULBs as mutually agreed upon by the parties.	
2.	To ensure processing of segregated combustible fractions (SCF) in existing and proposed MSW plants, ULB shall manage necessary investment either by themselves or through private company selected through competitive bidding process on agreed terms and conditions. The Swachh Bharat Mission funds may also be utilised in setting up such plants.	MoHUA through State Urban Development Departments/ ULBs
3.	Model Tender Documents and tripartite agreement between urban local bodies, SCF/ RDF manufacturer and Cement plants are placed in Annexure I for guidance and also uploaded on the Swachh Bharat Mission (Urban) website.	ULBs to lead conclusion of agreement with, SCF/ RDF manufacturer and Cement plants.
4.	To ensure financial viability of usage of MSW based SCF and RDF, the following guiding principles are suggested: (iv) The capital cost for setting up SCF/ RDF processing plant shall be managed either entirely/ partly by ULB through Swachh Bharat Mission Funds/ its own funds/ private sector. (v) SCF/RDF shall be lifted by Cement Plant /Waste to Energy plant on the terms and conditions mutually agreed by the parties on the lines of model agreements in the Report. (vi) The Cement Plant will pay for SCF/ RDF to ULB at mutually agreed Rates on the basis of caloric value of RDF/ SCF and other quality factors on the lines or cost per 1000	State Urban Development Department, ULB and Cement Plants

	Kcal/kg indicated in the report.	
5.	To reduce the dependence on cement plants, MoHUA may consider supporting applied Research and Development for conversion of RDF to liquid/solid/ gas fuel or other innovative options with potential replication in the form of 2-3 pilot plants. If successful, this will open additional avenues for RDF utilisation.	MoHUA through SBM or may contact Department of Science and Technology.

(Model Bid documents are separately under development. However, comments can be forwarded on it as well to get inputs)

Annexure I:

Model Agreement for management of Segregated Combustible Fraction (SCF) and / Refuse Derived Fuel (RDF) from Municipal Solid Waste (MSW) through co-processing in Cement Plants

DRAFT Agreement

for management of

Segregated Combustible Fraction (SCF) and / Refuse Derived Fuel (RDF) from Municipal Solid Waste (MSW) through co-processing in Cement Plants

Between

First Party -Urban Local Body

And

Second Party - Segregated Combustible Fraction and/ or Refuse Derived Fuel Manufacturer

And

Third Party - Cement Plant

Preamble

I. The Ministry of Housing and Urban Affairs (MoHUA), Government of India has launched Swachh Bharat Mission on 2nd October 2014, with the objectives of modern and scientific Municipal Solid Waste Management among others.
II. To enhance the progress towards the objective of modern and scientific Municipal Solid Waste Management, an Expert Committee was constituted by MoHUA in November 2017 to prepare "Standards/Norms for Refuse Derived Fuel (RDF) from Municipal Solid Waste for its utilization in Cement Kilns, Waste to Energy Plants and similar other installations".
III. Based on the recommendations, standards for Segregated Combustible Fractions (SCF) and Refuse Derived Fuel (RDF) from municipal solid waste shall be notified by Central Pollution Control Board.
IV. This agreement is a tripartite agreement between Urban Local Body, Segregated Combustible Fraction and/ or Refuse Derived Fuel Manufacturer and Cement Plant for usage of MSW based SCF/ RDF for co-processing.

****

This Agreement is made and entered into this _____day of _____2018 by and between:

First Party, which is the urban local body (municipality) of..... (Town or city), having its office at..... (hereinafter refer to as “ULB”) of the One Part;

And

Second Party, ……a company incorporated under the companies act, 1956 having its registered office at …….. is a company which is in the business of providing MSW Management services of collection, transportation, processing and disposal of MSW or Segregated Combustible Fraction (SCF) and/ or Refuse Derived Fuel (RDF) to Municipalities/ULBs, in compliance with

SWM Rules, 2016 .....(hereinafter refer to as “Segregated Combustible Fraction (SCF) and/ or Refuse Derived Fuel (RDF) Manufacturer”).

Third Party… a Company incorporated under the Indian Companies Act, 1913, having its registered office at ..... and having one of its Cement Plant at .....(hereinafter refer to as “Cement Company”) of the other part

AND WHEREAS the Urban Local Bodies (ULBs) are responsible for management of Municipal Solid Waste (MSW) generated within its jurisdiction as per Solid Waste Management Rules 2016. The MSW contains reasonable quantity of non-recyclable Segregated Combustible Fraction (SCF) containing plastics and other combustible materials (herein referred to as ‘Segregated Combustible Fraction (SCF) which are not biodegradable and release toxic gases when they get burnt or dumped in the dump yards / landfills. The SCF can further process by ULB or by third party for making refuse derived fuel (RDF) of different grades meeting standards / norms notified by CPCB.

AND WHEREAS, Cement Company is in the business of manufacture and sale of different types and grades of cement and has the capability to dispose the waste materials in an environment friendly manner in the cement kiln process having high temperature and long residence time (hereinafter referred to as “Co-Processing”) while simultaneously producing cement of desired quality and meeting the emission norms.

NOW, THEREFORE, to ensure the safe disposal of SCF segregated from the municipal solid waste and/ or RDF all parties have entered into this Agreement.

1. Term and Validity of the Agreement

The Agreement shall be valid for a period of ____ years from the date of signing and execution of this Agreement.

The Agreement may be amended by written consent of all the Parties to the Agreement. All amendments shall be documented and allotted a distinctive number and date.

2. Responsibility of the Parties

To deliver key objectives of this Agreement the parties' responsibilities are summarized as follows (In case ULB is directly supplying to cement plants the responsibility of SCF/RDF manufacturer shall be fulfilled by ULB).

2.1 Responsibility of ULB

a) To supply Municipal Solid Waste to the agency (Private party / NGO etc.) selected and responsible for MSW management contract of the city and / or process MSW to SCF/RDF.
b) Review of infrastructure and machinery available at the waste processing facility to ensure SCF/ RDF can be processed and supplied.
c) To set up a review and monitoring mechanisms to ensure that SCF/ RDF to be supplied meets the standards notified by CPCB.
d) To pay the operational and maintenance cost in form of tipping fees on per tonne SCF/ RDF produced basis quoted by the plant operator through competitive process.
e) To bear the cost of transportation of SCF/ RDF to cement plant; (not more than @INR 5 per km (till 100 Kms) and @INR 3 per km beyond 100kms).

2.2 Responsibility of SCF/RDF manufacturer by Private Company / NGOs

a) To manufacture SCF/ RDF as per standards notified by CPCB in line with agreement with ULB meeting all regulatory requirements and environmental clearances.
b) To pack and label the SCF/ RDF clearing defining the quality and quantity in line with guidance provided at annexure C.
c) To work jointly with ULB and Cement Plants to finalise the schedule of delivery as per annexure D.
d) To issue the pre-processing certificate to ULB as per annexure F.
e) To undertake the testing of SCF/ RDF as per requirements agreed in this Agreement.

2.3 Responsibility of Cement Plants

a) To accept and utilise the SCF/ RDF as per agreed schedule of delivery (annexure D) and meet emission norms.
b) To pay the price of SCF/ RDF to ULB as per commercial terms defined in section 4 of this Agreement.

c) To work jointly with ULB / Private Company / NGO as the case may be to finalise the schedule of delivery as per annexure D.
d) To issue the co-processing certificate to ULB as per annexure G.
e) To undertake the testing of SCF/ RDF as per requirements agreed in this Agreement.

3. Provisions for Collection, handling, storage, Segregation & Transportation of segregated Combustible Fraction (SCF) / Refuse Derived Fuel (RDF) from Municipal Solid Waste (MSW) for processing & disposal at Cement company's facility located at.....:

(A) Collection, handling, storage and transportation, unloading, storing, pre-processing, and Disposal of Segregated Combustible Fraction (SCF)/ RDF:

ULB or SCF/ RDF Manufacturer as the case may be (in line with ongoing MSW system) shall be responsible to collect, handle and store at a designated location the Segregated Combustible Fraction (SCF)/ RDF generated within its jurisdiction and transporting the same to the Cement Company cement plant located at ..... on the basis of basis of commercial terms defined in section 3 of the Agreement and ownership.

ULB or SCF/ RDF Manufacturer as the case may be, at its own cost, arrange to get every consignment of SCF/RDF weighed at an authorized weighbridge and issue the weighbridge challan to the approved transporter while dispatching the consignment of SCF/ RDF to the Cement Plant. The quantity of SCF/RDF in any consignment delivered by the ULB or SCF/ RDF Manufacturer to the Cement Plant shall be determined by the electronic weighbridge installed at the Cement Plant. All SCF/RDF related reports including inventory list shall be prepared as per electronic weighbridge records maintained at the Cement Plant, which shall be the conclusive documentary proof evidencing the actual quantity of SCF/RDF received by them. In the event of any dispute relating to the actual quantities of SCF /RDF dispatched by the ULB or SCF/ RDF Manufacturer and received by the Third Party, the Parties hereto shall resolve the same in good faith through discussion on the appropriate actions required to be taken for verification and correction of any discrepancy.

