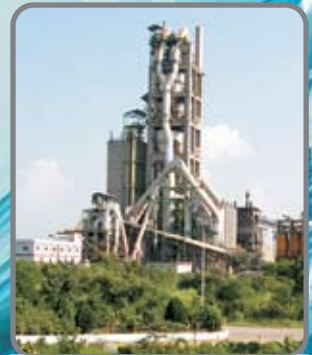
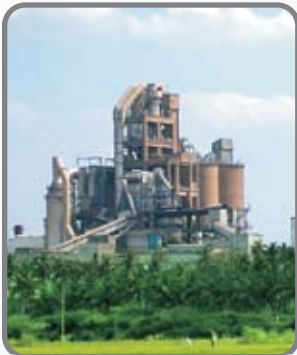
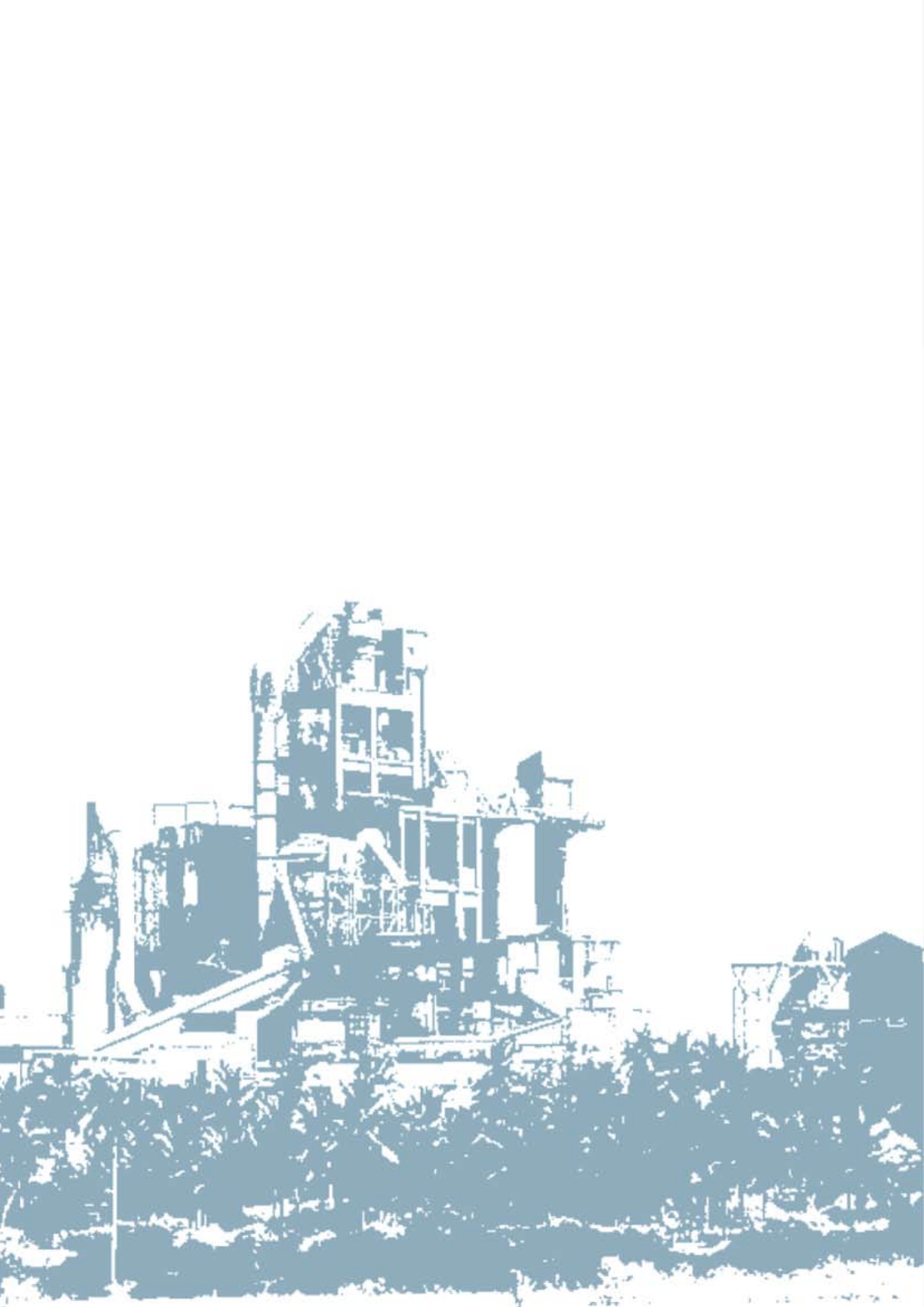




ACTION PLAN FOR ENHANCING THE USE OF ALTERNATE FUELS AND RAW MATERIALS IN THE INDIAN CEMENT INDUSTRY







Cement
Manufacturers'
Association



Institute for
**Industrial
Productivity**

ACTION PLAN FOR ENHANCING THE USE OF ALTERNATE FUELS AND RAW MATERIALS IN THE INDIAN CEMENT INDUSTRY



@Copy right

All Rights Reserved

This report has been prepared in partnership with:



HOLTEC

Holtec Consulting Private Limited

DISCLAIMER: None of the parties involved in the development and production of this report assume any responsibility, makes any warranty, or assume any legal liability for the accuracy, completeness, or usefulness of any information contained in this booklet.

This booklet and the information contained therein, cannot be reproduced in part or full without the written permission of the organizers.



Institute for Industrial Productivity (IIP) is an independent non-profit organization that operates globally with regional teams in China, India, the United States and Europe. Head quartered in Washington DC, IIP is independently funded by the Climate Works Foundation, serving as its Best Practice Network partner for the industrial sector.

IIP provides critical analysis, information, tools and expert support to assist two essential groups, Governments and Industry, in meeting important emission reduction and energy intensity goals. The Institute uses its broad integrated network of policy, technology and finance experts to identify, analyze and share best practices and resources for improving energy efficiency in industry, enhance productivity, and reduce GHG emissions. Through focused partnerships targeting the most energy intensive industries in the countries that use the most energy, IIP supports sustainable economic growth and progress towards a low carbon future.

Sharing best practices for the low carbon future | iipnetwork.org



Cement Manufacturers' Association (CMA), the apex body of large cement manufacturers in India was established in 1961. It is a unique body in as much as it has both the private and public sector cement companies as its members.

CMA acts as a bridge between Indian Cement Industry and the Government. It creates a conducive Environment to promote industry, through advice and consultation. It closely works with Government, various Regulators on policy issues, enhancing efficiency, competitiveness, growth and development opportunities for Indian cement industry. As a representative organization of cement industry, CMA articulates the genuine, legitimate needs and interests of the cement industry with an objective to protect the consumer interests and to identify newer applications of cement usage.

Its mission is to impact the policy and legislative environment so as to foster balanced economic, industrial and social development in the cement industry. CMA has been particularly active in the areas of Energy Efficiency, Environment-Friendliness and Sustainability Standards. Towards this end, CMA partners actively with like-minded and specialized organizations, such as, World Business Council for Sustainable Development (WBCSD) as a 'Communication Partner' for Cement Sustainability Initiative (CSI) and with Institute for Industrial Productivity (IIP), Washington, for conducting focused studies for sharing and dissemination of the latest technological information.

CONTENTS

Executive Summary	x
1. Background	x
2. Most promising alternate fuels and raw materials	x
3. Hazardous waste as an alternate fuel	x
4. Refuse derived fuel from municipal solid waste as an alternate fuel	x
5. Used tyres as an alternate fuel	x
6. Biomass as an alternate fuel	x
7. Industrial plastic as an alternate fuel	x
8. Flyash as an alternate raw material.....	x
9. SLAG as an alternate raw material.....	x
10. Case study to utilize Tirupur textile cluster ETP Sludge as an alternative raw material	x

EXECUTIVE SUMMARY

Preamble

India is the second largest cement producer in the world. Being an energy intensive industry, meeting its energy demand is a formidable challenge. While the Indian cement industry has achieved significant achievements in terms of improvement in energy efficiency, use of alternate fuels and raw materials (AFR) still remains a major area of concern. At present, the TSR (Thermal Substitution Rate) of the Indian cement industry ranges between 0.5-1%, while in some developed countries, this figure is as high as 60%. Use of Alternative fuels for meeting energy requirement is a sustainable initiative which can not only help save fossil fuel and mitigate GHG emissions, but also facilitate the intimidating task of waste disposal in an environmentally sound manner.

Project At A Glance

With the above backdrop, the Institute for Industrial Productivity (IIP) has initiated a project with the objective of increasing the Thermal Substitution Rate (TSR) in Indian Cement Industry. The initiative is aimed at developing an action plan to mainstream AFRs and then facilitate its implementation thereby helping the industry realize higher TSR levels with accompanying societal benefits. This multi stake holder initiative is anchored at Cement Manufacturer's Association of India (CMA), with Holtec Consulting Pvt. Ltd being the technical partner. Dr B. Sengupta (Ex. Member Secretary-CPCB), is an independent advisor to the project on regulatory issues. The project is also benefitted by the guidance and advisory support provided by a Forum of Regulators, Chaired by Shri Hardik Shah, Member Secretary, Gujarat Pollution Control Board.

Availability of Alternate Fuels & Raw Materials

A framework was developed to shortlist the most promising alternate fuels and raw material in the Indian context. The attributes considered for short listing of the alternate fuels and their availability include energy content, availability, CO₂ mitigation potential, ease of processing and addressing environmental concerns. The table below provides the final shortlist along with their availability.

Alternative Fuel	Total Availability (million tpy)	Percentage of total Availability considered	Availability for co-processing (million tpy)
Surplus Biomass	150	10	14.6
RDF from MSW	6.88	20	1.37
Used Tyres	0.83	50	0.40
Hazardous Waste	0.54	75	0.40
Industrial Plastic Waste	0.20	50	0.10

The attributes considered to short list the most promising alternative raw materials (Blending materials) included availability, addressing environmental concerns, CO₂ mitigation potential and ease of processing,, The following table provides the final shortlist and their availability

Alternative Raw Material	Total Availability (million tpy)
Fly ash	200
Slag	10

Characteristics of Alternate Fuels & Raw Materials

Alternative fuels may contain high percentages of chlorides, sulphur, heavy metals, moisture etc. Thermal substitution levels must be carefully determined in case of raw materials with high

chlorine and/or sulphur content. High input of these volatiles may lead to operational issues causing pre-heater blockages necessitating a gas bypass system. High moisture content in alternative fuels such as RDF may lead to reduction in kiln capacity if the exhaust fan has a limited margin. The specific heat rate of the kiln may also get adversely affected. Careful pre-processing is needed and the substitution rate needs to be adjusted based on the existing raw material quality and fuel characteristics.

