India's coal coup

With India's coal requirement set to soar, the domestic cement industry is taking an increasing interest in the co-processing of waste to make it less reliant on 'black gold' and help cut fuel costs. However, to increase thermal substitution rates, cement producers need to overcome several issues, including the availability of suitable waste, investments in associated infrastructure at cement plants and a stringent permitting process.

■ by ***Dr Kåre Helge Karstensen and Palash Kumar Saha**, SINTEF, Norway*

In terms of global rankings, India is currently the world's second-largest cement producer, the third-largest electricity producer and the fourth-largest crude steel producer. These three sectors consume more than 624Mta of coal and are responsible for nearly 50 per cent of India's CO_2 emissions. However, the country's cement, steel and electricity per capita consumption levels are among the lowest in the world, indicating considerable demand growth potential.

The Planning Commission of India predicts that by the end of the 2021-22 period coal demand within the cement, steel and power sectors would almost double to 1247Mt (Sachdev, 2012). India spent INR888bn (US$13.6bn) on coal imports in 2014 (Prithiani, 2014). Therefore, substituting significant coal volumes with waste is expected to reduce the country's coal import bill by billions of rupees.

In terms of the role the cement sector could play, achieving a thermal substitution rate (TSR) of 20 per cent by 2030 could substitute up to 19Mt of Indian coal or 13Mt of coal imports.

The Indian cement industry has a key role to play in helping the country raise its waste treatment capacity, as cement plants such as ACC's Kymore works (pictured) co-process various wastes as alternative fuels

Waste status

At present waste generation in India is still relatively moderate and currently stands at approximately 120Mta of mixed wastes (excluding industrial non-hazardous wastes). However, this volume is expected to increase significantly on the back of improvements in GDP and living standards. Meanwhile, waste treatment capacity is insufficient, and the current situation results in pollution and the release of GHG emissions.

Industry trials runs

Therefore, the utilisation of industrial, municipal and hazardous waste disposal in cement kilns creates a win-win situation at both the local administration and cement plant level: the administration is able to utilise the infrastructure already in place at cement plants (thus spending less on waste management), while the cement producer is paid by the polluter for the safe disposal of waste and can meet part of its fuel requirements for cement manufacture.

To date 75 co-processing trial runs have been conducted in cement kilns in India, with approval from and under the guidance of the State Pollution Control Boards (SPCBs) and the Central Pollution Control Board (CPCB).

According to the CPCB guidelines, a waste type that has been tested and approved in one cement plant can be used for regular co-processing in another cement works provided that a permit is given by the SPCB. Hence, a number of trials are needed for the various types of wastes generated. The trials that have already been conducted do make some of the wastes available to other cement plants, provided conditions are similar.

Furthermore, co-processing technology has also been used to destroy hazardous chemicals in India. On behalf of the CPCB, Karstensen et al (2014) participated in a test burn at ACC's Kymore cement works in Madhya Pradesh with three different ozone-depleting substances, or chlorofluorocarbons (CFCs). Ozone-depleting substances are regulated under the Montreal Protocol and countries are urged to destroy the five most potent CFC gases. The test at ACC's Kymore works destroyed 16,300kg of CFCs (CFC-11, 12 and 113), which is the equivalent of removing a global warming potential of 131,000t of CO_2. The test revealed excellent destruction efficiencies, much higher than that recommended by the Montreal Protocol and UNEP.

The CPCB has also conducted a few trials in captive power plants of industries using hazardous wastes such as effluent treatment plant (ETP) sludge, spent pot lining, resins and non-hazardous waste such as tyre chips, but the utilisation rate

Table 1: TSR achieved in major Indian cement companies, 2014

Cement company	TSR (%)	Waste used (t)	Reference
ACC	2.46	850*	ACC Ltd Sustainable Develvopment Report 2014
Ambuja Cements	3.95	178,000	Ambuja Cement Ltd Sustainable Development Report 2014
Binani Cement	2.17	394*	Binani Cement Ltd Sustainable Development Report 2010-11
UltraTech Cement	2.2	173,500	UltraTech Cement Ltd Annual Report 2014-15
Shree Cement	0.56	5086	Shree Cement Ltd Sustainable Development Report 2012-13

**Waste utilised expressed in heat value (in TJ)*

Test burn with ozone-depleting substances at ACC Ltd's Kymore cement works, India

has not exceeded the one per cent mark (Gupta, 2012).