The ULB at its own cost will make necessary arrangement to transport the material to Cement Plant as per guidelines in annexure C.

Cement company shall be responsible for unloading, storing, pre-processing, and Disposal of the Segregated Combustible Fraction (SCF) /RDF through co-processing in its kiln in the cement plant located in the .....The protocols for receiving the SCF/RDF are given in Annexure E.

(B) Quality of SCF/ RDF:

The Segregated Combustible Fraction should not contain any of the banned items listed in the Annexure B attached herein.

Wet fraction of the Municipal Solid Waste comprising kitchen waste and organics, construction and demolition waste and inert shall not be allowed to be mixed with the Segregated Combustible Fraction that is being sent for Co-processing.

(C) Quantity and schedule of delivery:

The delivery schedule of SCF /RDF shall be prepared in agreement with ULB, RDF/SCF Manufacturer and Cement Plants on daily/weekly/fortnightly/monthly basis by all the parties within two months from signing of Agreement as per guidance given in Annexure D attached herein.

In case of any change in the mutually agreed delivery schedule by parties, then the affected party will intimate to the other Parties and all parties will discuss and arrive at a mutually agreed solution to deal the situation.

(D) Refusal:

In case Cement company is in the receipt of consignment which is not matching with specifications given in Annexure A or contains banned items (as mentioned under Annexure B and/or kitchen wastes or organics other than the SCF/RDF, Cement company will be entitled to refuse the acceptance of the same and communicate such rejection within [4] days to ULB and such consignment will be taken back by ULB within [7] days of such intimation at their own cost and risk to an appropriate place for disposal. The delivery of the SCF/RDF is complete only after the communication of the acceptance of consignment by cement company to ULB subject to the terms herein mentioned.

(E) Storage, Handling & Processing of Segregated Combustible Fraction (SCF):

On completion of the Delivery of SCF, Cement company shall be responsible for safe storage, handling and processing of the SCF/ RDF at its cement plant located at..... The protocols for receiving the SCF/RDF are given in Annexure E.

(F) Testing of quality Parameters

The following specification should be considered for each consignment of SCF/RDF:

Parameters	SCF
Size	NA
Moisture (%) As Received Basis	…….
CV (Kcal/Kg) As Received Basis	……
S (%)	……
Cl (%)	……
Ash (%)	……

Each consignment of SCF/RDF received at the …… Facility of ....., ……. shall be tested at its laboratory. Each consignment of SCF /RDF shall be tested by both parties for the parameters stated above and the reports from both parties shall be shared every fortnight. In case of deviations in reports, both Parties have to resolve the same in good faith in view of the reasonable proofs.

(G) Certificate of Pre-processing and Co-Processing

The SCF/RDF Manufacturer shall at the beginning of each month during the term of this agreement, issue to the ULB Certificate of Pre-Processing of MSW to

deliver SCF/RDF during the previous month in the format set out in Annexure F attached to the Agreement.

The Cement Plant shall at the beginning of each month during the term of this agreement, issue to the ULB Manufacturer of Co-Processing for the SCF/RDF received for Co-Processing during the previous month in the format set out in Annexure G attached to the Agreement.

4. Commercial terms for the Disposal of Segregated Combustible Fraction (SCF) / RDF:

(A) The capital cost for setting up SCF/ RDF processing plant shall be borne by ULB.
(B) The ULB shall pay the operational and maintenance cost in form of tipping fees on per tonne SCF/ RDF produced basis and quoted by the plant operator through competitive process.
(C) SCF/RDF shall be delivered by ULB at the gate of cement plant located at..... Any taxes if applicable from time to time on the aforesaid services / transaction shall be to the account of ULB.
(D) The Cement Plant will pay for SCF/ RDF to ULB at mutually agreed rates calculated on the basis of caloric value and other parameters like pre-processing requirements at cement plant and grades of RDF as defined in annexure A.

5. Point of Contact

ULB, SCF/RDF Manufacturer and Cement Company shall nominate persons who should act as points of contacts during the term of the Agreement.

6. Force Majeure.

Neither party shall be considered in default in the performance of its obligation under the Agreement, if such performance is prevented or delayed on account of war, civil commotion, strike, epidemics, accidents, fires, unprecedented floods, earth quake or because of promulgation of any law or regulations by the Government, unforeseen breakdowns, operational and maintenance stoppages at the Second Party's Cement Plant or on account of Acts of God.

At the time of occurrence of a force majeure condition, the affected party shall give a notice in writing with documentary proof within Ten (10) days from the date of occurrence of the force majeure condition indicating the cause of force majeure condition and the period for which the force majeure condition was likely

to subsist. This agreement shall remain suspended during the period of force majeure. However, if the reason continues more than ninety (90) days, the parties hereto may mutually agree to modify the terms of the Agreement or terminate the same. On such termination, ULB shall be obliged to settle all dues to SCF/ RDF manufacturer.

7. Settlements of Disputes

The Parties shall endeavour to settle by mutual consultation any claim, dispute, differences or controversy ("Dispute") arising out of, or in relation to the Agreement, including any Dispute with respect to the existence or validity hereof, the interpretation hereof, the activities performed under the Agreement, or the breach of the Agreement.

Any Dispute which cannot be settled within Thirty (30) days of consultation as provided above shall be submitted to arbitration at the request of a Party ("affected Party") upon written notice to that effect to the other Party and such arbitration shall be conducted at place of ULB (or to be mutually decided by all parties) in accordance with the provisions of the Arbitration & Conciliation Act, 1996.

The Parties agree that the award passed by the arbitration panel shall be binding upon the Parties, and that the Parties shall not be entitled to commence or maintain any action in any Court of Law in respect of any matter in Dispute arising from or in relation to the Agreement, except for the enforcement of an arbitral award or for seeking injunctive relief or in case of appeal against arbitral awards passed by an arbitration panel pursuant to this Clause.

8. Indemnity

The Parties shall defend, indemnify and save harmless each other and their directors, employees and agents from and against any and all claims, demands, fines, loses, damages, costs, penalties, expenses, actions, suits or proceedings, injuries, monetary liability on account of death of any person, cost of response to any governmental inquiry, liability for loss of or damage to property and reasonable attorney and consulting fees and costs relating to any of the forgoing resulting from the act or omission, breach or non-conformance by either party with the provisions contained in the Agreement or any

statutory non-compliance. The foregoing indemnification shall not apply to the extent such claims are the result of the other Party's gross negligence or willful default.

9. Non-Waiver

Any delay or omission on the part of each Party in exercising any rights provided under applicable laws or under this Agreement shall not impair such rights or operate as a waiver thereof. The partial exercise of any right provided under applicable laws or under the Agreement shall not preclude any other or further exercise thereof or the exercise of any other rights under the Agreement.

10. Relationship

It is understood that this Agreement between the parties shall be on a principle to principle basis. None of the provisions of this Agreement shall be deemed to constitute a joint venture or a partnership or even agency between the parties hereto and party shall have any authority to bind the other or will be deemed to be agent of the other party in any way.

11. Notice

Unless otherwise provided in the Agreement, any notice, report or other communications given or made under or in connection with the matters contemplated by or arising herein, shall be deemed to have been duly given or made if sent by personal delivery or by facsimile transmission confirmed by email or upon receipted delivery at the address of the relevant Party.

12. Applicability

Any Purchase Orders issued for the transaction mentioned herein in this document shall be subject to the terms herein.

13. Non-Exclusive Transaction

This Agreement is nonexclusive in nature. The parties are free to enter into mutual understanding with any of the third parties for transaction of similar nature.

SIGNED AND DELIVERED for and on behalf of

First Party, by the hand of its authorized signatory,

_____ _____

Signature in the presence of:

_____ _____

Signature of Witness 1, (Name of Witness 1)

_____ _____

Signature of Witness 2, (Name of Witness 2)

Second Party, by the hand of its authorized signatory,

_____ _____

Signature

in the presence of:

_____ _____

Signature of Witness 1, (Name of Witness 1)

_____ _____

Signature of Witness 2, (Name of Witness 2)

SIGNED AND DELIVERED for and on behalf of

Third Party, by the hand of its authorized signatory,

_____ _____

Signature

in the presence of:

_____ _____

Signature of Witness 1, (Name of Witness 1)

_____ _____

Signature of Witness 2, (Name of Witness 2)

Annexure 1A

Specifications of SCF / RDF (on as received basis)

Parameters	Values
Size (mm)	
Moisture (%)	
NCV (Cal/gm)	
S (%)	
Cl (%)	
Ash (%)	

Annexure 1B

List of Banned Items

The Segregated Combustible Fraction (SCF) /RDF dispatched by ULB shall not contain following items that are listed as banned items for Co-processing.