Fly ash with high unburnt carbon is not suitable for blending. Such fly ash should be used as a raw material with useful heat content. Slag in granulated form is used as a blending material. However, high moisture and low glass content can restrict its usage. LD slag from steel plants can be used as raw material to partly replace limestone.

Benefits of Using Alternate Fuels & Raw Materials

Substantial volumes of fossil fuels can be saved and associated CO₂ emissions mitigated by co-processing alternative fuels in Cement Industry. The details are presented in subsequent papers. Co-processing will also help in safe and environmentally sound disposal of a variety of waste materials (e.g. municipal solid waste, hazardous wastes, used tyres, plastic waste etc.), the disposal of which are becoming an issue of increasing concern. Use of slag and fly ash as blending material can reduce the limestone requirement per tonne of cement and hence the energy requirement, thus saving on fossil fuels and mitigating both fuel as well as process related carbon emissions.

Recommendations for Promoting use of Alternate Fuels and Raw Materials

Based on a barrier analysis and detailed techno economic feasibility studies, the project has recommended a set of implementable action plans to enhance the use of AFRs. The recommended action plan is presented below for each of the five alternate fuels and two raw materials studied in detail.

Hazardous Waste (HW)

- Developing emission standards for Cement Industry using HW
- Recommend exemption of emission trials for selected categories of HW

- Suggest steps to increase availability of HW for co processing by including some part of land-fillable HW
- Develop guidelines for HW pre-processing units for cement industry
- Facilitate availability of HW Inventory data base on software platform in all relevant states
- Suggest amendments to existing HW rules to include co-processing of HW in Cement plants as a 4th option of HW disposal
- For HW Pre processing units for cement Industry, central/ states subsidy be encouraged based on viability gap funding

Residue Derived Fuel (RDF) from Municipal Solid Waste (MSW)

- Setting up a demonstration project in a public private partnership mode that addresses all the pillars of sustainability namely technical, institutional and financial
- RDF co-processing inclusion by MNRE under their waste to energy scheme
- RDF use for co-processing to be acknowledged as a CSR activity, which would unlock finances for this action that will have major societal benefits by partly solving the menace of MSW

Used Tyres

- Recommend ban on current practices of disposing used tyres that create huge environment pollution
- Recommend free import of tyre chips and rubber waste for co-processing

Biomass

- Represent to MNRE for including biomass co-processing in cement industry in their action agenda for utilizing surplus biomass
- Captive/neighbourhood energy crop plantation should be carried out by the cement industry as CSR activity

Industrial Plastic Waste

- Replicate Gujarat model of encouraging plastic waste co processing in cement plants in other states of India
- Normalization of policy with regard to categorization of plastic waste that facilitates its transportation across states

Fly ash

- Policy amendments to increase fly ash usage in cement industry to 40% from the present level of 35%

Slag

- Pre sorted and sized LD slag from steel plants to be used as raw material

1 BACKGROUND

Indian cement industry is the second largest in the world with a total installed capacity of 349 million tonnes as on March 2013. The requirement of coal is 32-35 million tonnes per annum, which is increasing at a fast pace with the rapid growth in cement manufacture. Large amount of coal is being imported as domestic coal production is not able to cope up with the demand. While the Indian cement industry has achieved significant achievements in terms of improvement in energy efficiency & productivity through various initiatives, alternate fuels and raw materials (AFR) usage still remains a major area of concern. At present, the TSR (Thermal Substitution Rate) of the Indian cement industry ranges between 0.5-1%, while in some developed countries, this figure is as high as around 60%. Various studies indicate that fossil fuel savings and the GHG emission reduction potential through waste utilization in cement kilns is extremely high. While the mitigation cost on one hand is reasonable, the replication potential is enormous.

Further, effective and efficient waste management in India is becoming a major concern. High pace of urbanization and rapid industrialization is posing major challenges in the waste management sector. Finding synergy between the problem of managing this waste and the shortage of coal is a possible ecological solution. Co-processing of waste derived fuels (alternative fuels) and raw materials in the cement industry, therefore, presents a win-win situation for a country like India.

With this background, Institute for Industrial Productivity (IIP), along with its partners Cement

Manufacturers Association of India (CMA) and Holtec Consulting Private Limited (Holtec), embarked on an initiative to 'Increasing the TSR in the Indian cement industry by promoting the use of alternate fuels and raw materials'. The scope of work for the Phase-I of this initiative is designed to come up with an implementable action plan, culminating in an International Conference to share the findings of the study, garner support from a larger stakeholder base and create a knowledge exchange platform by bringing in international players active in this area.

The background material compiled for the Conference is based on a detailed literature survey, field level techno-economic feasibility studies to further the existing knowledge on the subject and extensive engagement and interaction with a range of stakeholders that includes the regulators, industry, technology suppliers as well as civil society. For each of the chosen AFRs, the action plan reports broadly cover the following aspects;

- Inventory Status
- Waste Characterization
- Pre-processing Technologies
- Operational Health and Safety Considerations
- Environmental Implications
- Co-processing Technologies
- Potential Benefits of Co-processing
- Typical Case Studies, based on techno-economic feasibility analysis
- Barriers in mainstreaming the AFR, and
- Recommended Action Plan

2 MOST PROMISING ALTERNATE FUELS & RAW MATERIALS

In order to arrive at the most promising AFRs, separate frameworks were developed for alternate fuels and raw materials. Each of these frameworks were based on some important relevant attributes and assigned weightages as can be seen from Table 1 and Table 2. Table 3 summarizes the final list of chosen AFRs.

TABLE 1: Chosen attributes and weightages for shortlisting most promising alternate fuels

SN	Attribute	Weightage (Score)	Remarks
I	Energy Content (Calorific Value)	25	Highest Calorific Value gets maximum score due to attractiveness for co-processing
II	Availability	25	Includes existing and Potential availability in India. Highest availability gets maximum score
III	Addressing Environmental Concerns	20	Greatest contribution to addressing local pollution problems gets maximum score.
IV	Ease of Processing	20	Includes preprocessing needs, handling & firing equipments, transport logistics & Co-processing requirements. AFs which are easier and cheaper to process gets maximum score
V	CO2 Mitigation Potential	10	Highest mitigation potential gets maximum score.

TABLE 2: Chosen attributes and weightages for shortlisting most promising alternate raw materials

SN	Attribute	Weightage, (Score)	Remarks
I	Availability	30	Includes existing and Potential availability in India. Highest availability gets maximum score
II	Addressing Environmental Concerns	30	Greatest Potential to provide solutions to local pollution problem gets maximum score
III	CO2 mitigation potential	20	Highest mitigation potential gets maximum score.
IV	Ease of Processing	20	Ease of Processing includes preprocessing involved, handling, transport logistics & usage of raw materials. AF's which are easier to process gets maximum score

TABLE 3: Final list of chosen AFRs

Alternate Fuels	Alternate Raw Materials
Hazardous waste	Flyash Steel Slag
RDF from MSW	
Used tyres	
Biomass	
Plastic waste	

3 HAZARDOUS WASTE AS AN ALTERNATE FUEL

Hazardous wastes due to their physical, chemical reactive, toxic, flammable, explosive or corrosive properties pose health and environmental hazards and require sound and sustainable waste management practices for their disposal. Co-processing of hazardous wastes in cement plants is an environmentally sound option in this regard with added benefits of energy recovery and CO2 mitigation.

Hazardous Waste Generation in India

The estimated hazardous waste generation in India for the year 2012-13 was 8.14 million tonnes. Category wise distribution of the hazardous waste generated for the year 2007-08 and estimates for the year 2012-13, are illustrated in figure 1.

About half of the generated volume is recyclable with more than 40 % being disposed in secured landfills. Although the incinerable hazardous waste is less than 10% of the total volume, it amounts to about 0.54 million tonnes at present levels and is a potential source of alternative fuel for the cement industry.

Figures 2 & 3 illustrate the percentage contribution towards incinerable Hazardous waste Inventory

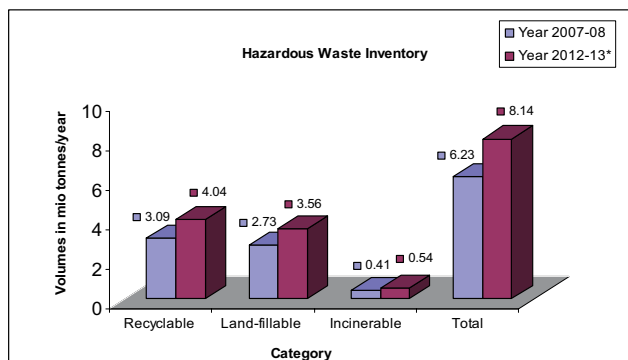


Figure 1: Category wise hazardous waste Inventory for the year 2007-08 and 2012-13 (* Estimated quantities as per CPCB)

and volumes of hazardous generated by various states for the year 2007-08.

Figure 2: Percentage contribution of Incinerable Hazardous Waste by Various States. Figure 3: State Wise Incinerable Hazardous Waste Generation volumes in million tonnes.

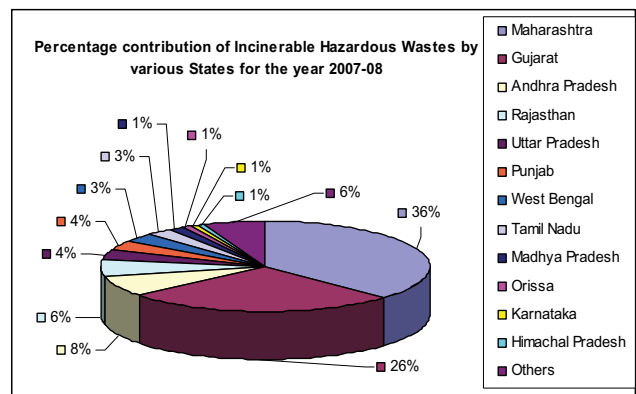


Figure 2: Percentage contribution of Incinerable Hazardous Waste by Various States.

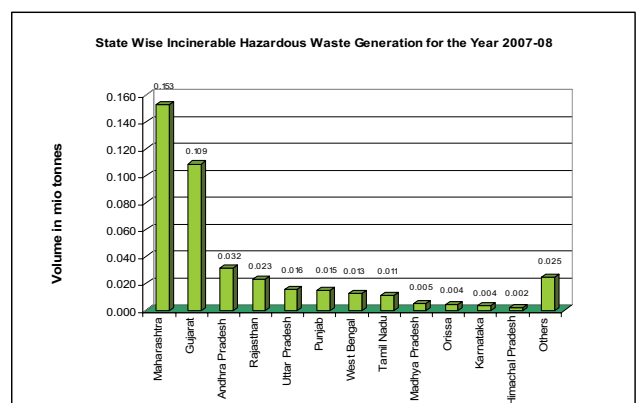


Figure 3: State Wise Incinerable Hazardous Waste Generation volumes in million tonnes.

