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Co-processing of Alternative Fuels & Resources in Indian Cement Industry- Baseline and Potential

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ABSTRACT *India is currently the second largest cement producer in the world and responsible for approximately 7% of India's CO2 emissions. Thermal Substitution Rate (TSR) for the Indian cement industry in average is currently 2,5%. The Indian cement industry is gearing up with its infrastructure, capacity and competence for enhancing TSR including installation of pre-processing platforms and adoption of newer technologies. For achieving 5% TSR in 2020 and 20% TSR in 2030, for every million tonne (Mt) of cement produced, 7 000 tonnes and 25 000 tonnes of alternative fuels need to be co-processed, respectively. SINTEF is currently working on a Norwegian government funded project in India –'Co-processing of Alternative Fuels and Resources in the Cement Industry: Phase II' (2017-2020) which is continuation of Phase I project (2010-2015) and aims to improve the waste treatment capacity in the country through co-processing.*

Keywords: *Co-processing, Cement, Waste, AFR, TSR, RDF, Greenhouse gases;*

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Introduction

Waste generation is an inevitable output of economic activities and its environmentally sound and safe management is critical. Poor waste management is an issue in all developing countries and countries in transition. Increasing quantities of waste are disposed of in an uncontrolled manner, incinerated or dumped in landfill sites. Various wastes are increasingly considered as resources that could be used as resource input in energy intensive industrial processes. In order to avoid loss of valuable resources and to safeguard precious land, the land-filling of waste is increasingly being prohibited or viewed as an option of last resort.

Co-processing is the use of waste as a source of energy or raw material, or both to replace natural mineral resources and fossil fuels such as coal, petroleum coke etc. in the manufacturing process. Basel and Stockholm Conventions highlighted the suitability of cement kiln for co-processing of hazardous and other wastes. Co-processing in cement kiln is scientific, sustainable, proven and established technology for disposing hazardous and non- recyclable waste in environmentally sound manner. This practise can be extremely attractive and cost-efficient, especially for emerging economies having insufficient waste treatment capacity.

Waste arising will increase significantly with growth in Gross Domestic Product (GDP) and living standard in India; treatment capacity for all waste streams is currently insufficient, causing local pollution, release of greenhouse gases and waste of valuable resources. India intends to reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level. This means while India's GDP is projected to increase by 5 to 7 times, absolute carbon emissions will increase by only 3 times by 2030 over 2005 levels. India in 2030 is projected to contribute about a tenth of global carbon emissions while being home to approximately a fifth of the global population (MoEFCC, 2015).

Co-processing leads to 100% energy and material recovery and does not leave behind any ash for further disposal (i.e. no liability for waste generators once waste is co-processed in cement kilns). Due to its economic, environmental and social benefits, it has been recognized as one of the five important levers for large scale reduction of CO_2 emissions from Indian cement industry, in the low-carbon technology roadmap.

Co-processing Baseline

India is currently the second largest cement producer in the world. Low per capita consumption indicates large growth potential in the sector in future. Indian cement industry consumes close to 50 million tonnes (Mt) of coal and 450 Mt of raw materials annually and responsible for 7% of India's CO_2 emissions.

Recovery of wastes and replacement of coal in the cement industry has been practiced a relatively short time in India; the Thermal Substitution Rate (TSR) is 2,5% in average; compared to EU’s average of almost 40% and Norway 70%. In a status report, published by CII in May, 2015, the average TSR of 36 cement plants, corresponding to 109 Mt cement production capacity, was 3,55% (highest single plant substitution is around 18% TSR). The Steel and Power industry have little experience in co-processing and are generally cautious to implement co-processing as they are afraid of possible negative impacts to their processes and their "product" quality.

The Indian cement industry is gearing up with its infrastructure, capacity and competence for enhancing thermal substitution rate (TSR), including installation of pre-processing platforms and adoption of newer technologies. This is evident from >80 numbers of co-processing trials and over 60 million USD of investment for installations, including installation of 10 pre-processing platforms and hot discs in pre-heater tower. There are about 54 cement plants permitted for co-processing.