- Anatomical Hospital Wastes
- Asbestos-containing Wastes
- Bio-hazardous Wastes
- Electronic Scrap
- Entire Batteries
- Explosives
- High-concentration Cyanide Wastes
- Mineral Acids
- Radioactive Wastes
- Unsorted Municipal Garbage

Annexure 1C

Guidelines for Packaging, Labelling and Transportation of SCF and /or RDF

ULB or SCF/RDF Manufacturer (as the case may be in line the agreement) shall ensure the following:

1. Arrange to load the SCF /RDF in trucks which are properly covered with tarpaulin and tied up with ropes to avoid any fall off of the material during transportation.
2. Label every vehicle of SCF /RDF as per format below specifying name of waste, quantity of waste, particle size of waste, size of packaging, Type of waste ("Hazardous/Other Waste") in bold letters both in English and Local Language and with other relevant identification as stipulated under applicable laws.
3. Transport Vehicle used for transporting the SCF/RDF should have valid authorization for transportation.
4. Transporter /driver shall be licensed for collection and transportation of the SCF/ RDF
5. Transport vehicle should be clean, fit for use and all safety equipment should be operational and easily accessible.
6. Transport vehicle used for transportation of SCF/RDF shall be marked with an emergency information panel and should be easily identifiable (number plate)
7. Only the compatible SCF/ RDF should be transported together

8. Transporter / driver shall carry 4 (Four) copies of manifest and shall be guided on the proper movement of the manifest documents.
9. Transporter/driver should be provided with relevant information in Form 11 (Transport Emergency (TREM) Card) of Hazardous and other Wastes (Handling and Transboundary Movement) Rules 2016, regarding the Hazardous nature of the waste and measures to be taken in case of any emergency
10. Logistics should be clearly defined for minimizing Occupational Health & safety risks
11. All relevant legal requirements for transportation should be fulfilled
12. Suitable specific emergency response procedures / crisis management plan and equipment should be in place and truck driver and cleaner should be trained accordingly.

FORM 8

[See rules 17 (1) and 18 (2)]

LABELLING OF CONTAINERS OF HAZARDOUS AND OTHER WASTE

Handle with care

Waste category and characteristics as per Part C of Schedules II and III of these rules ……	Incompatible wastes and substances ……
Total quantity ……	Date of storage
Physical State of the waste (Solid/Semi-solid/liquid):	
Sender's name and address	Receiver's name and address
Phone……	Phone……
E-mail……	E-mail……
Tel. and Fax No……	Tel. and Fax No……
Contact person……	Contact person……
In case of emergency please Contact ……	

Note:

1. *Background colour of label - fluorescent yellow.*
2. *The word, 'HAZARDOUS WASTES' and 'HANDLE WITH CARE' to be prominent and written in red, in Hindi, English and in vernacular language.*
3. *The word 'OTHER WASTES' to be written prominently in orange, in Hindi, English and in vernacular language.*
4. *Label should be of non-washable material and weather proof.*

ANNEXURE 1D

Quantity & Delivery Schedule

ULB or SCF/RDF Manufacturer (as the case may be in line with MSW system), during the term of the agreement, shall deliver the following quantities of SCF/ RDF to the..... Cement Plant on daily/ weekly/ monthly / yearly basis.

Segregated Combustible Fraction (SCF) or / and Refuse Derived Fuel (RDF): …….. Metric Tonnes per day/ week/month/annum

ULB or SCF/RDF Manufacturer (as the case may be in line with the agreement), during the term of the agreement, shall deliver the SCF/RDF to the Cement Plant on daily/ weekly/monthly basis as per the mutually agreed delivery schedule. The delivery schedule of the month will be prepared by the parties through mutual consent and will be finalized before 20th of the preceding month.

In case of any change or modification required in the agreed monthly delivery schedule of a particular month by either party, the same shall be brought to the notice of other party at least …….. days in advance or as mutually agreed.

Annexure 1E

Protocols for Receiving of SCF/RDF

The following procedures shall be followed when receiving SCF/RDF at the Cement Plant:

I. Transporter will report to the Cement Plant security gate for delivery of the SCF/RDF at storage area(s) of designated Cement Plants.
II. Security officer shall inform the concerned officer of the designated Cement Plant.
III. Cement Plant officer will undertake following activities: -

(a) Receive all relevant documents from the ULBs Transporter including;
  (i) Delivery document
  (ii) Certificate from ULBs/ SCF and/or RDF manufacturer specifying conformance to waste specifications.
  (iii) Any other document mutually agreed between the parties.

(b) Cement Plant shall arrange and record the weight of the Transport vehicle on the weigh bridge installed at the plant before and after unloading of the SCF/RDF at the designated storage area.

(c) Cement Plant shall make necessary arrangements for unloading and storage of the SCF/RDF at the designated storage area, as per the date on which the consignment is

delivered to the cement plant and shall also record the no. of bags, date of delivery, consignment no., truck no. etc.

(d) Cement Plant shall arrange to conduct inspection and sampling of the SCF/RDF as required and report to the ULB/ SCFOR RDF supplier (as the case may be) whether the SCF/RDF is conforming to specifications list in Annexure 1 and Annexure 2 with in …… (..) days of receipt of SCF/RDF.

(e) Incase SCF/RDF is not properly sealed/ packed as set out in the Agreement, Cement Plant shall inform the same and both the parties shall discuss and arrive at solution for safe handling and disposal of SCF/RDF.

(f) Cement Plant shall keep the storage area locked with appropriate surveillance by the security.

(g) To attend any emergency situation, the Cement plant shall maintain a copy of the risk assessment and crisis management plan with its security officer and also with its concerned officer.

Annexure 1F

CERTIFICATE OF PRE-PROCESSING

Certificate of Pre-Processing

…… (.....),

Issued To: M/s ……, ……. (……..)

Date: …….

This is to certify that we have supplied the following quantity of SCF/RDF to M/s ……. for Pre and / Or Co-processing in the Cement Kiln during the period……. to…….. . The same would be safely and completely disposed of within ….. days of delivery

The average specifications of the supplied SCF /RDF are as under:-

1. CV (Kcal/kg) = ……
2. Moisture (%) = ……..
3. Chloride (%) = ……
4. Ash (%) = ……

Waste Name: .....

Quantity (Tons): .....

Plant Head

(Authorized Signatory)

.... ……

Annexure 1G

CERTIFICATE OF CO-PROCESSING

Certificate of Co-Processing

Issued To: M/s.....

Invoice No...

Date: ……

This is to certify that we have taken receipt of the following quantities of..... (Name of the SCF/RDF) ..... sent by M/s ..... for Pre and / Or Co-processing in our Cement Kiln during the period ……..to ……. The same would be safely and completely disposed off within …. days of receipt and thereafter will not exist.

Waste Name: .....

Quantity (Tons): .....

Authorized Signatory

.....

Annexure II:

Emission norms for co-processing of waste / RDF in cement plants are notified by Ministry of Environment Forest and Climate Change

Annexure II

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय भारत सरकार
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE GOVT. OF INDIA

Speed Post

B-29016/(SC)/WtE/18/WM-II/Div. 17266 19.02.2018

To

Shri. J.B. Ravinder
Joint Adviser (PHEE)
Ministry of Housing and Urban Affairs (CPHEEO)
Nirman Bhawan, New Delhi-110011

Sub.:Emission Parameters and Air Pollution Control Equipment required for the use specific grades of RDF usage as supplementary fuel in Cement Kilns & Waste to Energy Plants etc.-reg.

Ref.: Letter No. Q-16019/6/2017-CPHEEO dated 13. 02.2018 from MoHUA (CPHEEO)

Sir,

This has reference to your above referred letter dated 13/2/2018 on the subject. Following are point-wise clarifications as sought vide the said referred letter:

(i) Boiler having proper combustion grate for drying, ignition, combustion, energy release and complete burn-out of RDF based pellets/briquetts may be used in Waste-to-Energy plant. Therefore, suitable Spreader Stoker Fired Boiler such as Tumbling Grate/Reverse Reciprocating Grate/Reverse Acting Stoker Boiler/etc. may be used.
The minimum temperature in the boiler may be maintained at 950 °C with minimum residence time of two seconds.

(ii) Part C of Schedule II of the Solid Waste Management Rules, 2016, lays down standards for incineration and a copy of the same is enclosed for ready reference. The same emission parameters and standards thereof, as prescribed under the said Schedule, may be applicable for use of RDF in the boilers of Waste-to-Energy plant.

Combination of various air pollution control devices such as Bag Filter, Electrostatic Precipitator, Scrubber (wet or dry), activated carbon beds, etc., are required as Air Pollution Control Devices to comply with the said emission standards. Air Pollution Control Devices viz. dosing of lime and activated carbon followed by Bag Filter have demonstrated compliance with the said emission parameters.