Current Hazardous Wastes Disposal Practices

Common TSDF (Treatment, Storage and Disposal Facilities) for disposal of land-fillable hazardous waste and incineration of HW is

practiced in the major waste producing states of Gujarat, Maharashtra, and Andhra Pradesh. Apart from the common facilities, many waste generators have installed their own captive incinerators.

Figure 4 illustrates the available and required capacities of TSDF's and Incinerators in the country and the shortfall in capacity for the year 2007-08.

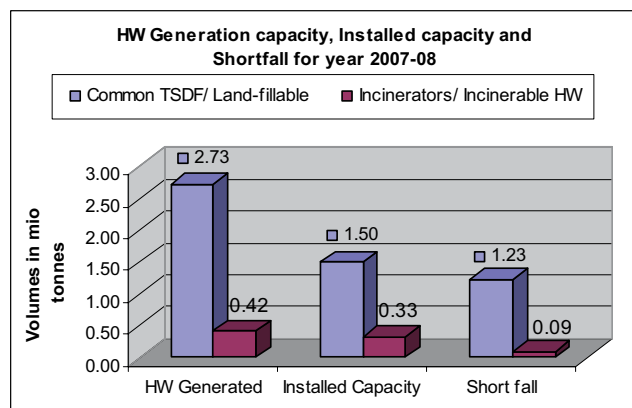


Figure 4: Land-fillable and Incinerable Hazardous waste generation, Common TSDF and Incinerator facilities capacities and Shortfall in capacity.

Due to this shortfall in capacity, illegal dumping and use of hazardous waste is prevalent. Additionally, the present HW incinerators do not have energy recovery features and are prone to very high emissions.

The shortfall in Incinerator capacity can be easily met by co-processing incinerable hazardous

wastes in cement plants. This will save capital investment for setting up additional incinerators, as well as lead to energy recovery and CO₂ mitigation.

At present only about 60,000 tonnes of incinerable hazardous waste mainly from Andhra Pradesh and Gujarat is being co-processed in the Cement Industry. The co-processing capacity of cement plants in India can absorb all the existing HW and eliminate the requirement of setting up of additional incinerators. However, a minimum capacity of common incinerator is still needed to take care of HW that cannot be accepted for co-processing in cement plants.

Preprocessing of Hazardous Wastes

Pre-processing is needed to ensure that HW are chemically and physically suitable for co-processing and provide uniform heating value with very little disruptions in kiln operations.. Based on the physical and chemical parameters, HW may require drying, shredding and blending to make an uniform mix. Transportation is carried out by authorized transporters following the manifest system and all safety guidelines. Solid HW has to be stored at impervious concrete platform, enclosed from all sides. Liquid HW need to be stored in properly designed tanks with cooling system, fire detection and fire fighting equipment.

Typical Characteristics and Possible Impacts

TABLE 1: Typical characteristics of hazardous waste

Fuel	Calorific Value kCal /kg		Moisture content (%)
	Min	Max	
Mix HW Liquid	3500	5000	15-20
Mix HW Solid	3000	4000	5-7
TDI Tar Waste	5800	6200	dry
Oil sludge	5000	9500	<5
Spent carbon	4000	5000	<5
Paint sludge	3500	3800	10-15
Spent Pot liner	2500	4000	dry
Spent solvent	5000	9500	10-12

- High amounts of alkalis, sulphur and/or chlorides may affect kiln operation. Gas-bypass may be required if these quantities can't be absorbed in clinker.
- High moisture in hazardous wastes can limit the production capacity of the kiln and an increase in specific heat consumption.
- Chlorine and Sulphur levels needs to be carefully monitored and controlled by periodically analyzing hot meal samples. This will help in reducing preheater blockages by taking preventive measures.

Co-Processing of Hazardous Wastes

Co-processing requires suitable conveying and firing system comprising of weight feeders, belt conveyors, bucket elevators, double flap valves for solid HW and extraction pumps, flow meters, pipelines, fine spray nozzles for liquid HW. Based on the physical and chemical nature of the HW, the feeding point is determined. Most Common feed points for HW firing are:

- Kiln main burner for liquids
- Kiln Inlet for lumpy solids
- Pre-calciner for sized solids

HW containing high chlorides (>1 %) should be fed to main burner to ensure complete combustion and controlled emissions.

Potential Benefits of Co-Processing HW

- HW co-processing is a sustainable and environmentally beneficial way of its disposal. It leads to energy recovery, GHG mitigation and also saves on capital cost and operational cost of establishing incineration facilities. It helps in reducing the pollutant load in critically polluted clusters of chemical industries. Co-processing can prevent illegal dumping of HW thereby preventing environmental hazards such as soil and ground water contamination.
- HW co-processing can potentially save 0.4 million tones per year (tpy) coal and 0.72 million tpy CO₂ emission based on an estimated TSR of 1.4 % by co processing 0.4 million tpy of HW.

CASE STUDY OF UTILIZING HAZARDOUS WASTE IN A 4500 TPD PLANT-BASED ON A TECHNO-ECONOMIC FEASIBILITY STUDY

The Project: The plant plans to achieve 6% TSR by co-processing of hazardous waste, comprising of both liquid hazardous waste primarily from pharmaceutical and chemical industry and solid hazardous waste from spent carbon, paint sludges, pharmaceutical powder, mix solid wastes etc. This is expected to yield a total coal savings of 0.012 million tpy and CO₂ savings of 0.02 million tpy.

Cost economics: Block cost estimate for solid hazardous feeding system is INR 60 Million, while that for liquid waste is INR 50 Million. For both solid as well as liquid hazardous waste, it is assumed that Rs 1000/ tonne will be the gate fee to the cement plant by the waste generator. However, transportation cost for bringing the hazardous waste to the plant premises is assumed to be borne by the cement plant. Hence, overall, landed cost for both wastes has been considered as zero. For Solid waste, the Internal Rate of Return (IRR) on total investment turns out to be 34.7% with a payback period of less than 3 years. For liquid waste, the IRR on total investment is 63.2% with a payback period as 1 year 7 months.

Based on the performance indicators, it is concluded that the project is financially attractive if the targeted solid and liquid volumes can be contracted and procured.

Main barriers

Technical

- Non uniform quality of hazardous wastes due to varying sources of industrial wastes
- High %age of moisture content in some industrial hazardous waste
- High chloride content which limits the TSR potential in cement kilns
- Lack of pre-processing facilities
- Limited technical knowledge and skilled manpower in cement plants for co-processing hazardous wastes
- Absence of aggregators and pre-processors

Policy and Regulatory

- Emission norms are not clear as cement industry has to demonstrate no change in emissions before and after hazardous waste use.
- Cement co-processing still has to follow incinerator standards as there are no specific emission standards for cement kilns
- Interstate transfer of HW is restricted by some state Pollution Control Boards
- Clear and transparent information on sources of HW, details on statewise / sector wise generation of wastes not readily available in public domain.
- Outdated classification of HW. Very low volumes categorized under incinerable HW category, high volumes under land fillable category.
- Preference to common TSDF, in spite of the advantages that co-processing offers.

Financial

- Time consuming and expensive trial runs for each hazardous waste are needed before permit for co-processing is granted. Utilizing small streams of hazardous waste become unviable.
- High capital cost for setting up pre-processing platform.
- Huge competition which may adversely impact gate fees, making HW co-processing economically unattractive.

Recommended Action Plan

Sr No	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Developing emission standards for Cement Industry using HW	Preparation of Draft emission standards.	Notification of Emission standards	2 to 3 years
2	Recommend exemption of emission trials for selected categories of HW.	Preparation of list of HW that can be co processed without emission trials.	list of exempted HW, approved by Regulatory agencies	1 to 2 years
3	Suggest steps to increase availability of HW for co processing by including some part of land-fillable HW.	Detailed technical paper listing wastes that should qualify under this criterion.	Increased availability of HW for Co processing	2 years
4	Develop guidelines for HW pre-processing units for cement industry.	Preparation of guidelines	Guidelines for setting up of pre-processing units.	1 year
5	Facilitate availability of HW Inventory data base on software platform in all relevant states.	Develop guidelines for preparation of HW data base. Sensitize and provide training to various state boards.	HW inventory updated in regular intervals & made available in public domain.	2-3 years
6	Suggest amendments to existing HW rules to include co-processing of HW in Cement plants as a 4th option of HW disposal.	Prepare a white paper recommending HW co processing to be included as fourth option of HW disposal.	Amendments in HW management rules.	1 year
7	For HW Pre processing units for cement Industry, central/ state subsidy be encouraged based on viability gap funding.	Gujarat subsidy model needs to be studied and recommended for implementation in other states as well.	Incentive policy for setting up HW pre processing units	1year

4 REFUSE DERIVED FUEL (RDF) FROM MUNICIPAL SOLID WASTE (MSW) AS AN ALTERNATE FUEL

Effective management and disposal of MSW has already reached a stage of major concern in India, as in many other countries. The rapid urbanisation and growing per capita income is only going to add to this problem and its disposal remains a huge challenge for the urban local bodies. In such a situation, it becomes imperative to look at customized non-conventional solutions involving all stakeholders responsible for solid waste management. In this regard, making RDF from MSW and using it gainfully as a fuel seems a sustainable long-term solution. RDF is the dry organic fraction

However, one of the major issues involving Indian MSW stems from the fact that the recycling rate of combustible paper and plastics is very high in India. These combustible paper and plastics are hand picked by rag pickers whose livelihood depends on selling these materials to recyclers. The resultant MSW is low on RDF content in terms of percentage recoverable RDF and its calorific value is also marginal due to low share of plastics in it.

Figure 2 : Share of major Indian States in MSW generation



Figure 1: Rag picker at a waste dump site in Delhi

of MSW which can be recovered by treating MSW using Mechanical Biological treatment. RDF comprises of plastics, paper, cardboard, cloth, wood, rubber, leather, etc. Apart from its possible use as a fuel for generating power, as is being promoted in India cement grade RDF can also be effectively used for co-processing in cement plants. This option represents a win-win situation by way of reducing coal usage in cement manufacture on one hand and in finding a long-term sustainable solution for managing urban waste effectively.

Msw Inventory Of India

Total estimated generation of MSW in India is about 68 million tonnes (2011-12) from urban sources alone.

State-wise MSW generation for major Indian states is illustrated Figure 2.