Regulatory Framework for Co-processing

The MoEFCC has recently amended the existing regulatory framework for environmentally sound management of the waste being generated in the country. MoEFCC has notified sets of waste management rules dealing with different kinds of waste: solid waste, plastic, biomedical, construction and demolition, electronic waste and hazardous waste. These new rules advocate for adopting more scientific, technology driven, sustainable, regulated and participative environment management.

Table 11: Countrywise TSR from alternative fossil wastes, mixed wastes and biomass in %

Countries	TSR (%)	Year	Reference
Austria	75	2014	WBCSD CSI GNR, 2014
Norway	70	2016	SINTEF, 2017
Germany	65	2014	WBCSD CSI GNR, 2014
Czech Republic	62	2014	WBCSD CSI GNR, 2014
Belgium	53	2016	Beer et al, 2017
Poland	52	2014	WBCSD CSI GNR, 2014
United Kingdom	49	2014	WBCSD CSI GNR, 2014
Sweden	48	2016	Beer et al, 2017
Hungary	40	2016	Beer et al, 2017
France	38	2014	WBCSD CSI GNR, 2014
Ireland	29	2016	Beer et al, 2017
Spain	28	2014	WBCSD CSI GNR, 2014
Portugal	28	2016	Beer et al, 2017
Philippines	23	2014	WBCSD CSI GNR, 2014
Bulgaria	21	2016	Beer et al, 2017
Brazil	19	2014	WBCSD CSI GNR, 2014
United States	15	2014	WBCSD CSI GNR, 2014
Italy	14	2014	WBCSD CSI GNR, 2014
Thailand	13	2014	WBCSD CSI GNR, 2014
Canada	13	2014	WBCSD CSI GNR, 2014
Egypt	9	2014	WBCSD CSI GNR, 2014
Greece	7	2016	Beer et al, 2017
India	2,5	2016	Estimated

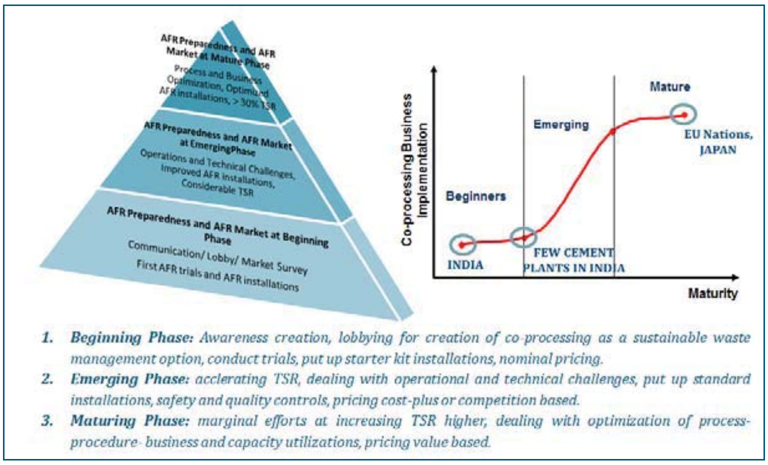

Figure 17: Different stages of co-processing

Hazardous Waste Management Rules 2016

The salient features of Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016 include, Co-processing as preferential mechanism over disposal for use of waste as supplementary resource, or for recovery of energy has been provided. The basic necessity of infrastructure to safeguard the health and environment from waste processing industry has been prescribed as Standard Operating Procedure (SOPs) specific to waste type. Waste Management hierarchy in the sequence of priority of prevention, minimization, reuse, recycling, recovery, co-processing and safe disposal has been incorporated. The approval process for co-processing of hazardous waste to recover energy has been streamlined and put on emission norms basis rather than on trial basis (MoEFCC, 2016).

Solid Waste Management Rules 2016

As per the new Municipal Solid Waste Management (Management and Handling) Rules 2016 non-recyclable waste having calorific value of 1500 Kcal/kg or more shall not be disposed of on landfills and shall only be utilized for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel. High calorific wastes shall be used for co-processing in cement or thermal power plants. 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.

CPCB Guidelines for Co-processing of Plastic Waste in Cement Kilns 2017

The Ministry also released Guidelines for Co-processing of Plastic Waste in Cement Kilns (As per Rule Plastic Waste Management Rules, 2016) in May 2017. The guidelines elaborate upon the collection, segregation, and transportation and co-processing of plastic waste in cement kiln with detailed procedures.