Yours faithfully,

(A. Sudhakar)
Member Secretary

'परिवेश भवन' पूर्वी अर्जुन नगर, दिल्ली-110032
Parivesh Bhawan, East Arjun Nagar, Delhi-110032

CENTRAL POLLUTION CONTROL BOARD

(Ministry of Environment & Forests, Govt. of India)
'Parivesh Bhawan' C.B.D. Cum-Office Complex,
East Arjun Nagar, Shahdara, Delhi-110032
Telefax-011-43102453, E-mail:ssskn2012@gmail.com, Website-www.cpcb.nic.in

F. No. B-130171/1/UPC-II/MSW(Corres.)/2017-18 Dated 22.02.2018

To,

J.B.Ravinder
Joint Advisor (PHEE)
Ministry of Housing and Urban Affairs
Nirman Bhawan

Sub : Emission Parameters and Air Pollution Control Equipment's required for the use specific grades of RDF usage as supplementary fuel in Cement Kilns & Waste to Energy Plants etc.

Sir,

184/UPC-II/18
21/2/18

This has reference to your letter dated **13.02.2018** regrading clarifications on Emission Parameters for Co-processing of Municipal solid Waste and plastics waste in Cement Kilns and Waste to Energy Plants. We would like to inform that **Emission Parameters** for Co-processing in Cement Kilns & Waste to Energy Plants have already been notified by Ministry of Environment, Forest and Climate Change.

A copy of notification dated 10.05.2016 for Co processing of wastes in cement plants & standards for Incineration of Waste to Energy Plant as notified in the Solid Waste Management Rules, 2016 is attached.

Yours faithfully,

(Dr.S.K.Nigam)
AD & I/c UPC – II

O/C

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 10th May, 2016

G.S.R. 497 (E). – In exercise of powers conferred by sections 6 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following rules further to amend the Environment (Protection) Rules, 1986, namely :-

1. Short title and commencement - (1) These rules may be called the Environment (Protection) Third Amendment Rules, 2016.

   (2) They shall come into force on the date of their publication in the Official Gazette.

2. In the Environment (Protection) Rules, 1986,-

   (a) in schedule I, after serial number 10 and the entries relating thereto, the following serial number and entries shall be inserted, namely:-

"S. No.	Industry	Parameter	Standards		
(1)	(2)	(3)	(4)		
"10A.	Cement Plant with co-processing of wastes		A- Emission Standards		
			Rotary Kiln – with co-processing of Wastes		
			Date of Commissioning	Location	Concentration not to exceed, in mg/Nm^3
			(a)	(b)	(c)
		Particulate Matter (PM)*	on or after the date of notification (25.8.2014)	anywhere in the country	30
			before the date of notification (25.8.2014)	critically polluted area or urban centres with population above 1.0 lakh or within its periphery of 5.0 kilometer radius	30
				other than critically polluted area or urban centres	30
		SO_2*	irrespective of date of commissioning	anywhere in the country	100, 700 and 1000 when pyritic sulphur in the limestone is less than 0.25%, 0.25 to 0.5% and more than 0.5% respectively.
		NOx*	After the date of notification (25.8.2014)	anywhere in the country	(1) 600
			Before the date of notification	anywhere in the country	(2) 800 for rotary kiln with In Line Calciner

			(25.8.2014)		(ILC) technology. (3) 1000 for rotary kiln using mixed stream of ILC, Separate Line Calciner (SLC) and suspension pre-heater technology or SLC technology alone or without calciner.

		HCl	10 mg/Nm^3
		HF	1 mg/Nm^3
		TOC	10 mg/Nm^3 **
		Hg and its compounds	0.05 mg/Nm^3
		Cd +Tl and their compounds	0.05 mg/Nm^3
		Sb+As+Pb+Co+Cr+Cu+Mn+Ni+V and their compounds	0.5 mg/Nm^3
		Dioxins and Furans	0.1 ngTEQ/ Nm^3

Note: The abbreviations used in the Table shall mean as under: SO_2- Sulphur dioxide; NO_x - Oxides of Nitrogen; HCl – Hydrogen Chloride; HF – Hydrogen Flouride; TOC - Total Organic Carbon; Hg – Mercury; Cd – Cadmium; Tl – Thallium; Sb – Antimony; As – Arsenic; Pb – Lead; Co – Cobalt; Cr – Chromium; Cu – Copper; Mn – Manganese; Ni – Nickel; and V - Vanadium.";

* The concentration values and timeline for implementation in respect of PM, SO_2 and NOx shall be governed in accordance with the provisions under notification published vide GSR No. 612 (E), dated the 25th August, 2014 and amended from time to time.

**Permitting authority may prescribe separate standards on case to case basis, if Total Organic Carbon (TOC) does not result from the co-processing of waste.

(a) The height of each individual stack connected to Kiln, Clinker Cooler, Cement Mill, Coal Mill, Raw Mill, Packaging section, etc. shall be of a minimum of 30 metres or, as per the formula $H = 14 (Q1)^{0.3}$ and $H = 74 (Q2)^{0.27}$ whichever is more, where "H" is the height of stack in metres and "Q1" is the maximum quantity of SO_2 expected to be emitted in kg/hr and "Q2" is the maximum quantity of PM expected to be emitted in tonnes/hr through the stack at 100 percent rated capacity of the plant;

(b) The monitored values of SO_2, NO_x, HCl, HF, TOC, Metals and Dioxins and Furans at main kiln stack shall be corrected to 10% Oxygen, on dry basis and the norms for SO_2, NO_x, HCl, HF, TOC, Metals and Dioxins and Furans shall be applicable to main kiln stack and the norms for Particulate Matter (PM) shall be applicable to all the stacks in the plant. PM, SO_2, NO_x shall be monitored continuously. HCl, HF, TOC, Metals and Dioxins and Furans shall be monitored once in a year;

(c) Scrubber meant for scrubbing emissions shall not be used as quencher and plants having separate stack for gaseous emission for the scrubbing unit, the height of this stack shall be at least equal to the main stack.

B- Service waste water (with co-processing of wastes)

All efforts shall be made by the industry for 'zero discharge' of service wastewater and in case, the industry prefers to discharge service wastewater, the following norms shall be complied with:

	Concentration not to exceed, milligram per litre (except pH and temperature)
pH	5.5 to 9.0
Suspended Solids	100

		Oil and Grease	10
		Temperature	not more than 5°C higher than the intake water temperature
		C- Storm water (I) Storm-water shall not be allowed to mix with effluent, treated sewage, scrubber water and or or floor washings. (II) Storm-water within battery limits of industry shall be channelised through separate drain(s).".	

(b) in Schedule VI, under 'Part-D' relating to General Emission Standards, in item III relating to Load or Mass based standards, after serial number 10 and the entries relating thereto, the following serial number and entries shall be inserted, namely:-

(1)	(2)	(3)	(4)
"10A	Cement Plants (with co-processing)	Rotary kiln based plants (Particulate Matter from raw mill, kiln and pre-calciner system put together)	0.125 kg/ tonne of clinker.".

[F. No.- Q-15017/30/2007-CPW]
Dr. RASHID HASAN, Advisor

Note .- The principal rules were published in the Gazette of India, Extraordinary, Part II, Section 3,Sub-section (i), *vide* number S.O. 844 (E), dated the 19th November, 1986 and subsequently amended *vide* the following notifications, namely:-

S.O. 433 (E), dated the 18th April 1987; G.S.R. 176(E), dated the 2nd April, 1996; G.S.R. 97 (E), dated the 18th February, 2009; G.S.R. 149 (E), dated the 4th March , 2009; G.S.R. 543(E), dated the 22nd July,2009; G.S.R. 739 (E), dated the 9th September, 2010; G.S.R. 809(E), dated, the 4th October, 2010, G.S.R. 215 (E), dated the 15th March, 2011; G.S.R. 221(E), dated the 18th March, 2011; G.S.R. 354 (E), dated the 2nd May, 2011; G.S.R. 424 (E), dated the 1st June, 2011; G.S.R. 446 (E), dated the 13th June, 2011; G.S.R. 152 (E), dated the 16th March, 2012; G.S.R. 266(E), dated the 30th March, 2012; and G.S.R. 277 (E), dated the 31st March, 2012; and G.S.R. 820(E), dated the 9th November, 2012; G.S.R. 176 (E), dated the 18th March, 2013; G.S.R. 535(E), dated the 7th August, 2013; G.S.R. 771(E), dated the 11th December, 2013; G.S.R. 2(E), dated the 2nd January, 2014; G.S.R. 229 (E), dated the 28th March, 2014; G.S.R. 232(E), dated the 31st March, 2014; G.S.R. 325(E), dated the 07th May, 2014, G.S.R. 612, (E), dated the 25th August 2014; G.S.R. 789(E), dated the 11th November 2014; S.O. 3305(E), dated the 7th December, 2015; S.O.4(E), dated the 1st January 2016; G.S.R. 35(E), dated the 14th January 2016 and lastly amended vide notification G.S.R. 281 (E), dated the 7th March, 2016.