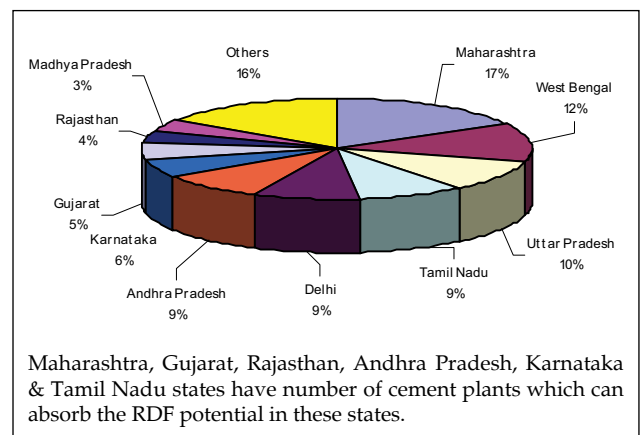


Figure 2: Share of major Indian States in MSW generation

Current MSW Disposal Practices

- **Open area Land filling:** It still remains one of the most common practices in India. Simple MSW dumping is generally carried

out in remote low lying areas, located away from habitation.

- **Sanitary Landfills (SLFs):** A scientific approach to dispose MSW in properly designed landfills with lining and leachate collection wells. Currently 8 cities have SLFs. These are at Pune, Ahmedabad, Surat, Jodhpur, Chandigarh, Navi Mumbai, Mangalore & Nashik.
- **Composting or Mechanical Biological Treatment (MBT):** On an average, 6% of MSW collected is composted in MBT plants across India. This is the most widely employed technology to process MSW. Rejects from composting plants are normally land filled.
- **Waste-to-Energy Combustion (WTE):** WTE is a process of generation of energy from incineration of MSW. Recently, a WTE MSW mass burn combustion plant was set up at Okhla landfill site, New Delhi in Public Private Partnership (PPP) mode.
- **Refuse Derived Fuel (RDF):** Out of 6 RDF plants in India (located near Hyderabad, Vijayawada, Jaipur, Chandigarh, Mumbai and Rajkot), only the RDF plants near Jaipur and Chandigarh are operational, because of a multitude of reasons.

There is an increased thrust towards processing of MSW for reducing the requirement of landfill. Such policy initiatives through Jawaharlal Nehru National Urban Renewal Mission (JNNURM) are promoting WTE projects at present as the cement Industry has not shown much initiative to participate in the PPP projects.

RDF Characteristics and its Possible Impacts

The quality of RDF should be suitable to the cement plants for co processing. High moisture and chlorine and high percentage of heavy metals are not acceptable.

The range of quality for raw MSW and the resultant RDF is tabulated below for reference (Table 1).

Typically, RDF may replace up to 15-20% of primary fossil fuels used in Indian cement plants. This proportion may increase for high quality RDF with low moisture and low chlorine content. There are some cement plants in Europe where more than 80 % of the conventional fuel is replaced with RDF.

Conversion Process - MSW to RDF

Many technologies are available and are employed worldwide. Essentially, it is a Mechanical Biological Treatment process where the compost able wet organics are removed and converted to manure. The recyclable portion like glass & metal are segregated for selling off. The remaining portion is shredded and sieved to remove the inerts. The RDF fraction is dried and compacted in hydraulic presses to increase the bulk density to about 0.7 t/m³ for economical transportation. In some countries, biological drying of the MSW has been attempted which increases the yield of RDF (A portion of wet organic fraction is also recovered as dried RDF).

TABLE 1: Range of quality for MSW and RDF

Parameter	Unit	Raw MSW	Acceptable RDF
Yield of RDF	%	100	10-15
Calorific Value	kcal/kg	1500-2000	2500-3000
Moisture Content	%	40-45	20-25
Chlorine content	%	1-2	< 1
Ash Content	%	20 - 40	< 25
Bulk Density	t/m ³	0.5	0.1 - 0.2
Particle Size	Mm	Up to 1000	< 25X25X1

- **Moisture:** High moisture content in RDF will have a negative effect on the specific heat consumption. If pre-heater fan capacity is a limitation, the clinker production from the cement kiln may be adversely impacted.
- **Chloride levels:** High chloride levels in RDF can impact clinker quality and it may lead to material build up in the kiln inlet and pre heater cyclones. This may cause kiln stoppages and loss of production. A gas bypass system may be needed to purge excess chlorine from the kiln system.
- **Heavy metal percentage:** High percentage of heavy metals in RDF will restrict its use to low TSR levels to safeguard clinker quality.

For general MSW quality available in India, the average yield of RDF is estimated as about 10%. The net calorific value is estimated as 2,500 kcal/kg with 25% moisture and with about 20 to 25 % ash content.

Co-Processing of RDF

RDF sized to less than 25mm (two dimensions) is baled and transported to cement plant. At the plant, it is debaled and fired in the calciner or burner either pneumatically or by mechanical transport. Reasonably high TSR percentages of RDF can be used depending on the quality of RDF.

Potential Benefits of Co-Processing RDF

- **Addressing local environment issues:** Co processing of RDF derived from MSW will result in reduction of volume of MSW

destined for landfills. This will greatly reduce the local waste management problems and save on land area and other costs required for MSW sanitary landfills.

- **CO₂ reduction potential:** Co-processing RDF will reduce green house gas emissions from landfills(methane avoidance). Additional CO₂ mitigation also on account of replacing fossil fuels in cement kilns. Co-processing of RDF can potentially save about 1.7 million tones of CO₂ emissions.
- **Coal saving potential of RDF – TSR:** Co-processing of RDF can replace about 0.9 million tpy of coal usage in the cement industry. The potential to replace fossil fuel in terms of TSR is calculated as 3.2 % by co processing 1.37 million tpy of RDF. Share of RDF for cement industry is taken as 20 % of the total availability.

CASE STUDY ON UTILIZING RDF IN A CEMENT PLANT – BASED ON TECHNO-ECONOMIC FEASIBILITY STUDY

The Project: The plant can use about 45,000 tpy of RDF, which can be generated from MSW collected from districts within 200 kms of the cement plant periphery. This volume of RDF represents 7.5% TSR for one of the kilns. The resultant coal savings will be 0.037 million tpy and CO₂ savings of 0.06 million tpy.

Cost economics: Block cost estimate for RDF feeding system is INR 100 million. It is assumed that the total cost for RDF at firing point will be INR 1,500/ tonne. The Internal Rate of return (IRR) on total investment comes to 43.1% with the payback period as 2 years 4 months.

Based on the performance indicators, it can be concluded that the project is financially attractive if targeted volume of RDF can be procured at the estimated cost.

Main barriers

Technical

- Poor quality of MSW since most of the combustible paper and plastic is picked out by recyclers (rag pickers).
- High moisture content in MSW and also in processed RDF.
- High chloride percentage in RDF restricts the percentage substitution in the cement process.
- Heavy metal content needs to be analyzed regularly as it is a limiting factor for thermal substitution.
- MSW to cement grade RDF conversion plants are in existence but the technology used needs to be customized and fine tuned to meet the local requirements.

Policy & regulatory

- Clear, transparent and detailed information on MSW availability is not readily available in public domain.
- There is no clear policy that encourages disposal of MSW by converting to RDF and co-processing it in cement plants as a preferred alternative.

Financial

- The installation cost of a state-of-the art MSW to RDF conversion unit is high, requiring adequate gate fee for processing raw MSW.
- Collection and transportation cost of MSW may become exorbitant

Recommended Action Plan

Sn	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Setting up a demonstration project in a public private partnership mode that addresses all the pillars of sustainability namely technical, institutional and financial.	Developing a proposal to bring together all the necessary stakeholders in a meaningful coalition.	Setting up of a RDF demonstration project in a PPP model	2-3 years
2	RDF co-processing inclusion by MNRE under their waste to energy scheme	Preparing a white paper for MNRE, clearly articulating the merits of the case	RDF co-processing in cement plants included under MNREs waste to energy scheme	1-2 years
3	RDF use for co-processing to be acknowledged as a CSR activity, which would unlock finances for this action that will have major societal benefits by partly solving the menace of MSW	Preparing a white paper for making a case for qualifying RDF use in cement kilns as a CSR activity	RDF co-processing in cement plants acknowledged as a CSR action	1 year

5 USED TYRES AS AN ALTERNATE FUEL

Recycling of used tyres is freely practiced in India with a high percentage of old tyres being used as raw material for making rubber based products and for extracting value added materials such as carbon black and oil. In this section, the possibility of using tyres that have completed their useful life for cement co-processing is being analyzed and an action plan suggested for promoting such an application.

With the phenomenal increase in the number of automobiles in India, the demand for tyres has increased significantly over the years. Figure 1 illustrates the growth in production of tyres. About 119 million tyres were manufactured in the year 2010-11, compared to 82 & 97 million

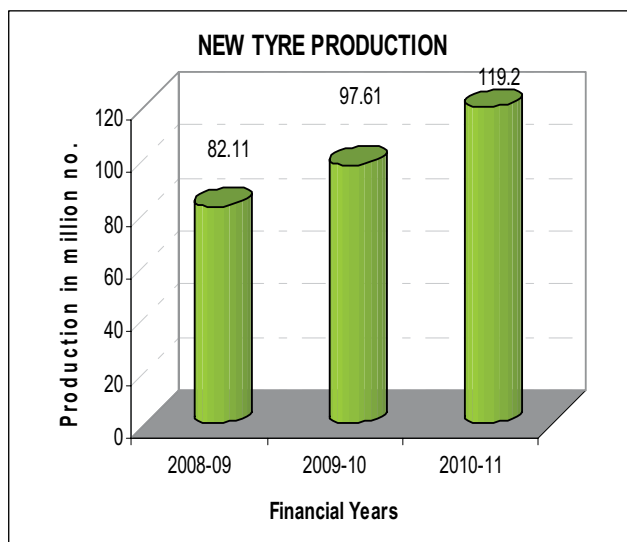


Figure 1: New tyres production trend

in the year 2008-09 & 2010-11 respectively, as can be seen from Figure 1. This suggests that despite a booming re-treading business, used tyres being discarded has increased significantly and will continue to do so in future.

Total production of tyres in the year 2011-12 was 1.5 million tonnes as per All India Tyre Manufacturers

Association (AITMA) and the estimated inventory of used tyres was 0.83 million tonnes.

The tyre recycling industry is a small-scale operation, without any regard to environmental concerns. Incomplete burnout of organics leads to formation of carcinogenic pollutants such as dioxins and furans. Environmental problems including fires and health hazards are also associated with stockpiles of used tyres. Considering the above problems, co-processing of used tyres in the cement kilns is a potential and sustainable solution for their disposal. High temperature in the kiln ensures complete burnout of organics, preventing the formation of pollutants.