TSR trends in India's cement industry

The TSR in India's cement works has increased significantly over the last few years. As at 1 February 2011, the TSR rate for UltraTech Cement and ACC was 0.47 and 0.59 per cent, respectively. (Karunakaran and Ghosh, 2011).

While the thermal substitution of coal with waste has increased since, it still remains low at an average one per cent. Co-processing is now, however, being implemented by other large domestic producers such as Ambuja Cements, Shree Cements, Jaypee, Dalmia Cement, Lafarge, India Cements, Bharathi Cement, CRH, HeidelbergCement India, Zuari Cement and Madras Cement.

In 2014 UltraTech Cement and ACC had achieved a TSR of 2.22 and 2.46 per cent, respectively. The larger companies, which make up a combined market share of 60 per cent, are currently estimated to have a TSR of 2.5 per cent.

Table 1 shows the TSR achieved by five major cement companies in India in 2014. It should be noted that these firms are also the frontrunners of AFR utilisation and therefore their TSR achievements cannot be extrapolated across the whole industry.

A status report published by the Confederation of Indian Industry (CII) in May 2015 showed that the average TSR of 36 cement plants, corresponding to 109Mta of cement capacity, was 3.55 per cent.

Waste availability

In terms of the availability of wastes suitable for co-processing, studies conducted by India's Ministry of New and Renewable Energy (MNRE) have estimated surplus biomass availability at about 120-150Mta, covering agricultural and forestry residues. The 62Mt of municipal solid waste (MSW) generated in urban India includes a combustible fraction of 12Mt that can be potentially converted to RDF, thereby replacing 8Mt of coal, according to a waste-to-energy report published by the Planning Commission's task force. Out of the current generation of 4Mt of landfillable and incinerable hazardous wastes, 2.5Mt (60 per cent) is awaiting proper disposal.

The availability of wastes/AFs between 2015-30 is given in Table 2. It is expected that the availability from current levels (ie, 2015), will grow by five per cent per annum, which is a conservative estimate given that GDP projections over the same period are more optimistic.

Present and potential waste types used

The cement industry currently utilises 45Mt of fly ash (from coal-based power plants) to produce Portland pozzolana cement (PPC) and 10Mt of granulated blast furnace slag or GBFS (from pig iron production) to manufacture Portland slag cement (PSC). The share of PPC and PSC in total cement output is 66 and nine per cent, respectively (Rajya Sabha secretariat, 2011).

At present, the average utilisation of fly ash in PPC is 27 per cent and GBFS in

Table 2: availability of fossil AFs and mixed wastes, 2015-30

	2015*	2020	2025	2030
Hazardous industrial wastes (Mt)	2.5	3.2	4.1	5.2
RDF (Mt)	12.0	15.3	19.5	24.9
Industrial plastics (Mt)	0.2	0.3	0.3	0.4
Tyres (Mt)	0.7	0.9	1.2	1.5
Total (Mt)	8.9	11.4	14.5	18.6

** 2015 figures are sourced from the latest available data*

PSC is 40 per cent (WBCSD CSI, 2012). The Bureau of Indian Standards (BIS) allows up to 35 per cent of fly ash in PPC and up to 70 per cent of GBFS in PSC. If the share of PPC and PSC in total cement output remains the same, to achieve 35 per cent of fly ash utilisation in PPC and 70 per cent of GBFS in PSC, 138-196Mt of fly ash and 38-53Mt of slag would be required by 2030.

GBFS, fly ash, steel/LD slag, carbide sludge and lead-zinc slag can also be used as alternative sources of decarbonated calcium. The use of decarbonated/non-carbonate lime-bearing raw materials offers the dual benefit of CO_2 reduction and energy efficiency. GBFS and copper slag can be utilised as alternative sources of mineralisers to accelerate reaction rates at some or all stages of clinkerisation. Mineralisers enable the use of low-quality limestone and more pozzolanic material. Steel/LD slag and copper slag can be used as alternative sources of iron corrective.