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अधिसूचना

नई दिल्ली, 8 अप्रैल, 2016

C. **Standards for incineration:** The Emission from incinerators /thermal technologies in Solid Waste treatment/disposal facility shall meet the following standards, namely:-

Parameter	Emission standard	
(1)	(2)	(3)
Particulates	50 mg/Nm^3	Standard refers to half hourly average value
HCl	50 mg/Nm^3	Standard refers to half hourly average value
SO2	200 mg/Nm^3	Standard refers to half hourly average value
CO	100 mg/Nm^3	Standard refers to half hourly average value
	50 mg/Nm^3	Standard refers to daily average value
Total Organic Carbon	20 mg/Nm^3	Standard refers to half hourly average value
HF	4 mg/Nm^3	Standard refers to half hourly average value
NOx (NO and NO2 expressed as NO2)	400 mg/Nm^3	Standard refers to half hourly average value
Total dioxins and furans	0.1 ng TEQ/Nm^3	Standard refers to 6-8 hours sampling. Please refer guidelines for 17 concerned congeners for toxic equivalence values to arrive at total toxic equivalence.
Cd + Th + their compounds	0.05 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Hg and its compounds	0.05 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours.

Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V + their compounds	0.5 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Note.- All values corrected to 11% oxygen on a dry basis.		

Note:

(a) Suitably designed pollution control devices shall be installed or retrofitted with the incinerator to achieve the above emission limits..

(b) Waste to be incinerated shall not be chemically treated with any chlorinated disinfectants.

(c) Incineration of chlorinated plastics shall be phased out within two years.

(d) if the concentation of toxic metals in incineration ash exceeds the limits specified in the Hazardous Waste (Management, Handling and Trans boundary Movement) Rules, 2008, as amended from time to time, the ash shall be sent to the hazardous waste treatment, storage and disposal fcaility.

(e) Only low sulphur fuel like LDO, LSHS, Diesel, bio-mass, coal, LNG, CNG, RDF and bio-gas shall be used as fuel in the incinerator.

(f) The CO2 concentration in tail gas shall not be more than 7%.

(g) All the facilities in twin chamber incinerators shall be designed to achieve a minimum temperature of 950^0C in secondary combustion chamber and with a gas residence time in secondary combustion chamber not less than 2 (two) seconds.

(h) Incineration plants shall be operated (combustion chambers) with such temperature, retention time and turbulence, as to achieve total Organic Carbon (TOC) content in the slag and bottom ash less than 3%, or the loss on ignition is less than 5% of the dry weight.

(i) Odour from sites shall be managed as per guidelines of CPCB issued from time to time

Annexure III:

List of operational and under construction waste to energy plant

List of operational waste to energy plants

S. No	State	Name of the City/ Town	Capacity (MW)
1	Maharashtra	Pune	10
2	Maharashtra	Solapur	3
3	New Delhi	Okhla	12
4	New Delhi	Ghazipur	16
5	Telangana	Karimnagar	12
6	Madhya Pradesh	Jabalpur	11.4
7	Delhi	Narela-Bawana	24
		Total	88.4

Source: SBM data

List of proposed/ under construction waste to energy plants

S.No.	State	City	Total (MW)
1	Andhra Pradesh	Guntur	15
2	Andhra Pradesh	Tirupati	6
3	Andhra Pradesh	Vizianagaram	4
4	Andhra Pradesh	Tadepalligudam	5
5	Andhra Pradesh	Machilipatnam	4
6	Andhra Pradesh	Peddapuram	NA
7	Andhra Pradesh	Mandapeta	NA
8	Andhra Pradesh	Eleshwaram	NA
9	Andhra Pradesh	Samalkot	NA
10	Andhra Pradesh	Narasaraopet	NA
11	Andhra Pradesh	Kadapa	5
12	Andhra Pradesh	Anantapur	4
13	Andhra Pradesh	Nellore	4
14	Andhra Pradesh	Kurnool	1
15	Andhra Pradesh	Vishakhapatnam	5
16	Bihar	Patna	10
17	Chhattisgarh	Durg-Bhilai	5
18	Chhattisgarh	Raipur	5
19	Goa	Pernem	5
20	Gujarat	Surat	13.5
21	Haryana	Karnal	3.5
22	Haryana	Sonipat	5
23	Haryana	Bandhmadi	10

24	Haryana	Faridabad	10
25	Himachal Pradesh	Shimla	1.7
26	Himachal Pradesh	Dharamshala	NA
27	J&K	Srinagar	6.5
28	Jharkhand	Ranchi	11
29	Jharkhand	Dhanbad	12
30	Karnataka	Bengaluru (7 plants)	20
31	Kerala	Kochi	10
32	MP	Bhopal	20
33	MP	Rewa	6
34	MP	Indore	20
35	MP	Gwalior	10
36	Maharashtra	Nagpur	11.5
37	Maharashtra	Kalyan-Dombivli	NA
38	Manipur	Imphal	2
39	New Delhi	Kidwai Nagar	1.6
40	Odisha	Bhubaneswar & Cuttack, Odisha	11.5
41	Punjab	Amritsar	11.5
42	Rajasthan	Jaipur	15
43	Rajasthan	Kota	7
44	Rajasthan	Jodhpur	3
45	Tamil Nadu	Pallavapuram &Tambaram Venkatamangalam	4
46	Tamil Nadu	Rameswaram	NA
47	Telangana	Cluster of 18 ULBs (M/ S Shalivahana MSWM Green Energy Ltd)	12
48	Telangana	Cluster of 16 ULBs (M/s Hemasri Power	12.6

		Projects Ltd.)	
49	Telangana	Greater Hyderabad Municipal Corporation (RDF Power Projects Ltd.)	11
50	Telangana	Greater Hyderabad Municipal Corporation (SELCO)	6.6
51	UP	Kanpur	15
52	UP	Agra	10
53	UP	Rampur	8
54	UP	Meerut	10
55	Uttarakhand	Roorkee (Cluster of 18 ULBs)	11
56	Punjab	Amritsar Cluster (include Amritsar, Jandiala, Patti, Tarantaran, Raja Sansi, Majitha, Rayya, Khemkaran)	12
	Total		413

Source: SBM Data

Annexure IV to IX:

Financial Sustainability for Standalone & Cluster Model and Business model of Cement Plant with 100 TPD co-processing platform along with IRR Calculations

Annexure –IV

IRR CALCULATION FOR 100 TPD RDF PLANT WITHOUT CONSIDERING REVENUE FROM RECYCLABLES

A: BASIS

Assumptions:	Total	Grade 1	Grade 2	Grade 3
TPD(MT)	100			
Days Of Operation In an Year	300			
Yearly Production(MT)	30000			
Product Mix(%)		40%	30%	30%
Production(MT)		12000	9000	9000
Viable selling price per1000 Kcal/Kg in Rs^	0.40			
calorific value in Kcal		4500	3750	3000
Selling Price(RS/MT)		1800	1500	1200
Revenue (in Rs)	45900000	21600000	13500000	10800000
CAPEX(approx)(in Rs)^	140,000,000			
Subsidy @ 50%(in Rs)	70,000,000			
Net Capex(in Rs)	70,000,000			
Discounting period(In Years)	10			
OPEX (IN Rs/MT)(approx)^	1200			
Transportation cost Rs/ MT for 100 Km distance^	300			

Variables to be addressed for improving the IRR

B: CALCULATION OF
Yearly IRR

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	45,900,000	36000000	9000000	900000	900000	900000
2	45,900,000	36000000	9000000	900000	900000	900000
3	45,900,000	36000000	9000000	900000	900000	900000
4	45,900,000	36000000	9000000	900000	900000	900000
5	45,900,000	36000000	9000000	900000	900000	900000
6	45,900,000	36000000	9000000	900000	900000	900000
7	45,900,000	36000000	9000000	900000	900000	900000
8	45,900,000	36000000	9000000	900000	900000	900000
9	45,900,000	36000000	9000000	900000	900000	900000
10	45,900,000	36000000	9000000	900000	900000	900000
				IRR	-33%	-26%

Annexure –V

IRR CALCULATION FOR 100 TPD RDF PLANT WITH 10% QUANTITY OF RECYCLABLES

A: BASIS

Assumptions:	Total	Grade 1	Grade 2	Grade 3
Days Of Operation In an Year	300			
Recyclables(MT)*	10			
Yearly Production(MT)	3000			
Net Selling Price(RS/MT)#	8000			
Revenue (in Rs)(i)	24000000			
RDF				
TPD(MT)*	90			
Yearly Production(MT)	27000			
Product Mix(%)		40%	30%	30%
Production(MT)		10800	8100	8100
Viable selling price per1000 Kcal/Kg in Rs^	0.40			
calorific value in Kcal		4500	3750	3000
Selling Price(RS/MT)		1800	1500	1200
Revenue (in Rs)	41310000	19440000	12150000	9720000
CAPEX(approx)(in Rs)^	140,000,000			
Subsidy @ 50%(in Rs)	70,000,000			
Net Capex(in Rs)	70,000,000			

Discounting period(In Years)	10			
OPEX (IN Rs/MT)(approx)^	1200			
Transportation cost Rs/ MT for 100 Km distance^	300			

* the ratio of Recyclables to RDF is assumed at 10:90

Net of expenses ,if any for waste segregation etc.