Figure 2 illustrates the state wise used tyre inventory for the year 2010-11. The estimates are based on registered motor vehicle data as on 31st March 2011.

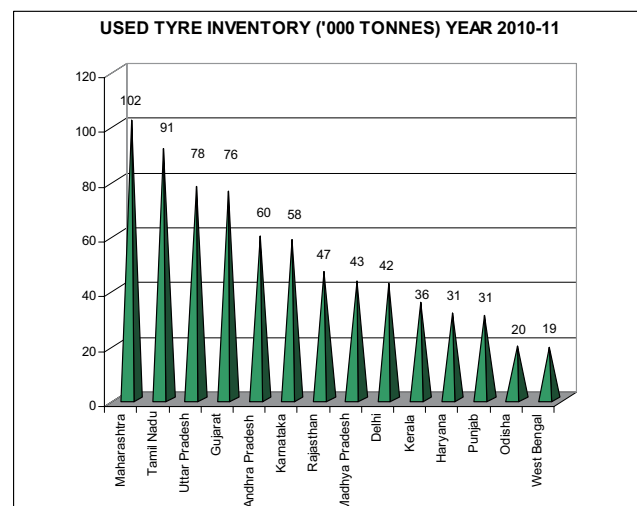


Figure 2: State wise used tyre inventory ('000 tonnes) for Year 2010-11

Current Tyre Disposal Practices in India

Used tyres are recycled for recovery for materials such as rubber, steel, nylon cord, carbon black

etc. Chemicals such as fuel oil and carbon black are obtained through pyrolysis.

Brick kilns and boilers also utilize tyres as fuels. However, such burning at low temperatures lead to incomplete combustion which causes emissions of toxic gases.

Used tyres in the form of whole tyres and chips (< 50 mm) are being used in some cement plants, but their share in total disposal of used tyres is insignificant.

Typical Characteristics of Tyres and its Impact

The proximate and ultimate analysis of used tyres are presented in Tables 1 and 2. As can be seen, the characteristics do not pose any major quality problem, except for the sulphur tolerance limit when using high sulphur limestone.

TABLE 1: Proximate Analysis of tyres

Parameter	Value
Moisture (%)	~ 1
Ash (%)	~ 3
Volatile Matter (%)	~ 96
NCV (kcal/kg)	~7500

TABLE 2: Ultimate analysis of tyres

Parameter	Value
Moisture (%)	~ 1
Ash (%)	~ 3
Volatile Matter (%)	~ 96
NCV (kcal/kg)	~7500

- High TSR (up to 50 %) can be achieved by co-processing tyre chips in the pre-calciner without any adverse effect on the cement quality.
- SO2 emissions are mitigated by direct absorption into product due to presence of alkalis.
- TSR values can be limited for high sulphur bearing limestone and high sulphur fuel due to maximum sulphur tolerance limit for the process and cement quality.

Pre-Processing of Used Tyres

Used tyres are collected and stored by individual tyre dealers in India. Transportation of used tyres

for pre-processing is through trucks and lorries and handling is manual.

Whole tyres directly fed to the kiln do not require any pre-processing. For feeding tyre chips in calciner, tyres need to be processed using shredders. Tyre shredders should be designed for extremely close knife tolerances to produce cleanly cut chips with minimum exposed wire, thus preventing clogging while being delivered to calciner.

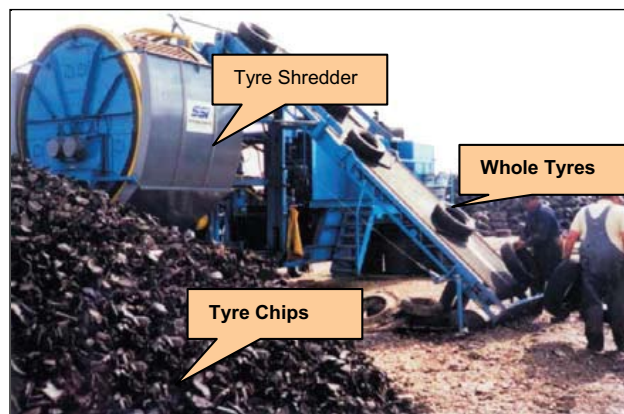


Figure 3: Shredding of whole tyres to chips

Co-Processing of Used Tyres

Used tyres can be fired either at kiln inlet or in pre-calciner. Whole tyres are fed at kiln inlet through a chute and tyre chips are injected into the pre-calciner. The tyre chips are extracted from storage and passed through a weigh feeder to a combination of belt conveyors and bucket elevator to convey the material to pre-calciner through a double flap valve and emergency shut off gate.

Potential Benefits of Co-Processing

- Burning of tyres in brick kilns or small boilers result in high air pollution. Burning at low temperature results in incomplete combustion leading to formation of dioxin and furan. Low height of chimneys of these small scale industries causes health hazards. Co-processing of tyres is environmentally safe and sustainable.
- Tyres manufactured from natural rubber come under the category of biomass and are considered CO2 neutral to the extent of their biomass content. Co processing of tyres has GHG mitigation potential apart from saving of coal.
- TSR potential by using about 0.4 million

tpy (50% of total availability) of used tyres is estimated as 2.22 %. The corresponding

coal saving will be 0.64 million tpy and CO₂ mitigation of 1.2 million tpy.

CASE STUDY OF UTILIZING USED TYRES IN CEMENT PLANT-BASED ON A TECHNO-ECONOMIC FEASIBILITY STUDY

The Project: The Cement plant at present has a feeding system through which biomass is being presently co-processed. The cement plant plans to achieve a TSR of 5% by using whole tyres. Tyre chips can also be either imported or shredded at the plant. Due to SLC (Separate Line Calciner) system, it is not recommended to fire tyre chips in calciner. A 5 % TSR shall bring about a total Coal Savings of 0.021 million tpy and a CO₂ reduction of 0.036 million tpy to the plant.

Cost Economics: Block cost estimate for co-processing system of whole tyres at Kiln - 2 is Rs. 15 million. It is estimated that domestic whole tyres shall be available at a price of Rs. 10,000/ tonne. For a TSR of 5% by using whole tyres at line 2 (6,700 tpy), the financial analysis indicate an IRR of 34.4% on total Investment.

Based on the performance indicators, it is concluded that the project is financially attractive if the targeted volumes of tyres can be procured.

Main barriers

Technical

- Possibility of ring formation at kiln Inlet due to high sulphur content in tyres
- Poor availability of tyres.

Policy and Regulatory

- Lack of information on used tyre inventory, district and sector wise break up on distribution of waste in public domain
- No clear policy that prefers co-processing of tyres to other modes of disposal
- Cumbersome import permit process
- Requirement of emission trials by MoEF for every new source of imported tyres.

Financial

- High price of tyres due to other uses
- High financial risks in setting up co-processing system due to uncertainty in availability of whole tyres and tyre chips at targeted cost
- High transportation and collection cost

Recommended Action Plan

Sn	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Recommend ban on current practices of disposing used tyres that create huge environment pollution.	Prepare a white paper for MoEF to present the merits of co-processing used tyres against its present ways of disposal.	MoEF policy on encouraging Co-processing of used tyres as a preferred option for environment friendly disposal.	1 year
2	Recommend free import of tyre chips and rubber waste for co-processing.	CMA to take initiative and approach MoEF.	Amendments regarding policy on Import of used tyres/chips.	1 year

6 BIOMASS AS AN ALTERNATE FUEL

Introduction

Biomass is plant matter which includes forest residues, agricultural residues, agro-industrial wastes, energy crops, etc. which has always been a vital source of energy (both for household as well as industrial requirements) in India. It is still one of the most commonly used domestic fuel in most of the rural and traditional sectors, apart from being a source of energy for several small-scale industries as well as for independent power plants. Ministry of New and Renewable Energy (MNRE) website claims that about 32% of the total primary energy use in the country is still derived from biomass and more than 70 % of the population depends upon it for its energy needs.

Biomass Inventory in India

As per MNRE estimates, the current availability of biomass in India is about 500 million tonnes

per year. The studies estimate the surplus biomass availability at about 120-150 million tonnes per annum covering agricultural and forest residue. This corresponds to a potential which is almost 3 times the coal being used by the cement Industry at present. Even if just 10

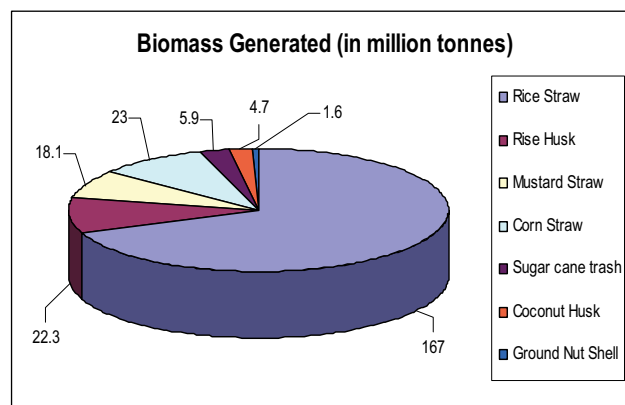


Figure 1: Inventory of surplus biomass in India

TABLE 1: State-wise biomass generation for major Indian states (million tpy)

Biomass State	Rice Husk	Rice Straw	Ground nut shell	Corn straw	Mustard straw	Sugar Cane trash	Coconut husk
West Bengal	3.59	26.9		0.18	0.576		0.0943
Punjab	2.81	21.1		0.28	0.828		
Uttar Pradesh	2.7	20.3		0.65	1.782	2.38	
Andhra Pradesh	2.64	19.8	0.3	2.25		0.24	0.377
Odisha	1.73	13	0.03				
Tamil Nadu	1.42	10.6	0.27	0.68		0.6	1.6
Chattisgarh	1.03	7.7			0.216		
Karantaka	0.92	6.9	0.15	1.64		0.62	0.471
Haryana	0.91	6.8			1.62	0.11	
Bihar	0.9	6.8		0.93	0.108	0.1	
Maharashtra	0.55	4.1	0.11	0.85		1.3	
Gujarat	0.32	2.4	0.53	0.4	0.594	0.25	
M.P.	0.32	2.4	0.07	0.62	1.332	0.05	
Rajasthan			0.11	0.99	6.3		

% of it is made available to cement plants, a TSR of more than 30 % can be achieved.