Economics and pricing

The pricing of waste management services is a key factor, both to ensure waste minimisation at source (to reduce disposal costs for waste generators) as well as making them affordable for cement manufacturers (encouraging cement producers to install the infrastructure needed for proper handling, storage and firing at their plants) for increased TSR. The "polluter-pays" principle should be the basis for the economic and financial analysis of waste utilisation.

For commodity-like materials such as processed RDF, used tyres and biomass, cement plants should be able to achieve a payback for their investments (ie the benefits of substitution outweighing material costs and preparation and handling costs). Prices of such commodity-like wastes depend on market dynamics. Waste source-to-cement plant logistics also play an important role in determining the price. For biomass and RDF, where bulk density is low, logistical costs become even more important.

For an RDF manufacturer, the tipping fee from the municipality plus the revenue from selling RDF should offset the costs. The municipality, in turn, may recover the costs by charging citizens for the services provided, in terms of user fee or taxes.

Restrictions or limits on landfill (or the inclusion of externality charges or future liability costs to landfill charges), rising fossil fuel prices and the possible price on carbon and carbon trading schemes are some of the initiatives which will give impetus to co-processing initiatives in India. It is not possible to provide an accurate and universal economic calculation or business model for all of India as this will depend on local circumstances.

Infrastructure and investment status

More than US$60m has been invested in the last four years to develop pre-processing facilities for the Indian cement sector. For the cement industry to achieve a 20 per cent TSR by 2030, massive investments would be required for pre-processing, storage, handling, feeding and the change of burners and/or emission abatement systems (filters, catalysts, etc) with typical payback of 6-8 years. For a 1Mta cement plant, the costs of pre-processing and co-processing installations is calculated to be INR400m (US$6m).

With a strong focus on the increased and accelerated use of AFR, it is necessary for newer cement plants to consider AFR storage, handling and feeding systems in the design phase, taking into consideration future scalability and retrofits.

Emission standards and permitting procedure

The CPCB guidelines on co-processing mandates zero net emissions from co-processing, ie, emissions during co-processing should not be different from the emissions during cement production with conventional fuels. There are currently no emission limits for cement kiln co-processing.

The cement industry prefers uniform emissions standards for co-processing rather than case-by-case permits. In India it normally takes more than a year for a waste stream to obtain regular permits for co-processing. Firstly, the law and guidelines mandate that trial runs be conducted for each new waste streams. The trials and regular usage must then be approved by both the SPCB and CPCB.

For some special and difficult-to-treat hazardous wastes (such as pesticides, PCB, CFC), it is particularly important that trials are carried out to ensure compliance with environmental as well as occupational health and safety guidelines.

Co-processing competence and capacity

There are currently no Indian institutions with formal competence on co-processing. However, larger cement producers that are part of international companies are developing their expertise. There are also experts within the CPCB. In addition, stakeholder meetings, workshops and international study tours in the last four years under the CPCB-SINTEF co-processing project, have contributed to improving industry and regulator competence levels.

Meeting the TSR target

While the Indian cement industry generally welcomes the idea of co-processing, comparatively stringent and costly permitting processes can create a disincentive for some companies. A permitting system resembling "international best practice" will probably stimulate broader interest. A revision and update of the existing guidelines and permitting requirements, addressing issues such as interstate transportation and emission limits, is considered to be of crucial importance in terms of stimulating increased co-processing practice.

To supply future requisite quantities of RDF to cement industries, several MSW-to-RDF facilities need to be set up in all major metropolitan and class 1 cities. This may be achievable through public-private partnerships with funding and aid from the central government or other agencies.

With proper government preparation, planning and guidance, co-processing of various wastes in energy-intensive industries can be expected to contribute significantly to waste treatment capacity in India, thereby reducing the need to build incinerators and landfills. Moreover, it can reduce CO_2 emissions significantly.

The co-processing of waste in cement plants requires highly-qualified experts to install and set up the equipment and train personnel to operate this equipment. Indian industries still need to develop the capacity and competence. The aspiration of achieving a 20 per cent TSR by 2030 in the Indian cement industry is challenging but achievable. ■

REFERENCES

[1] ACC LTD (2014) *Sustainable development report 2014*. http://www.accLtd.com/newsite/pdf/ACCSR030915_1.pdf.

[2] AMBUJA CEMENTS LTD (2014) *Sustainable development report 2014.* http://www.ambujacement.com/sustainability/report2014/.