CPCB Guidelines for Pre-Processing and Co-Processing of Hazardous and Other Wastes in Cement Plant 2017

CPCB released guidelines for pre-processing and co-processing of hazardous and other wastes in Cement Plant in July 2017. The guidelines have been revised for complying with the conditions as specified in the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

- No trial runs would be necessary for grant of authorisation for co- processing of wastes in cement kilns: No trial runs would be necessary for grant of authorisation for co-processing of wastes in cement kilns since MoEFCC has notified the Emission Standards for co-processing of wastes in cement kiln vide GSR No. 497 (E) dated 10.5.2016 under the Environment (Protection) Rules, 1986. However, demonstration trials would be conducted for specific wastes such as POPs, PCBs, obsolete and date expired pesticides, Ozone Depleting Substances etc. Kiln specific trial runs may be required for such wastes to study the destruction and removal efficiencies (as per the requirement of Stockholm convention). Trial/ approval from CPCB would also be required of waste is fed through coal or raw material route.
- SPCB’s can issue approval without CPCB: SPCBs may grant Authorisation to cement plants for co-processing of wastes listed in Schedule I (38 industrial processes), Schedule II (hazardous characteristics) and Schedule III (import/export of hazardous wastes) of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

For co-processing of hazardous and other wastes, cement plants shall obtain Consent to Establish (CTE) and Consent to Operate (CTO) prior to obtaining authorisation under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

- SOP for pre-processing and co-processing defined: Regular co-processing shall be carried out as per the guidelines and SOPs. Continuous Emissions Monitoring System installation is mandated in stack for PM, SOx and NOx in 1st phase (with data uplinked to SPCB, CPCB). There are detailed parameters mentioned for pre-qualification and fingerprint analysis of wastes, infrastructure required for transport-storage-pre-processing and co-processing of hazardous wastes and the emission parameters.
- Inter-state transfer simplified: Facilitate movement of waste across different states and procedures to be followed for same highlighted in the document.
- Co-processing as lever to achieve Intended Nationally Determined contribution (INDC): Utilising waste materials as AFRs will also reduce large quantity of GHG emissions of the country which is in line with Paris agreement.

Co-processing Potential in India

Around 7.7 Mt of hazardous waste is currently generated annually, of which around 3.61 Mt is recyclable, 0.65 Mt is incinerable and 3.39 Mt is land fillable (Gupta, 2012); current disposal capacity is inadequate addressing only 40% of the land fillable and incinerable wastes generated. Cement kilns have in general better destruction performance for organic hazardous wastes than existing incinerators at disposal facilities in India.

Studies conducted by the Ministry of New and Renewable Energy have estimated surplus biomass availability at about 120-150 Mt per annum (MNRE, 2011). Gujarat, Uttar Pradesh, Maharashtra and Odisha generate 92 000 to 110 000 tonnes of industrial plastic wastes (IIP, 2014). 700 000 tonnes of used tyre is available in India, mostly in the states of Maharashtra, Tamil Nadu, Uttar Pradesh, Gujarat, Andhra Pradesh, Karnataka, Rajasthan and Madhya Pradesh (IIP, 2014). Both plastic wastes and used tyres have higher energy content than Indian coal.

At present only half of ground granulated blast furnace slag generated is sent to cement plants. The estimated generation will be around 44 Mt in 2020 and about 95 Mt in 2030. Fly ash generation is expected to reach 450 Mt by 2020, and 900 Mt by 2031. Granulated blast furnace slag and fly ash when mixed with cement clinker will reduce both CO_2 from calcination of limestone and fuel related emissions.

Therefore, more than 150 Mt of hazardous and non-hazardous wastes are available for co-processing. Considering the availability, ease of processing and potential GHG mitigation, refuse derived fuels from MSW, biomass (e.g. rice husk, bagasse, coconut shells and wood chips.), industrial plastics; used tyres and industrial hazardous wastes/mixed industrial wastes are considered as potential AFs for utilisation in REIIs, especially cement.