Estimated inventory of surplus biomass in India is shown in figure1;

State-wise biomass generation for major Indian states is tabulated below;

Current Biomass Usage Practices

- Rice Husk: Used in brick kilns, industrial boilers, as fuel in independent grid connected power plants. Also being used as an alternate fuel in cement plants in Chhatisgarh, Gujarat & Tamil Nadu.
- Rice Straw: Used as fodder in states like Chhatisgarh, as a packing bed material, feedstock in paper mills and also burnt to clear fields in states like Punjab and Haryana.
- Ground Nut: Used in small steam boilers and in cement plants in states of Gujarat, Tamil Nadu and Odisha.
- Coconut Husk: Used mainly in the coir industry, as domestic fuel and also extensively used for production of activated carbon.
- Corn Straw: Used as domestic fuel, fodder and as fuel in small industrial boilers.
- Mustard Straw: Used in steam boilers.
- Bagasse: Used in captive cogeneration plants of sugar mills and as feedstock for paper mills.
- Wheat Straw: Used as animal fodder.
- Cashew nut shells, tamarind husk & straws from pulses cultivation: Used in steam boilers and cement plants.
- Energy Crops: Jatropha, Poplar, Juliflora, Hybrid Napier Bajra Grass, Eucalyptus, etc. are being cultivated by biomass based power plants as well as some cement plants too.

Typical Characteristics & Possible Impacts

Important characteristics such as calorific value, moisture and ash content of some commonly used biomass as alternative fuels in the cement plants is given in table 2;

In all cases, chemical composition of any biomass needs to be analyzed for compatibility with

TABLE 2: Typical characteristics of biomass

Fuel	CV (avg) kcal/kg	Moisture Content wt (%)	Ash Content wt (%)
Rice husk	3,200	10-15	18-22
Rice straw	3,000	10-15	15-16
Coconut husk	4,000	8-10	2-3
Corn residue (corn cob, husk, straw)	4,000	10-20	10-13
Ground nut husk	4,200	5-10	3-5
Mustard straw	3,000	10-15	4-5
Sugar cane trash	3,000	15-20	5-8

- **Alkali, Sulphur & Chloride levels:** High levels of alkali, sulphur and chloride in biomass materials which are absorbed from soil or from the fertilisers and agrochemicals can result in coating build-ups and blockages in pre-heater system.
- **Moisture & Specific fuel consumption:** While firing biomass in kiln main burner, high percentage of moisture may lower the flame temperature. Based on quantity of biomass fired, specific fuel consumption increases and may also result in incomplete combustion.

existing raw materials and fuels before considering it as an alternate fuel in the cement plant.

Pre Processing and Co-Processing of Biomass

Biomass is generally manually collected and loaded into tractor trolleys for short distances. For longer distances, it is baled and transported to cement plants in trucks. At the plant, it is debaled and chipped/ shredded (in case of mustard straw, rice straw, sugarcane trash, etc.) and fired in the calciner or kiln main burner either pneumatically or by mechanical transport.

Potential Benefits of Co-Processing Biomass

- Addressing local environment issues: Burning biomass in the fields causes high

local pollution and using it in small boilers and furnaces generate flyash and bottom ash which is usually dumped openly causing local environment nuisance. Biomass can be better utilized in cement plants, as they have a much better heat efficiency without leaving any ash residue or gaseous emissions.

- Coal saving potential and TSR: As per estimates, co-processing of biomass can replace 10.38 million tpy of coal used in the cement industry. This is equivalent to TSR potential of 36 %.
- CO2 reduction potential: Using biomass as alternative fuels in place of coal mitigates green house gas emissions. For TSR potential of 36%, CO2 reduction potential is estimated as 17.6 million tpy.

Main Barriers

Technical

- Bailing required for long distance transportation due to low bulk density of biomass.
- Most of the biomass is being burnt in boilers, furnaces, brick kilns making availability for the cement plants difficult.
- Huge quantity of rice straw is still being burnt in the fields to clear them for the next crop.

- Straws of rice, mustard and corn require installation of shredder/ chippers in the cement plant for size reduction.
- Chemical composition (e.g. potassium & sodium salts) of certain biomass may cause kiln operational problems.

Policy and Regulatory

- Biomass based power plants are being encouraged by state nodal agencies. Recently, states like Chhatisgarh have restricted usage of rice husk only for the power plants. This is a big regulatory setback for use of biomass in cement plants.
- Practice of burning rice straw to clear the fields is still being carried out in states like Punjab & Haryana. Ban on such practice is not enforced rigorously.

Financial

- Investment and operational cost for setting up biomass handling and feeding systems is not viable due to the uncertainty in availability of biomass. Low profit margins due to competitive prices of biomass.
- High cost of biomass handling, bailing and transportation over long distances.
- Cultivating energy crops needs vast land area and cement plants generally have limited land holdings.

Recommended Action Plan

Sn	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Represent to MNRE for including biomass co-processing in cement industry in their action agenda for utilizing surplus biomass as green fuel	Preparing a white paper on biomass co-processing in cement plants, bringing out the merits of the case	Revision of MNRE policy to include co-processing as another option of utilizing biomass (other than power generation)	1-2 years
2	Captive/ neighborhood energy crop plantation should be carried out by the cement industry as CSR activity	Preparing a white paper on energy crop plantation benefits as CSR initiative by cement industry.	Increase in captive energy crops plantation and use as AF	1 year

7 INDUSTRIAL PLASTIC AS AN ALTERNATE FUEL

India has witnessed a substantial and steady increase in plastic consumption as well as generation of plastic waste over the last decade, as it has become one of the most favoured mode of packaging, especially for food and water. Rise in plastic consumption has led to indiscriminate littering in populated areas, open lands, rivers, drains etc.

Plastic consumption in India is estimated to be 8 million tonnes per annum, out of which, 70% i.e. 5.6 million tonnes transforms to waste. 60% of the total plastic waste generated is recycled. Remaining 40% is littered around and remains uncollected.

Plastic waste are categorised as under;

- **Recyclable (Thermoplastics):** Polyethylene terephthalate (PET), High density poly ethylene (HDPE), Low density poly ethylene (LDPE), Poly vinyl chloride (PVC), Polypropylene (PP), Polystyrene (PS), etc. They form about 80% of the total plastic waste generated.
- **Non-recyclable (Thermoset & others):** Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon, etc. They form the remaining 20% of the total plastic waste generated.

Littered plastic eventually gets mixed up with other wastes in the form of municipal solid waste (MSW). MSW contain about 4% of such plastic wastes which is recovered as refuse derived fuel (RDF), which can subsequently be used as an alternate fuel in the cement industry.

Primarily, in India, the industrial waste plastic for cement plant co-processing is available from waste paper based paper mills. These wastes appear in the paper mill as wrappings, laminations, plastic covers, etc.

Plastic waste from other sources is not significant in terms of volume as most of it is being recycled.

Plastic Waste Generation in Major States

Major plastic waste generating states are India is shown in Figure 1;

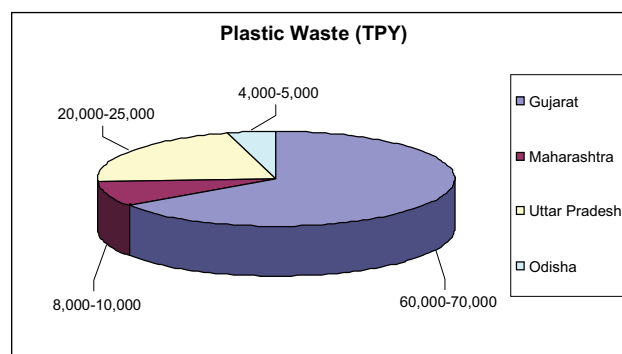


Figure 1: Industrial plastic waste generation in major states

Gujarat, Maharashtra, Uttar Pradesh and Odisha are the top plastic waste generating states in India. Gujarat has a number of cement plants which can absorb its plastic waste. However, Maharashtra and Uttar Pradesh have fewer cement plants, hence plastic waste generated from these states needs to be transported to cement plants in neighbouring states of Karnataka and Madhya Pradesh respectively if they are to be gainfully utilized for cement co-processing.

Current Plastic Waste Disposal Practices

- **Land filling:** It still remains one of the most common practices in India as it is the lowest cost option. Land filling causes enormous local environment nuisance as plastic is a non biodegradable material.



Figure 2: Indiscriminate dumping of plastic waste

- Plastic waste co-processing in cement plants:** Dried and shredded, processed industrial plastic waste has a high calorific value and can be used as an alternate fuel in the cement industry. Recently, a few cement plants in Gujarat, Odisha and Chhatisgarh have started co-processing plastic waste from paper plants.

Typical Characteristics and Possible Impacts

Major fraction of the waste from paper mills is plastic matter (50-60%) and associated paper pulp (40-50%) on dry basis. The waste contains 40 to 50 % moisture and is left for sun drying to reduce the moisture content to about 20-25 % before it can be compressed into bales and stored.

Characteristics of typical plastic waste material is shown in table 1;

TABLE 1: Characteristics of typical plastic waste

Parameter	Unit	Raw waste	Processed waste
Wet plastic waste	%	100	60-65
Calorific Value	kcal/kg	2000-2500	3500-4000
Moisture content	%	55-60	20-25
Bulk density	t/m ³	0.6	0.2
Feed size	mm	upto 100	<25

Co-Processing of Plastic Waste

Plastic waste is baled and transported to cement plants. There, it is shredded to reduce the size to 25 mm before firing in either the pre-calcliner or kiln inlet. Typically, industrial plastic waste can replace 5-20% of primary fossil fuel used in the cement plants. It has reached to as high as 30% in some Japanese plants.

The equipment used for conveying and dosing plastic waste in the cement kiln inlet or calciner consist of mechanical belt conveyors, bucket elevators and air locks with weigh feeder for accurate dosing of material.

Potential Benefits of Co-Processing Plastic Waste

- Addressing local environment issues:** By co-processing plastic waste in the cement plants, local environment nuisance can be avoided besides effectively destroying these non-biodegradable materials without any additional environmental issues like gaseous emissions.
- Coal saving potential of Plastic:** Co-processing of plastic waste can replace 0.1 million tpy coal usage in the cement industry. TSR potential of plastic waste is estimated as 0.4 % based on current availability.
- CO₂ reduction potential:** Using plastic waste reduces green house gases and mitigates equivalent CO₂ emissions. For TSR potential of 0.4%, CO₂ reduction potential turns out to be 0.2 million tpy.

- Moisture content:** High moisture content in plastic, limits feeding due to negative effect on clinker production and resultant higher heat consumption.
- Chloride levels:** High chlorine percentage in plastic waste may require the need of a by pass system or low firing rate to avoid bypass system.

Main Barriers

Technical

- Moisture content as well as impurities in the plastic waste generated from the paper industry is high. Also, paper plants do not have sufficient area for sun drying these wastes.
- Lack of technology, machinery suppliers and qualified experts for erection, commissioning and operation of pre-processing plants for plastic waste that could convert raw waste to fuel suitable for the cement industry.