Variables to be addressed for improving the IRR

B: CALCULATION OF

IRR IN 5 YEARS

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	65,310,000	32400000	8100000	24810000	24810000	24810000
2	65,310,000	32400000	8100000	24810000	24810000	24810000
3	65,310,000	32400000	8100000	24810000	24810000	24810000
4	65,310,000	32400000	8100000	24810000	24810000	24810000
5	65,310,000	32400000	8100000	24810000	24810000	24810000
				IRR	-4%	23%

IRR IN 10 YEARS

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	65,310,000	32400000	8100000	24810000	24810000	24810000
2	65,310,000	32400000	8100000	24810000	24810000	24810000
3	65,310,000	32400000	8100000	24810000	24810000	24810000
4	65,310,000	32400000	8100000	24810000	24810000	24810000
5	65,310,000	32400000	8100000	24810000	24810000	24810000
6	65,310,000	32400000	8100000	24810000	24810000	24810000
7	65,310,000	32400000	8100000	24810000	24810000	24810000
8	65,310,000	32400000	8100000	24810000	24810000	24810000
9	65,310,000	32400000	8100000	24810000	24810000	24810000
10	65,310,000	32400000	8100000	24810000	24810000	24810000
				IRR	12%	33%
				NPV	₹ 152,446,710	₹ 152,446,710

Annexure –VI

IRR CALCULATION FOR 100 TPD RDF PLANT WITH 20% QUANTITY OF RECYCLABLES

A: BASIS

Assumptions:	Total	Grade 1	Grade 2	Grade 3
Recyclables(MT)*	20			
Yearly Production(MT)	6000			
Net Selling Price(RS/MT)#	8000			
Revenue (in Rs)(i)	48000000			
RDF				
TPD(MT)	80			
Days Of Operation In an Year	300			
Yearly Production(MT)	24000			
Product Mix(%)		40%	30%	30%
Production(MT)		9600	7200	7200
Viable selling price per1000 Kcal/Kg in Rs^	0.40			
calorific value in Kcal		4500	3750	3000
Selling Price(RS/MT)		1800	1500	1200
Revenue (in Rs)	36720000	17280000	10800000	8640000
CAPEX(approx)(in Rs)^	140,000,000			
Subsidy @ 50%(in Rs)	70,000,000			
Net Capex(in Rs)	70,000,000			

Discounting period(In Years)	10			
OPEX (IN Rs/MT)(approx)^	1200			
Transportation cost Rs/ MT for 100 Km distance^	300			

* the ratio of Recyclables to RDF is assumed at 20:80

Net of expenses ,if any for waste segregation etc.

Variables to be addressed for improving the IRR

B: CALCULATION OF

IRR IN 5 YEARS

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	84,720,000	28800000	7200000	48720000	48720000	48720000
2	84,720,000	28800000	7200000	48720000	48720000	48720000
3	84,720,000	28800000	7200000	48720000	48720000	48720000
4	84,720,000	28800000	7200000	48720000	48720000	48720000
5	84,720,000	28800000	7200000	48720000	48720000	48720000
				IRR	22%	64%

IRR IN 10 YEARS

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	84,720,000	28800000	7200000	48720000	48720000	48720000
2	84,720,000	28800000	7200000	48720000	48720000	48720000
3	84,720,000	28800000	7200000	48720000	48720000	48720000
4	84,720,000	28800000	7200000	48720000	48720000	48720000
5	84,720,000	28800000	7200000	48720000	48720000	48720000
6	84,720,000	28800000	7200000	48720000	48720000	48720000
7	84,720,000	28800000	7200000	48720000	48720000	48720000
8	84,720,000	28800000	7200000	48720000	48720000	48720000
9	84,720,000	28800000	7200000	48720000	48720000	48720000
10	84,720,000	28800000	7200000	48720000	48720000	48720000
				IRR	33%	69%
				NPV	₹ 299,363,309	₹ 299,363,309

Annexure –VII

IRR CALCULATION FOR 100 TPD RDF PLANT WITH 30% QUANTITY OF RECYCLABLES

A: BASIS

Assumptions:	Total	Grade 1	Grade 2	Grade 3
Recyclables(MT)*	30			
Yearly Production(MT)	9000			
Net Selling Price(RS/MT)#	8000			
Revenue (in Rs)(i)	72000000			
RDF				
TPD(MT)	70			
Days Of Operation In an Year	300			
Yearly Production(MT)	21000			
Product Mix(%)		40%	30%	30%
Production(MT)		8400	6300	6300
Viable selling price per1000 Kcal/Kg in Rs^	0.40			
calorific value in Kcal		4500	3750	3000
Selling Price(RS/MT)		1800	1500	1200
Revenue (in Rs)	32130000	15120000	9450000	7560000
CAPEX(approx)(in Rs)^	140,000,000			
Subsidy @ 50%(in Rs)	70,000,000			

Net Capex(in Rs)	70,000,000			
Discounting period(In Years)	10			
OPEX (IN Rs/MT)(approx)^	1200			
Transportation cost Rs/ MT for 100 Km distance^	300			

* the ratio of Recyclables to RDF is assumed at 20:80

Net of expenses ,if any for waste segregation etc.

Variables to be addressed for improving the IRR

B: CALCULATION OF 0

IRR IN 5 YEARS

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	104,130,000	25200000	6300000	72630000	72630000	72630000
2	104,130,000	25200000	6300000	72630000	72630000	72630000
3	104,130,000	25200000	6300000	72630000	72630000	72630000
4	104,130,000	25200000	6300000	72630000	72630000	72630000
5	104,130,000	25200000	6300000	72630000	72630000	72630000
				IRR	43%	101%

IRR IN 10 YEARS

YEAR	Revenue(in Rs)	Opex(in Rs)	Transport cost(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0					-140,000,000	-70,000,000
1	104,130,000	25200000	6300000	72630000	72630000	72630000
2	104,130,000	25200000	6300000	72630000	72630000	72630000
3	104,130,000	25200000	6300000	72630000	72630000	72630000
4	104,130,000	25200000	6300000	72630000	72630000	72630000
5	104,130,000	25200000	6300000	72630000	72630000	72630000
6	104,130,000	25200000	6300000	72630000	72630000	72630000
7	104,130,000	25200000	6300000	72630000	72630000	72630000
8	104,130,000	25200000	6300000	72630000	72630000	72630000
9	104,130,000	25200000	6300000	72630000	72630000	72630000
10	104,130,000	25200000	6300000	72630000	72630000	72630000
				IRR	51%	104%

Annexure-VIII

Business model of Cement Plant with 100 TPD co-processing platform

Description	Amt.(Lakhs)
Capital cost for co-processing platform	550
Interest @ 10% on 75% Capital Cost*	54
Depreciation @ 10%**	55
Operating Cost of co-processing platform***	75
Cost of procurement of RDF****	360
Increase in fuel cost due to moisture in RDF	32
Cost impact due to reduction in production*****	180
Total Cost	756
Revenue on Cost saving in thermal substitution	788
Total Revenue before tax	788
Total profit before tax	32
Income Tax on profit @ 35%	11.2
Profit after tax	20.8
Total Cash in hand(Add Depreciation)	75.8
Payback Period	7.25 Years

For a 4 year payback period	values
Additional Revenue required(approx in Rs)	11200000
cement to clinker ratio	1:1.35
cement production(MT)	1350000
Cement production in KGS	1350000000
no. of bags (assuming a bag of 50 kgs)	27000000
Impact per bag of cement(Rs)	0.41

* For the first year, This would diminish with the diminishing balance over the subsequent years

** on Straight line method basis

*** Operation & Maintenance cost of Laboratories , storage, handling and feeding systems in to the kiln

**** @Rs1200 per MT(on an assumption of Rs.0.40 per 1000 Kcal/Kg where average energy in RDF is assumed at 3000Kcal/kg)

***** Assuming capacity utilization of more than 90%. This will also vary slightly with overall increase in clinker cost due to increase in energ

	costs & other costs over the years
Assumptions	
1	Operating days is considered as 300 days i.e. 30000Tons per annum
2	Moisture in RDF is considered as 20%
3	1 Ton of moisture in RDF will have a loss of 2 Ton of clinker production
4	Cost of clinker is considered as Rs. 1500/Ton
5	Calorific value of RDF is considered as 3000 Kcal/Kg

Annexure-IX

IRR CALCULATION FOR CEMENT PLANT WITH CO PROCESSING PLATFORM OF 100 TPD RDF

A: BASIS

Assumptions:	Total
CLINKER TPA(MT)	1000000
Revenue due to cost saving on thermal substitution(in Rs)	78800000
CAPEX(approx)(in Rs)^	55,000,000
Subsidy @ 50%(in Rs)	27,500,000
Net Capex(in Rs)	27,500,000
Discounting period(In Years)	10
OPEX (IN Rs/MT)(approx)^	70100000
(refer cement cost impact sheet)	