For achieving 5% TSR in 2020 and 20% TSR in 2030, for every Mt of cement produced, 7 000 tonnes and 25 000 tonnes of AFs need to be co-processed, respectively. In 2030, by achieving 20% TSR in cement kiln, up to 19 Mt of Indian coal or 13 Mt of imported coal can be substituted.

Production of RDF

Presently, more than 30% of India's population live in cities; projected to be 50% by 2050. MSW in India is generally unsegregated with high moisture content, low calorific value, odour and wide range of particle size. As per the planning commission task force report (2014), of the

62 Mt of Municipal Solid Waste (MSW) generated in urban India, 12 Mt is combustible fraction which can be potentially converted to refuse derived fuel (RDF), thereby replacing 8 Mt of coal.

For dumping of 62 Mt of MSW without treatment, 1240 hectares per year of precious land is required. With projected MSW generation of 165 Mt by 2031, the requirement of land for setting up landfill for 20 years (considering 10 meter high waste pile) could be as high as 66 000 hectares. As per the Central Pollution Control Board (CPCB) study in 2015, there are 22 operating RDF plants in the country.

The principle of RDF production is recovering quality fuel fractions from the waste, particularly removal of recyclable particles like metal, glass and converting the raw waste in to more usable form of fuel with uniform particle size and higher calorific value than raw MSW. Required quality of RDF is determined by the end use of the fuel. For example, Ministry of Urban Development (MoUD), specifies broad specification of RDF, suitable for the Indian cement plants, as the following:

- Moisture, preferably < 20%;
- Size, 2D < 120 mm, 3D < 70 mm depending on process limitation of specific cement plant;
- Chlorine, preferably < 0.7% depending on particular raw mix & fuel mix;
- Calorific Value, preferably > 3000 kcal/kg; the calorific value of RDF produced in Europe is in the range of 4000-6000 kcal/kg;
- Sulphur, < 2% however depends on particular raw mix & fuel mix; and
- Free of restricted items such as PVC, explosives, batteries, aerosol containers, bio-medical waste etc.

The quantity of RDF that can be produced per tonne of MSW varies depending on the type of collection, pre-processing and composition of waste source. Usual yield of RDF from mixed MSW is in the range of 20-30%; if the waste is properly; segregated yield can go as high as 80-90%. Depending on the need of the end user, RDF fluff is further processed in the densification unit to produce RDF pellets.

GHG Emissions Mitigation Potential through Co-processing in India

Indian cement industry is anticipated to reach production of between 598 (low demand) and 848 Mt (high demand) by 2030. In absence of any action, CO_2 emissions from the sector will be 419 to 594 Mt by 2030 respectively. Indian cement industry is one of best in the world in terms of energy efficiency, i.e. there seems to be a limited potential in further energy efficiency. Availability of alternative fuels and raw materials (AFRs), especially large quantities of inorganic mineral additives makes clinker substitution, raw material substitution and high TSR important levers for CO_2 reduction from Indian cement industry. Work on CCS (carbon capture and storage) has not yet been initiated and it will take some time for inception of the CCS technologies in Indian cement industries.

As per the SINTEF estimates, by 2030, clinker substitution could save 47 to 67 $MtCO_2$; utilisation of alternative fuels, with 20% thermal substitution rate, could save 21.2 to 29.9 $MtCO_2$ and utilisation of alternative sources of de-carbonated lime and mineralizers could save 5.7 to 8 $MtCO_2$. These initiatives may reduce CO_2 emissions by 18% from business as usual scenario.

CFC Trial at ACC Limited, Kymore Cement Works

SINTEF participated on behalf of CPCB in the Test Burn with three different Ozone Depleting Substances, or chlorofluorocarbons (CFCs), in ACC Limited, Kymore cement works, Madhya Pradesh in December 2012. Ozone Depleting Substances are regulated under the Montreal Protocol and countries are urged to destroy the five most potent CFCs gases as they destroy the Ozone layer and contribute to global warming.

The full scale demonstration involving high feeding rates of Ozone Depleting Substances (ODS), CFC-gases demonstrated that the kiln was able to destroy several concentrated CFC-gases effectively in an irreversible and environmental sound manner without causing increased releases of HCl, HF or PCDD/PCDF. The destruction and removal efficiency was >99.9999% and the overall environmental performance in compliance with Indian regulation and international best practice.