Policy and Regulatory

- Inadequate enforcement of plastic waste management rules. Tolerance level of low cost dumping in vacant land areas is still very high without any concern for its impact on the environment.
- Policy at Central and state level is not clear about the need for environmental permits

for co-processing despite the fact that trials with plastic wastes have already been taken by the cement industry.

- Non uniform policy at state level regarding classifying plastic waste as hazardous or non-hazardous restricts interstate movements of these materials.
- There are no clear rules for importing such wastes for cement plant co-processing.

Financial

- Paper mills still resort to landfill disposal as the dumping charges are traditionally quite low.
- Uneconomical transportation cost as generally, cement plants are located at faraway places.
- Unavailability of plastic waste quantity on consistent basis for justifying installation of co-processing facility in the cement plants.

Recommended Action Plan

Sn	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Replicate Gujarat model of encouraging plastic waste co processing in cement plants in other states of India.	Sensitization and training of relevant stakeholders in other states.	More plastic waste going for co-processing. More plastic waste going for co- processing.	2 years
2	Normalization of policy with regard to categorization of plastic waste that facilitates its transportation across states	Preparing a white paper and persuading concerned agencies for having an uniform classification for plastic waste	Interstate transportation facilitated from states rich in this resource to states that can utilize these wastes for co-processing	1-2 years

8 FLYASH AS AN ALTERNATE RAW MATERIAL

Fly Ash Generation in India

In India, generation of fly ash has been on a steady rise as most of the electricity demands are still met by coal based thermal power plants. The total fly ash generation, from various sectors (state, private & central) is estimated to be 200 million tonnes per annum.

The various initiatives taken by the Government of India for turning fly ash from a waste material to a resource material, has resulted in utilization of fly ash to the extent of about 100 million tonnes. This has in turn reduced annual CO₂ generation by 55 million tonnes and also reduced consumption of various mineral resources.

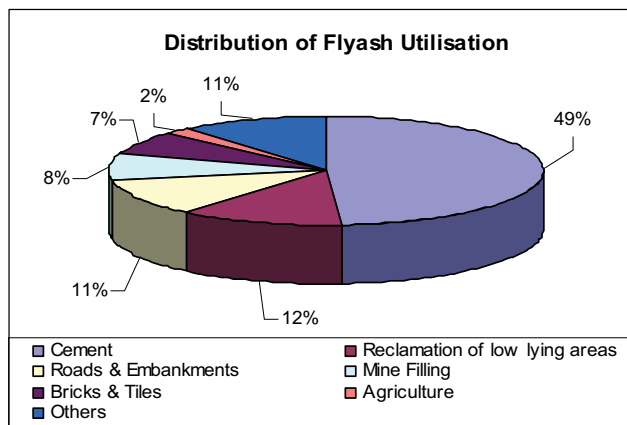


Figure 1: Distribution of fly ash utilization

From the above, it is clear that in the cement sector, utilization of fly ash is about 36 million tonnes (Year 2010-11), constituting 49% of the total utilization. Indian cement plants have the potential to absorb more fly ash annually, but is restricted by Bureau of Indian Standards that limits using up to 35% of fly ash for blending to produce Portland pozzolana cement (PPC)

Fly ash can also be used as an alternative raw material for substitution of silica source. It has



Figure 2: Fly ash silo at an Indian Cement Plant

a potential to replace existing use of sand stone, river sand or clay directly.

High carbon bearing fly ash can be injected directly into the calciner to recover the energy content and provide required silica substitution

Present Flyash Disposal Practices

- Wet fly ash: Pumped in the form of slurry to ash ponds or to nearby low lying areas.
- Dry fly ash: Dry fly ash is utilized in cement manufacturing, brick making, roads, mines filling, etc.

Mapping of Cement Plants and Flyash for Major States

Figure 3 illustrates the volumes of Fly ash generated (in million tonnes) by major Fly ash generating states in India.

Maharashtra, Gujarat, Uttar Pradesh and Andhra Pradesh are amongst the top fly ash generating states. The states of Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh have large cluster of cement plants to utilize the fly

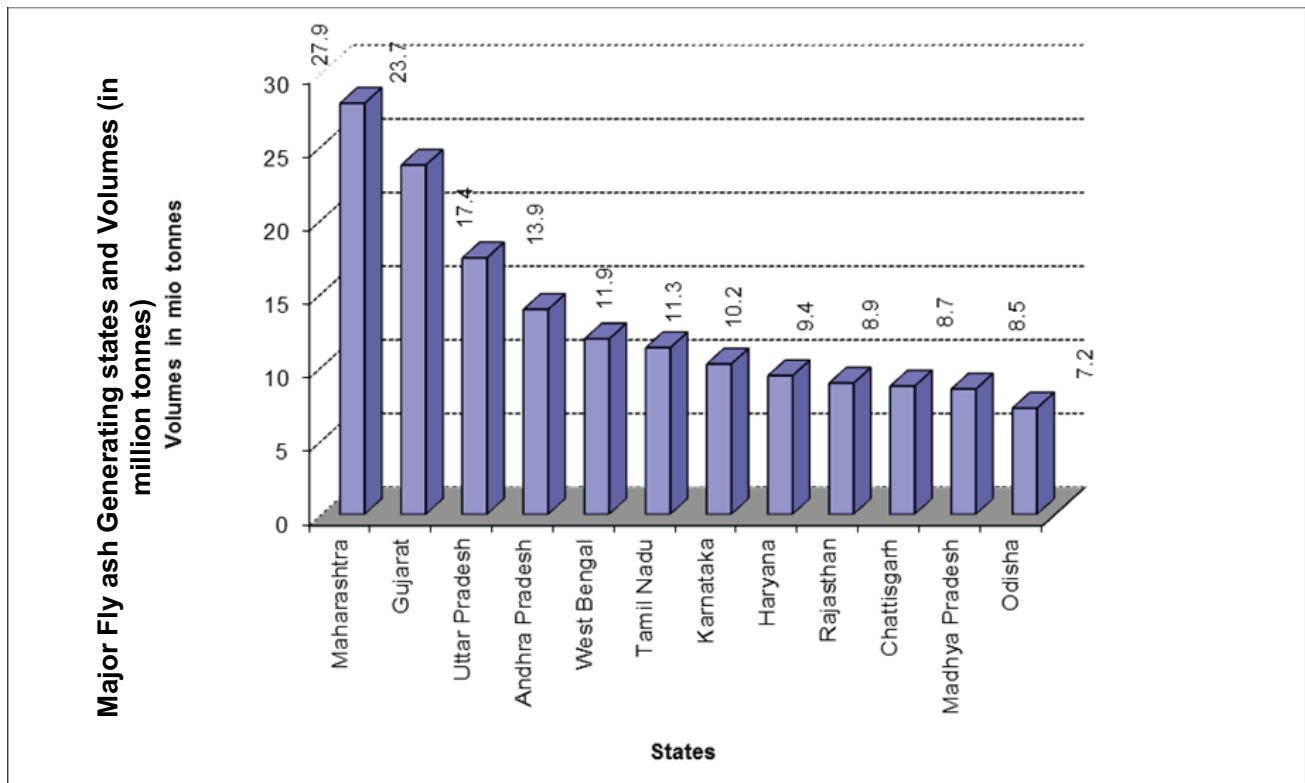


Figure 3: Fly ash generation in major states

ash. In Uttar Pradesh, the number of cement plants are less but a number of grinding units have been set up to utilize the fly ash. In Andhra Pradesh and Rajasthan, there are many cement plants and fly ash shortages are reported.

Almost all the cement producers in India produce fly ash based PPC. Total PPC production in India is about 70% of total cement produced.

Typical Characteristics of Flyash

- Physical Characteristics: Fly ash consists of particles, differing in size and shape significantly due to differences in degree of pulverization of coal, associated impurities in the coal, boiler type, power load and efficiency of the collection systems. Fineness of Indian fly ash generally varies within the range of 300-600 m²/kg and its lime reactivity varies between 3.5-6.5 N/mm².
- Chemical Characteristics: It depends on the geological and geographic factors of the coal deposits and combustion conditions. In general, fly ash contains SiO₂ (45-60%), Al₂O₃ (15-30%) & Fe₂O₃ (5-10%) besides unburnt carbon and small amounts of calcium, magnesium, alkalis and sulphates.

Fly ash with high percentage of unburnt carbon, however, is not suitable for blending. Such fly ash can be used as alternative raw material with useful heat content.

Potential Benefits of Utilizing Flyash

- Addressing local environment issues: Utilization of fly ash in PPC provides lasting solution to the local environment concerns. It saves land required for ash ponds and mitigates dust nuisance created by open dumping of fly ash.
- Coal saving potential of Ash : By using high carbon fly ash/bottom ash/ pond ash, coal substitution can be achieved to the tune of unburnt carbon content in the fly ash used.
- CO₂ reduction potential: Increase of 1% fly ash in blended cements (PPC) reduces about 9.5 kg CO₂ per tonne of cement.
- Raw material saving potential: Total clinker requirement for producing same volume of cement reduces, thereby saving on limestone and coal needed per tonne of cement.(PPC)
- Superior quality: PPC based concrete is superior in quality. It has high durability, low

permeability and reduced heat of hydration.

Main Barriers

Following are the barriers faced in the enhanced utilization of fly ash in the Cement Industry :

Technical

- Medium to low grade limestone deposits in India resulting in limiting the extent of addition of fly ash in PPC.
- Reactivity and fineness of available fly ash is of average grade, limiting % addition to PPC.

Policy and Regulatory

- No freight equalization policy for fly ash transportation.
- Government departments are still reluctant to use fly ash based cement.
- BIS does not permit fly ash addition beyond 35% in PPC.

Financial

- Mismatch between the location of power plant and cement plant, thereby increasing the cost of transportation.

Recommended Action Plan

Sn	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Policy amendments to increase fly ash usage in cement industry to 40% from the present level of 35%.	Prepare a white paper for BIS and National fly ash mission for steps related to increasing the consumption of fly ash in cement industry.	Amendment of existing policy for fly ash utilization 2009. BIS amendment to increase the % utilization of fly ash to 40% in PPC.	2 years

9 SLAG AS AN ALTERNATE RAW MATERIAL

Granulated Blast Furnace Slag Generation in India

In India, growth in the steel industry has been quite rapid. Crude steel production has registered a 19% growth rate since 2008-09, with the total crude steel production for 2012 being estimated at 69.58 million tonnes. Typically, for an iron ore feed containing 60-65% iron, blast furnace slag production ranges between 300-540 kg per tonne of pig iron produced. The total potential generation of water quenched Granulated Blast Furnace Slag (GBFS) is estimated to be 10 million tpy. Total cement production in India is about 220 million tones. However, due to low availability of slag, production of Portland Slag Cement (PSC) is about 15 million tonnes only.