0

Variables to be addressed for improving the IRR

B: CALCULATION OF Yearly IRR

YEAR	Revenue(in Rs)	Opex(in Rs)	Net Cash Flows(in Rs)	IRR	IRR with subsidy
0				-55,000,000	-27,500,000
1	78,800,000	70100000	8,700,000	8700000	8700000
2	78,800,000	70100000	8,700,000	8700000	8700000
3	78,800,000	70100000	8,700,000	8700000	8700000
4	78,800,000	70100000	8,700,000	8700000	8700000
5	78,800,000	70100000	8,700,000	8700000	8700000
6	78,800,000	70100000	8,700,000	8700000	8700000
7	78,800,000	70100000	8,700,000	8700000	8700000
8	78,800,000	70100000	8,700,000	8700000	8700000
9	78,800,000	70100000	8,700,000	8700000	8700000
10	78,800,000	70100000	8,700,000	8700000	8700000
			IRR	9%	29%
			NPV	₹ 53,457,734	₹ 53,457,734

Annexure X

Company-wise List of Cement Plants in India

1.	ACC Limited	
	1. Damodar Cement Works	West Bengal
	2. Bargarh Cement Works	Orissa
	3. Chaibasa Cement Works	Jharkhand
	4. Chanda Cement Works	Maharashtra
	5. Gagal Cement Works-I	Himachal Pradesh
	6. Gagal Cement Works-Ii	Himachal Pradesh
	7. Jamul Cement Works	Chhattisgarh
	8. Kudithini Cement Works	Karnataka
	9. Kymore Cement Works	Madhya Pradesh
	10. Lakheri Cement Works	Rajasthan
	11. Madhukkarai Cement Works	Tamil Nadu
	12. New Wadi Cement Works	Karnataka
	13. Sindri Cement Works	Jharkhand
	14. Thondebhavi Cement Works	Karnataka
	15. Tikaria Cement Works	Uttar Pradesh
	16. Vizag Cement Works	Andhra Pradesh
	17. Wadi Cement Works	Karnataka
2.	Adhunik Cement Ltd	
	1. Adhunik Cement Ltd	Meghalaya
3.	Aditi Industries	
	1. Aditi Industries	Assam
4.	Ambuja Cement Ltd	
	1. Ambuja Cements Ltd (Unit: Ambuja Nagar)	Gujarat
	2. Ambuja Cements Ltd (Unit: Bhatapara II)	Chhattisgarh
	3. Ambuja Cements Ltd (Unit: Bhatapara)	Chhattisgarh
	4. Ambuja Cements Ltd (Unit: Bhatinda) (G)	Punjab
	5. Ambuja Cements Ltd (Unit: Dadri) (G)	Uttar Pradesh
	6. Ambuja Cements Ltd (Unit: Darlaghat)	Himachal Pradesh
	7. Ambuja Cements Ltd (Unit: Farakka) (G)	West Bengal
	8. Ambuja Cements Ltd (Unit: Magdalla) (G)	Gujarat

9.	Ambuja Cements Ltd (Unit: Maratha)	Maharashtra
10.	Ambuja Cements Ltd (Unit: Nalagarh)((G)	Himachal Pradesh
11.	Ambuja Cements Ltd (Unit: Rabriyawas)	Rajasthan
12.	Ambuja Cements Ltd (Unit: Rauri)	Himachal Pradesh
13.	Ambuja Cements Ltd (Unit: Roorkee) (G)	Uttarakhand
14.	Ambuja Cements Ltd (Unit: Ropar) (G)	Punjab
15.	Ambuja Cements Ltd (Unit: Sankrail) (G)	West Bengal
5. Anjani Portland Cement Ltd		
1.	Anjani Portland Cement Ltd	Andhra Pradesh
6. Asian Concretes Cement Ltd		
1.	Asian Concretes Cement Ltd	Himachal Pradesh
7. Bagalkot Cement & Inds.Ltd		
1.	Bagalkot Cement & Inds.Ltd	Karnataka
8. Bharti Cement Corpn. Pvt. Ltd		
1.	Bharti Cement Corpn. Pvt. Ltd	Andhra Pradesh
9. Bhavya Cement Ltd		
1.	Bhavya Cement Ltd	Andhra Pradesh
10. Binani Cement Ltd		
1.	Binani Cement Ltd - Sikar	Rajasthan
2.	Binani Cement Ltd - Sirohi	Rajasthan
11. Birla Corporation Ltd		
1.	Birla Cement - Raebareli	Uttar Pradesh
2.	Birla Cement Works & Chanderia	Rajasthan
3.	Birla- Durga Hitech Cement	West Bengal
4.	Birla- Durgapur Cement Works	West Bengal
5.	Birla Vikas & Satna Cement Works	Madhya Pradesh
12. Calcom Cement Ltd		
1.	Calcom Cement Ltd	Assam
13. Cement Corporation of India Ltd		
1.	Cement Corporation of India Ltd- Adilabad	Telangana
2.	Cement Corporation of India Ltd- Bokajan	Assam
3.	Cement Corporation of India Ltd- Nayagaon	Madhya Pradesh
4.	Cement Corporation of India Ltd- Rajban	Himachal Pradesh
5.	Cement Corporation of India Ltd- Tandur	Telangana

6. Cement Corporation of India Ltd-Akaltara — Chhattisgarh
7. Cement Corporation of India Ltd-Chakhi Dadri — Haryana
8. Cement Corporation of India Ltd-Delhi — Delhi
9. Cement Corporation of India Ltd-Kurkunta — Karnataka
10. Cement Corporation of India Ltd-Mandhar — Madhya Pradesh

14. Cement Manufacturing Co.Ltd
    1. Cement Manufacturing Co.Ltd - Jaintia Hills — Meghalaya
    2. Cement Manufacturing Co.Ltd - Megha T & E Ltd — Meghalaya
15. Century Textiles & Inds.Ltd
    1. Century Cement - Mahiar — Madhya Pradesh
    2. Century Cement - Manikgarh — Maharashtra
    3. Century Cement - Raipur — Chhattisgarh
16. Chettinad Cement Corpn. Ltd
    1. Chettinad Cement - Ariyalur — Tamil Nadu
    2. Chettinad Cement – Karikali — Tamil Nadu
    3. Chettinad Cement - Puliyur — Tamil Nadu
    4. Chettinad Cement -Kallur — Karnataka
17. Dalmia Cement (Bharat) Ltd
    1. Dalmia Cement (Bharat) Ltd- Ariyalur — Tamil Nadu
    2. Dalmia Cement (Bharat) Ltd- Dalmiapuram — Tamil Nadu
    3. Dalmia Cement (Bharat) Ltd- Kadapa — Andhra Pradesh
18. Deccan Cement Ltd
    1. Deccan Cement Ltd — Telangana
19. Green Valley Industries Limited
    1. Green Valley Industries Limited — Meghalaya
20. Gujarat Sidhee Cement Ltd
    1. Gujarat Sidhee Cement Ltd — Gujarat
21. Heidelberg Cement India Ltd
    1. Heidelberg Cement India Ltd- Ammasandra — Karnataka
    2. Heidelberg Cement India Ltd- Damoh — Madhya Pradesh
    3. Heidelberg Cement India Ltd- Jhansi — Uttar Pradesh
    4. Heidelberg Cement India Ltd- Raigad — Maharashtra
22. Hemadri Cement Ltd
    1. Hemadri Cement Ltd — Andhra Pradesh

23. India Cements Ltd

1.	The India Cements Ltd- Chilamkur Works	Andhra Pradesh
2.	The India Cements Ltd- Dalavoi	Tamil Nadu
3.	The India Cements Ltd- Parli	Maharashtra
4.	The India Cements Ltd- Raasi Cement	Telangana
5.	The India Cements Ltd- Sankari Durg	Tamil Nadu
6.	The India Cements Ltd- Sankarnagar	Tamil Nadu
7.	The India Cements Ltd- Trinetra	Rajasthan
8.	The India Cements Ltd- Visaka Cement	Telangana
9.	The India Cements Ltd- Yerraguntla	Andhra Pradesh
10.	The India Cements Ltd. - Vallur	Tamil Nadu

24. J. S. W Cement Ltd

1.	J. S. W Cement Ltd	Maharashtra

25. J.K. Cement Ltd

1.	J.K. Cement Ltd- Gotan	Rajasthan
2.	J.K. Cement Ltd- Jharli	Haryana
3.	J.K. Cement Ltd- Mangrol	Rajasthan
4.	J.K. Cement Ltd- Muddapur	Karnataka
5.	J.K. Cement Ltd- Nimbahera	Rajasthan

26. Jagdamba Industries Limited

1.	Jagdamba Industries Limited	West Bengal

27. Jaiprakash Associates Ltd

1.	Jaypee Cement - Bela	Madhya Pradesh
2.	Jaypee Cement - Rewa	Madhya Pradesh
3.	Jaypee Cement - Baga(Himachal)	Himachal Pradesh
4.	Jaypee Cement - Bagheri	Himachal Pradesh
5.	Jaypee Cement - Bakaro	Jharkhand
6.	Jaypee Cement - Balaji	Andhra Pradesh
7.	Jaypee Cement - Bhilai	Chhattisgarh
8.	Jaypee Cement - Bhilai (clinker)	Madhya Pradesh
9.	Jaypee Cement - Dalla	Uttar Pradesh
10.	Jaypee Cement - Kutch	Gujarat
11.	Jaypee Cement - Panipat	Haryana
12.	Jaypee Cement - Roorkee	Uttarakhand