[3] BINANI CEMENT LTD (2012) *Sustainability report 2010-11*. http://binaniindustries.com/wp-content/uploads/binani-sustainability-report-nov-2012.pdf.

[4] CONFEDERATION OF INDIAN INDUSTRIES (CII) (2015) *Status paper on AFR usage in Indian cement industry – an initiative by CII-CMA, May 2015*.

[5] GUPTA, P K (2012) 'Scenario of co-processing of wastes in India'. *CPCB and SINTEF Workshop*, Bhopal, India, 1 November 2012.

[6] KAMYOTRA, J S, BALA, S S, GUPTA, P K AND KARSTENSEN, K H (2013) 'Co-processing of wastes in resource and energy intensive industry in India – an introduction' in: *ICR*, March, p91-95.

[7] KAMYOTRA, J S, BALA, S S, GUPTA, P K AND KARSTENSEN, K H (2013a) 'Regulatory requirements and co-processing experiences in India' in: *ICR*, March, p95-100.

[8] KARSTENSEN, K H, PARLIKAR, U V, AHUJA, D, SHARMA, S, CHAKRABORTY, M A, MAURYA, H P, MALLIK, M, GUPTA, P K, KAMYOTRA, J S, BALA, S S AND KAPADIA, B V (2014) 'Destruction of concentrated chlorofluorocarbons in India demonstrates an effective option to simultaneously curb climate change and ozone depletion' in: *Environmental Science Policy*, 38, p237-244.

[9] KARUNAKARAN, N AND GHOSH, A (2011) 'The Waste Wars' in: *Economic Times of India*, 1 February 2011.

[10] Ministry of New and Renewable Energy (MNRE) – Government of India (sd) *Biomass and co-generation programme* http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/ (accessed 24 January 2015)

[11] PRITHIANI, R (2014) 'India Inc to benefit as imported coal prices set to fall' in: *The Hindu*, 29 December. http://www.thehindu.com/business/Industry/india-inc-to-benefit-as-imported-coal-prices-set-to-fall/article6730983.ece.

[12] PLANNING COMMISSION (2014) *Report of the task force on waste to energy (volume 1) – in the context of integrated MSW management, May 2014*.

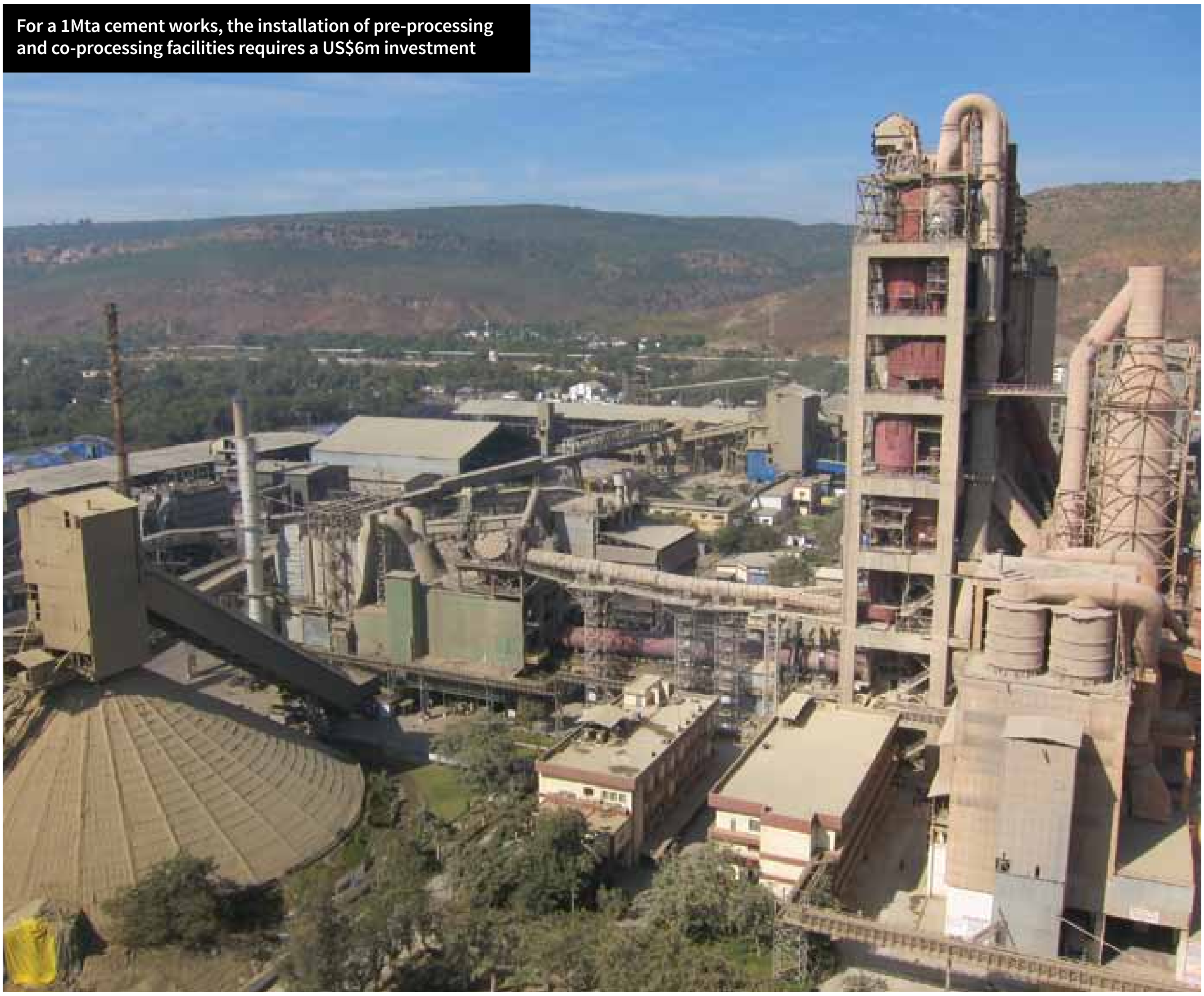
[13] Rajya Sabha Secretariat (2011) 95th report on performance of cement industry (presented to the Rajya Sabha on 24th February, 2011 and laid on table of the Lok Sabha on 24th Feb, 2011). Department related to parliamentary standing committee on commerce. Parliament of India.