Slag has the property of working synergistically with cement to increase strength, reduce permeability, improve resistance to chemical attack and also inhibit rebar corrosion. However, since it is dominated by a dense glassy structure with pores, it results in hard grinding. On an average, 30-50% more grinding energy is required to achieve the desirable cement fineness. As per BIS specification, slag constituent in the cement to produce Portland slag cement (PSC) is restricted between 25-70%.

Mapping of Cement Plants and Slag for Major States

Jharkhand, Chhatisgarh, Karnataka, Andhra Pradesh, West Bengal and Odisha have a number of cement plants which have absorbed the slag potential in these states.

Only a few cement producers in India manufacture PSC. Total PSC production in India is only about 7% of the total cement production.

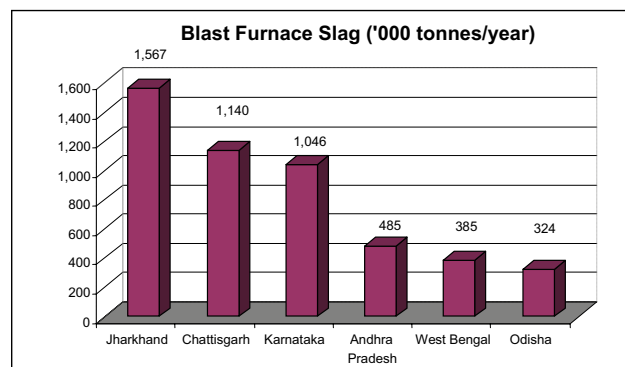


Figure 1: Major Slag producing states and generated volumes

However, PSC production has a huge potential to grow as more slag becomes available.

Typical Characteristics of Slag

- Physical Characteristics: Size of granules varies up to maximum of 4 mm. The Bond grindability index in Indian slag varies between 15-18 kWh/t. Specific gravity of slag is about 2.90 and its bulk density ranges from 1.2 to 1.3 t/m³.
- Chemical Characteristics: Depending on the composition of iron ore, fluxing agent and coke, the chemical characteristics of resultant slag varies. Typical values are tabulated.

TABLE 1: Chemical composition of a typical granulated Blast Furnace Slag

S.No.	Constituents	Percentage
1	SiO ₂	30 - 35
2	CaO	35 - 40
3	Al ₂ O ₃	10 - 15
4	MgO	2 - 10
5	Mn	0.1 - 1.2
6	Fe	0.2 - 0.4
7	S	1.0 - 2.0

Current Slag Usage & Disposal Practices

Usage Practices:

- Granulated blast furnace slag is used as a blending material to produce Portland slag cement and other type of cements like super sulphated cement and pozzolana metallurgical cement.
- High lime L.D. slag can be used as an alternate raw material (up to 10%) to manufacture clinker.
- Air cooled slag are used mainly as road metal and bases, asphalt paving, railway ballast and concrete aggregate.

Disposal Practices:

- Air cooled slag that cannot be used by the cement industry is dumped in open areas causing problems such as leaching, chemical degradation, local environment nuisance, breeding of insects, etc.

Utilization of Slag

Blast furnace slag can be either ground together with clinker or can be ground separately and then blended subsequently with cement in required proportion.

LD slag on the other hand is used as a raw material in manufacturing cement as a sweetener to compensate the lime quality in low grade limestone. LD slag also helps reduce specific heat consumption of kiln as it already de-carbonated.

Potential Benefits of Utilizing Slag

Blast Furnace Slag as a Blending Material

- Thermal energy saving potential: Manufacturing of PSC consumes only about 50% of thermal energy.
- CO₂ reduction potential: For every 1 tonne production of blast furnace slag cement containing 50 % slag, 0.66 tonnes of CO₂ is

mitigated.

- Raw material saving potential: Total clinker requirement for producing same volume of cement reduces, thereby saving on limestone and coal.
- Superior quality: PSC based concrete exhibits superior quality. It has high durability and low permeability.

Ld Slag as an Alternative Raw Material

- Thermal energy saving potential: For every 1% LD slag substitution in raw meal, the specific heat consumption gets reduced by about 5 kcal/kg clinker.
- CO₂ reduction potential: For a typical 1 million tonne clinker plant, about 70,000 tonne of CO₂ can be saved per year, if 10% LD slag is used as an alternate raw material.
- Raw material saving potential: Total limestone requirement for producing same volume of clinker reduces, thereby saving on limestone.

Main Barriers

Following barriers are faced in the enhanced usage of Slag in the Cement Industry:

Technical

- Lack of infrastructure in steel plants to convert blast furnace slag to granulated slag.
- Lack of infrastructure for granulation of LD slag in steel plants.
- High moisture and low glass content in slag restricts its usage in cement production.

Policy and Regulatory

- No national policy in force to encourage enhanced use of slag in the cement industry.

Financial

- High landed cost. Availability of slag is regional as steel plants are located in few states having iron ore deposits. Transportation of slag over long distances is not viable.

Recommended Action Plan

Sn	Recommended Action Plan	Next steps for implementation	Expected final outcome	Time frame
1	Pre sorted and sized LD slag from steel plants to be used as raw material	Approach steel industry to provide sized LD slag to cement industry at their doorstep, as slag which is a by-product is lying in huge quantities at steel plants. This will also help the steel plants in solving their slag disposal problem.	LD slag usage as part replacement of limestone	2 years

10

CASE STUDY TO UTILIZE TIRUPUR TEXTILE CLUSTER ETP SLUDGE AS ALTERNATIVE RAW MATERIAL

Background

In Tirupur cluster of Tamil Nadu, there are a number of textile industries (850 units) generating effluent treatment plant (ETP) sludge which creates environmental problems due to lack of disposal options. This sludge which has accumulated over the years is available as stockpiled quantity of more than 200,000 tonnes and every year about 20,000 tonnes of fresh sludge is added to it.

The entire Tirupur environment (water, land and air) is found to be polluted due to the industrial process of the textile industries. Due to the disposal of this sludge in non engineered landfills, the ground water as well as soil is found to be polluted. River Noyyal flowing through Tirupur region is completely polluted, effecting irrigation of around 16,000 acres of land.

The sheer volume of the sludge generated by the Tirupur based dyeing and bleaching units is proving to be a knotty issue for the local dyers for its disposal, especially when there is no viable technology available for recovery or reusing these treated effluents discharged from the units.

Apart from Tirupur, similar textile mills are concentrated in Ahmedabad, Mumbai, Erode, Coimbatore, Kanpur and Delhi. Hence, the issue of pollution caused by the effluents from textile mills is a very serious concern. It is therefore necessary to chalk out a safe disposal plan for this sludge in the Tirupur region, which can further be implemented in the textile mill clusters in other parts of India.

Vision

A Coordinated effort by the waste generators, cement plants as well as the local authorities in getting rid of this menace.

Study reveals that the available ETP sludge shows high quality fluctuations and contains high moisture content of around 40 – 50%, as generated. It is necessary to blend the material and reduce the moisture content before using it in the cement plant as an alternative raw material. Therefore, a pre-processing unit is required near to the textile industry cluster. Such a unit may be installed by a waste management company under Public Private Partnership (PPP) mode with the State Pollution Control Board or by Textile Mills Association. The pre-processing plant operator can enter into long term agreements for disposal of ETP sludge from the textile units. Cement plants can take advantage of uniform quality of waste requiring a single environment permit. The pre-processing plant operator should get optimum gate fee per ton of ETP sludge received at its unit to offset the capital cost, operating cost and the cost for transporting processed sludge to the cement plant.

Typical characteristic of ETP sludge and its impact: The important characteristics of ETP Sludge as alternate raw material are the moisture, chlorine and heavy metals content. Characteristics of ETP sludge are:

- High levels of chloride can cause operational and quality problems and may lead to a

TABLE 1: Typical Characteristics of ETP sludge

Sn	Parameter	Value	
1	Lime (CaO)	4.6 – 44.1 %	
2	Moisture	20 – 36 %	
3	Heavy Metals	MnO	1 – 990 ppm
		Cr2O3	0.1 – 390 ppm
		NiO	0 – 540 ppm
4	Chloride	0.09 – 0.91 %	

requirement of gas by pass arrangement.

A cement plant located nearby Tirupur is already consuming 50 tpd of ETP sludge as ARM mixed with limestone. However, due to high moisture content, operational problems related to material handling have been experienced. Due to high fluctuation in the quality of the material, low lime content, high level of chlorides and heavy metals, the replacement of ETP sludge is restricted to only 1% in the raw mix.

This percentage in raw mix can be increased if uniform quality of dry sludge is provided and is made economically viable to the cement plant.

Cost Economics: The total project cost estimate for installing pre-processing unit near Tirupur is INR 45 million. Net revenue of pre-processing unit of ETP is assumed as INR 1,000/ tonne and sludge volume as 15,000 tpy. The Internal Rate of return (IRR) on total investment comes to 27.3% with the payback period as 3 years 6 months.

Based on the performance indicators, it can be concluded that the project is financially attractive for the targeted volumes and gate fee.

Main Barriers

Technical

- At Tirupur there are 850 such sources (textile units) that generate ETP sludge in small quantities. This makes the sourcing logistics very complex to the cement plant.
- The sludge contains high moisture level, high level of heavy metals and chlorides.

Policy & regulatory

- The requirement from the CPCB to carry out Emission trials for every source of ETP

sludge waste is prohibitively expensive and time consuming.

Financial

- Transportation cost is high from Tirupur to the cement plant.
- Cost of setting up a centralized preprocessing unit for collection, drying, mixing and testing may be expensive and the funding can become a constraint.

Recommendations:

- Centralized collection and pretreatment facility should be created in Public Private Partnership (PPP) mode or by cement plant for ETP sludge utilization from the textile cluster of Tirupur.
- The requirement of taking trials for each source of ETP sludge should be re examined and waived off.
- This model should be replicated in other similar textile clusters in the country.
- Adequate gate fee should be paid by textile plants for safe disposal of their ETP sludge. It should cover costs for pre processing, transportation, material handling at plant etc. Apart from cost coverage there should be a financial attraction for the cement plant for making an extra effort to co process ETP sludge.
- The State Pollution Control Board can facilitate implementation of the recommended model, which can set the stage for replication of similar models in other parts of the country for dealing with site specific environmental menace.





Comments and questions are welcome and should be addressed to:

Somnath Bhattacharjee or Ritu Bharadwaj

INSTITUTE FOR INDUSTRIAL PRODUCTIVITY

E-mail: Somnath.Bhattacharjee@iipnetwork.org, Ritu.Bharadwaj@iipnetwork.org