13. Jaypee Cement - Sadva Khurd	Uttar Pradesh
14. Jaypee Cement - Sidhee	Madhya Pradesh
15. Jaypee Cement - Sikandarabad	Uttar Pradesh
16. Jaypee Cement - Wanakbori	Gujarat
17. Jaypee Cement- Ayodhya	Uttar Pradesh
18. Jaypee Cement- Chunar	Uttar Pradesh
19. Jaypee Cement- Durga Cement Works	Andhra Pradesh
20. Jaypee Cement- Visaka Cement Works	Telangana
28. Jammu & Kashmir Cements Ltd	
1. Jammu & Kashmir Cement Ltd.	Jammu & Kashmir
29. JK Lakshmi Cement Ltd	
1. JK Lakshmi Cement Ltd- Jharli	Haryana
2. JK Lakshmi Cement Ltd- Kalol	Gujarat
3. JK Lakshmi Cement Ltd- Sirohi	Rajasthan
30. K. J. S. Cement Ltd	
1. K. J. S. Cement Ltd	Madhya Pradesh
31. K.C.P. Ltd	
1. The K.C.P. Ltd- Muktyala	Andhra Pradesh
2. The K.C.P. Ltd.- Macherla	Andhra Pradesh
32. Kakatiya Cement & Sugar Industries Ltd	
1. Kakatiya Cement & Sugar Industries Ltd	Telangana
33. Kalyanpur Cements Ltd	
1. Kalyanpur Cements Ltd	Bihar
34. Kamdhenu Cement Ltd	
1. Powercon Cement Ltd	Uttar Pradesh
35. Kesoram Cement	
1. Kesoram Cement- Basant Nagar	Telangana
2. Kesoram Cement- Vasavadatta	Karnataka
36. Khyber Industries (P) Ltd	
1. Khyber Industries (P) Ltd	Jammu & Kashmir
37. Lafarge India (P) Ltd	
1. Lafarge India (P) Ltd- Arasmeta Cement	Chhattisgarh
2. Lafarge India (P) Ltd- Jojobera	Jharkhand
3. Lafarge India (P) Ltd- Mejia	West Bengal

4.	Lafarge India (P) Ltd- Sonadih	Chhattisgarh
38.	Lanco Industries Ltd	
1.	Lanco Industries Ltd	Andhra Pradesh
39.	Madras Cements Ltd	
1.	Madras Cements Ltd- Alathiyur I & II	Tamil Nadu
2.	Madras Cements Ltd- Ariyalur	Tamil Nadu
3.	Madras Cements Ltd- Jayanthipuram	Andhra Pradesh
4.	Madras Cements Ltd- Kolaghat	West Bengal
5.	Madras Cements Ltd- Ramasamyraja Nagar	Tamil Nadu
6.	Madras Cements Ltd- Salem	Tamil Nadu
7.	Madras Cements Ltd- Uthiramerur	Tamil Nadu
40.	Malabar Cements Ltd	
1.	Malabar Cements Ltd- Palakkad	Kerala
2.	Malabar Cements Ltd- Pallipuram	Kerala
41.	Mancherial Cement Ltd	
1.	Mancherial Cement Ltd	Telangana
42.	Mangalam Cement Ltd	
1.	Mangalam Cement Ltd & Neershree	Rajasthan
43.	Mawmluh Cherra Cements Ltd	
1.	Mawmluh Cherra Cements Ltd	Meghalaya
44.	Meghalaya Cements Ltd.	
1.	Meghalaya Cements Ltd.	Meghalaya
45.	My Home Inds. Ltd.	
1.	My Home Industries Ltd	Telangana
2.	My Home Industries Ltd-Vizag	Andhra Pradesh
46.	OCL India Ltd	
1.	OCL India Ltd- Kapilas	Orissa
2.	OCL India Ltd- Rajgangpur	Orissa
47.	Orient Cement	
1.	Orient Cement- Devapur	Telangana
2.	Orient Cement- Jalgaon	Maharashtra
48.	Panyam Cement & Mineral Industries Ltd.	
1.	Panyam Cement & Mineral Industries Ltd.	Andhra Pradesh
49.	Parasakti Cement Ltd	

	1. Parasakti Cement Ltd	Andhra Pradesh
50.	Penna Cement Industries Ltd	
	1. Penna Cement Industries Ltd- Boyareddypalli	Andhra Pradesh
	2. Penna Cement Industries Ltd- Ganeshpahad	Telangana
	3. Penna Cement Industries Ltd- Tadipatri	Andhra Pradesh
	4. Penna Cement Industries Ltd- Tandur	Telangana
51.	Prism Cement Ltd.	
	1. Prism Cement Ltd. - I & II	Madhya Pradesh
52.	Purbanchal Cement Ltd	
	1. Purbanchal Cement Ltd	Assam
53.	Rain Cements Ltd	
	1. Rain Cements Ltd- UN -I	Telangana
	2. Rain Cements Ltd- UN- II- Line I	Telangana
	3. Rain Cements Ltd- UN II- Line II	Telangana
54.	Reliance Cement Company Private Limited	
	1. Reliance Cement Company Private Limited	Maharashtra
55.	RNB Cements (P) Ltd	
	1. RNB Cements (P) Ltd	Meghalaya
56.	Sagar Cement Ltd	
	1. Sagar Cement Ltd	Sagar Cement Ltd
57.	Sanghi Cement Ltd	
	1. Sanghi Cement Ltd	Delhi
58.	Sanghi Industries Ltd	
	1. Sanghi Industries Ltd	Gujarat
59.	Saurashtra Cement Ltd	
	1. Saurashtra Cement Ltd	Gujarat
60.	Shree Cement Ltd	
	1. Bangur Cement - A Unit of Shree Cement	Bihar
	2. Shree Cement Ltd - Jaipur	Rajasthan
	3. Shree Cement Ltd- Khushkhera	Rajasthan
	4. Shree Cement Ltd- Ras	Rajasthan
	5. Shree Cement Ltd- Roorkee	Uttarakhand
	6. Shree Cement Ltd- Suratgarh	Rajasthan
	7. Shree Cement Ltd.- Beawar	Rajasthan

61. Shree Digvijay Cement Co. Ltd
    1. Shree Digvijay Cement Co. Ltd — Gujarat
62. Shree Jagjothi Cement Ltd
    1. Shree Jagjothi Cement Ltd — Tamil Nadu
63. Shriram Cement Works
    1. Shriram Cement Works — Rajasthan
64. Tamil Nadu Cements Corpn. Ltd.
    1. Tamil Nadu Cements Corpn. Ltd.- Alangulam — Tamil Nadu
    2. Tamil Nadu Cements Corpn. Ltd.- Ariyalur — Tamil Nadu
65. Tata chemicals Ltd
    1. Tata chemicals Ltd — Gujarat
66. UltraTech Cement Ltd
    1. UltraTech - AP Cement Works — Andhra Pradesh
    2. UltraTech - Hirmi Cement Works — Chhattisgarh
    3. UltraTech - Gujarat Cement Works — Gujarat
    4. UltraTech - Jafrabad Cement Works — Gujarat
    5. UltraTech - Magdalla Cement Works — Gujarat
    6. UltraTech - Panipat Cement Works — Haryana
    7. UltraTech - Rawan Cement Works — Chhattisgarh
    8. UltraTech- Aditya Cement Works — Rajasthan
    9. UltraTech- Aligarh Cement Works — Uttar Pradesh
    10. UltraTech- Arakkonam Cement Works — Tamil Nadu
    11. UltraTech- Awarpur Cement Works — Maharashtra
    12. UltraTech- Bathinda Cement Works — Punjab
    13. UltraTech- Dadri Cement Works — Uttar Pradesh
    14. UltraTech- Ginigera Cement Works (G) — Karnataka
    15. UltraTech- Hotgi Cement Works — Maharashtra
    16. UltraTech- Jharsuguda Cement Works — Orissa
    17. UltraTech- Kotputli Cement Works — Rajasthan
    18. UltraTech- Rajashree Cement Works — Karnataka
    19. UltraTech- Ratnagiri Cement Works — Maharashtra
    20. UltraTech- Reddipalayam Cement Works — Tamil Nadu
    21. UltraTech- Vikram Cement Works — Madhya Pradesh
    22. UltraTech- West Bengal Cement Works — West Bengal

67. Uma Cement Industries
    1. Uma Cement Industries — Jammu & Kashmir
68. Viket Sagar Cement
    1. Viket Sagar Cement — Andhra Pradesh
69. Wonder Cement Ltd
    1. Wonder Cement Ltd — Rajasthan
70. Zuari Cement Ltd
    1. Zuari Cement Ltd.- Chennai — Tamil Nadu
    2. Zuari Cement Ltd.- Krishnanagar — Andhra Pradesh
    3. Zuari Cement Ltd.- Sri Vishnu Cement — Andhra Pradesh