UK Government

G20 भारत 2023 INDIA

Azadi Ka Amrit Mahotsav

LiFE Lifestyle For Environment

ASPIRE PROGRAMME

Accelerating Smart Power & Renewable Energy in India

iDEEKSHA NEWSLETTER

Industrial Energy Efficiency/ Decarbonisation Outlook

Case Studies on select global technologies and best practices

June 2023

iDeeksha

Industrial Decarbonization and Energy Efficiency Knowledge Sharing Platform

TABLE OF
CONTENTS

Message from the Director General, BEE.....03

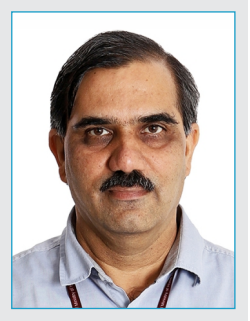
Message from the British High Commissioner to the Republic of India.....04

Introduction.....05
About ASPIRE Programme.....05
About IDEEKSHA Platform.....05

Section 1 - International Case Studies.....06
1.1 Carbon Capture Technology Decarbonising the Cement Industry: Carbon8, Vicat Case Study.....07
1.2 Cambridge Electric Cement: A Zero-Emissions Breakthrough.....09
1.3 Decarbonising Cement Production: Carbon Re's AI-based Delta Zero Cement Platform.....11

Section 2 - National Case Studies.....14
2.1 Co-processing of Spent Pot Lining (SPL) Mixed Fines in Cement Plants - A Sustainable Solution.....14
2.2 Energy Savings & Greenhouse Gases Mitigation to Manage Climate Change- Raymond Ltd, Vapi.....17

Section 3 - From the Archives.....20
3.1 From the Archives: Timeless Gems to Revive Your Reading List!.....21



Message from Mr. Abhay Bakre

Director General, Bureau of Energy Efficiency

Warm greetings to esteemed industry peers and colleagues!

India's remarkable growth trajectory and unwavering commitment to a sustainable future is evident as we embark on an ambitious path. Under the guidance of the Ministry of Power, the Bureau of Energy Efficiency (BEE) has been persistent in strengthening India's energy security and promoting energy efficiency through concerted efforts.

Our ambitious commitments made during the COP26 summit in Glasgow, emphasises on India's determination towards reducing total projected carbon emissions by one billion tons, reducing carbon intensity of GDP by less than 45% by 2030, and achieving net-zero carbon emissions by 2070. Central to fulfilling these COP26 commitments and ensuring energy security is the crucial aspect of Energy Efficiency (EE) and decarbonisation of the industrial sector. According to a recent study by IEA, there was a ~1% rise in global energy consumption. Concurrently, energy-related carbon emissions demonstrated a growth of 0.9%, reaching ~36.8 Gt in 2022. The global energy efficiency progress has increased to over 2% in 2022 from 0.5% in 2021. This progression is instrumental, as without it, the energy demand would have been three times its current magnitude.

The Bureau of Energy Efficiency (BEE) has been vanguard in promoting EE in various demand sectors, with a special focus on the industrial sector, as it is one of the major contributors to total GHG emissions in India and holds immense energy-saving potential. Our Perform, Achieve, and Trade (PAT) scheme, now in its eighth cycle, has been instrumental in orchestrating the adoption of various low-hanging energy efficiency measures by large energy-intensive industries in thirteen sectors, with more sectors to be included soon. As we continue striving to achieve the targets set under the PAT scheme, the adoption of emerging low-carbon technologies becomes imperative for unlocking the next level of incremental savings and decarbonisation.

To support industries in their journey towards decarbonisation, I am pleased to introduce the IDEEKSHA platform which was launched by Mr. R.K. Singh, Hon'ble Cabinet Minister for Power and New and Renewable Energy, at 21st Foundation Day of BEE and a Decade of PAT Scheme event on March 01, 2023. The platform has been developed by the Accelerating Smart Power and Renewable Energy in India (ASPIRE) programme in collaboration with the Bureau of Energy Efficiency (BEE). ASPIRE is a bilateral programme implemented by Foreign, Commonwealth and Development Office, Government of UK and Ministry of Power, Government of India.