The test revealed that cement kilns have a much higher disposal capacity than previously anticipated and that such undertaking can contribute significantly to reduce the release of both ODS and greenhouse gases; the destruction of 16.3 ton of CFCs done in this demonstration was saving the release of 131 265 ton of CO_2 to the atmosphere. The global potential to prevent future emissions of ODS gases are formidable; the UN has estimated that more than 400 Mt of CO_2 equivalents will originate from discharges of cooling gases in 2015. The impact of this test is that India now has a facility with demonstrated capability to destroy such gases in the future; a showcase which can be replicated elsewhere.

About SINTEF and its association with the co-processing initiatives in India

SINTEF is one of the leading applied multidisciplinary research institutions in Europe with more than 2000 professional employees. SINTEF has a long and relevant experience with capacity building & technical assistance in international projects for governments, industry and international organizations within industrial and hazardous waste management in general, and with co-processing in particular, i.e. improved energy and resource efficiency and green-house gas emission reduction by substitution of non-renewable fossil fuel and virgin raw materials with alternative fuels and raw materials in resource intensive industry.

CPCB-SINTEF Phase I Co-processing Project (2010-2015)

CPCB and SINTEF have since 2010 cooperated in the Norwegian government supported programme “Recovery of alternative fuels and raw materials (AFR) and treatment of organic hazardous wastes through co-processing in resource and energy intensive industry (REIIs) in India”. The project have been raising awareness, built capacity, shared knowledge of best international practice, and provided technical support and disseminating information to industry and authorities. This process has contributed to create confidence and a positive climate for investments, manifested by industries willingness to invest in future co-processing activities.

SINTEFs role has been to provide inputs on relevant issues of co-processing of hazardous and industrial wastes and to build capacity and knowledge among stakeholders; to assist CPCB, State PCBs and industry in implementing best practices and to convey lessons learned on possibilities and limitations in co-processing; and finally to contribute to achieve an international benchmark when it comes to process and quality performance, as well as on health, safety and environmental issues.

Phase II Co-processing Project (2017-2020)

SINTEF is currently working on a Norwegian government funded project in India –'Co-processing of Alternative Fuels and Resources in the Cement Industry: Phase II' (2017-2020) which is continuation of Phase I project (2010-2015), with focus on the following issues:

- Provide professional technical assistance on waste related issues in the GIZ-MoEFCC SEIP project for providing technical support and capacity building on sustainable management of industrial wastes and sewage sludge, and for cleaning up of critically polluted areas in the two selected SEIP project sites- Delhi and Vapi, Gujarat;
- Demonstrate the potential to increase the TSR by utilising RDF out of MSW and dried sewage sludge;
- Strengthen the capacity of CPCB and S-PCBs on opportunities and limitations of using cement kilns for co-processing of problematic wastes;
- Strengthen the role of CPCB as a pool of competence for environmental authorities in neighbouring South Asian countries; and
- Evaluate the potential for resource conservation by utilising C&D-wastes and increased use of other inorganic waste streams.

Conclusion

Many developed nations globally have utilized cement kilns in their countries as a sustainable solution for industrial, municipal and hazardous waste disposal (called co-processing) as this creates a win-win situation for both the local administration and the cement plants. Spiralling fuel costs, uncertainty in fuel availability and goal to reduce CO_2 emissions are drivers for enhancing AFR utilization in Indian cement plants.

'Polluter pays principle' must be implemented for managing industrial wastes. For commodity like materials such as processed RDF, used tyres and biomass, substitution benefits in a cement plant must outweigh material costs and preparation and handling costs. Regular supply of wastes to cement plants at agreed tipping fee or price is essential for optimising the return on investments.

By integrating co-processing and treatment of wastes in energy and resource intensive industry, India can forego or significantly reduce investments in costly waste incinerators; save large amounts of non-renewable fossil fuels and virgin raw materials; reduce greenhouse gas emissions; increase its waste treatment capacity and reduce exposure and negative impacts of hazardous chemicals. The aspiration of achieving 20% TSR by 2030 by Indian cement industry is challenging but surely achievable.

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