[14] SACHDEV, R K (2012) 'Indian coal sector' in: *India Energy Book*. New Delhi, India: World Energy Council, 154p. http://www.indiaenvironmentportal.org.in/files/file/ieb2012.pdf.

[15] SHREE CEMENT LTD (2013) *9th Corporate sustainability and responsibility report 2012-13*. http://www.shreecement.in/pdf/shree-cement-csr.pdf.

[16] ULTRATECH CEMENT LTD (2015) *Annual report 2014-15*. http://www.ultratechcement.com/common/images/downloads/07302015175503_2014-15 per cent20Annual per cent20Report.pdf.

[17] WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT – CEMENT SUSTAINABILITY INITIATIVE (WBCSD – CSI) (2012) *Existing and potential technologies for carbon emissions reductions in the Indian cement industry* – a set of technical papers produced for the project 'Low Carbon Technology Roadmap for the Indian Cement Industry'.



For a 1Mta cement works, the installation of pre-processing and co-processing facilities requires a US$6m investment

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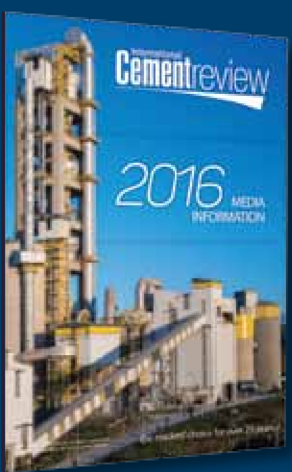

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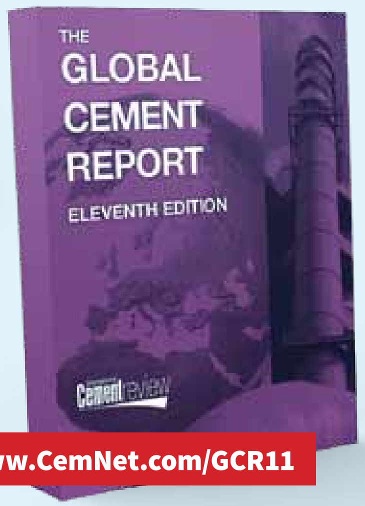

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