IDEEKSHA Platform serves as a one-stop shop solution, catering to all the needs of Indian energy-intensive industries. It offers access to databases of proven and emerging technologies and their global providers, fostering peer-to-peer learning, sharing best practices across sectors, providing energy management tools, cutting-edge technologies, data sources, and knowledge repositories, thereby fostering knowledge and commercial partnerships.

It brings me pleasure that IDEEKSHA Platform is publishing its third newsletter, featuring national and international case studies on energy efficient, low carbon technologies and best practices. I am confident that this carefully curated newsletter

will empower our energy-intensive industries with transformative insights, catalysing deeper explorations into sustainable pathways.

I congratulate the authors of this newsletter and hope that information presented will be useful for the stakeholders.

Message from Alex Ellis

British High Commissioner to the Republic of India

Climate change is an existential challenge for our race and planet. Increasing numbers of extreme weather events around the world show the risks to our livelihoods, jobs and the natural environment.

So we need to act together if we are avert the worst impacts of climate change. At COP26 in Glasgow, we did just that. Almost 200 countries came together to sign the Glasgow Climate Pact which strengthens our resilience to climate change, to cut greenhouse gas emissions and to provide finance for the green transition. Prime Minister Modi proposed ambitious new targets for 2030 and pledged India would have net zero emissions by 2070. A year later, at COP 27, the Government of India published a Long-Term Strategy, setting out how India will achieve these targets.

To go further down the path of decarbonisation requires renewed focus on the industrial sector. Industries are one of the most significant contributors to emissions in India - around 25% of total emissions, second only to power generation. India's Long-Term Strategy sets out how it might develop an efficient and innovative low-emission industrial system. It highlights the opportunities to improve energy and resource efficiency, material efficiency and recycling, to strengthen the circular economy and to promote emerging technologies such as green hydrogen and carbon capture and storage technologies.

The UK must act as well, so it recently established the Energy Efficiency Taskforce to reduce energy demand through promoting energy efficiency across the economy. The taskforce will work to reduce total UK energy demand by 15% from 2021 levels by 2030, across domestic and commercial buildings and industrial processes.

The UK and India are also working together on the green transition and industrial energy efficiency. In October 2021, we launched a new UK-India bilateral programme: "Accelerating Smart Power and Renewable Energy" (ASPIRE) which aims to work with India to reach India's 2030 targets.

I am delighted to announce that under ASPIRE, 'iDEEKSHA: Industrial Decarbonisation and Energy Efficiency Knowledge Sharing Platform' has been developed in collaboration with the Bureau of Energy Efficiency (BEE). The iDEEKSHA platform will share best practices and Industrial Energy Efficiency and Decarbonisation (IEED) technologies among energy intensive industries. The newsletters will provide case studies on new and emerging low-carbon technologies and industry best practices. I hope that the information in these will help industries in reducing their energy and carbon consumption, contributing to India's efforts to achieve its climate goals.

INTRODUCTION

ABOUT ASPIRE PROGRAMME

The UK and India share a key strategic partnership, which has strengthened over the years with growing cooperation and bilateral engagements across multiple fields including the industrial energy efficiency and decarbonisation sector. To take this partnership forward and support sustainable development and inclusive growth, the bilateral Technical Assistance Programme, on "**Accelerating Smart Power and Renewable Energy**" **(ASPIRE)** was launched in October 2021. **ASPIRE** is being implemented by Foreign Commonwealth and Development Office (FCDO), Government of UK in association with Ministry of Power and Ministry of New and Renewable Energy, Government of India[1]. The programme aims to catalyse increased investment that supports sustained & inclusive economic growth, low carbon and leads to poverty reduction including through the promotion and empowerment of women and other socially weaker groups.

ABOUT IDEEKSHA PLATFORM

Under the ASPIRE programme, '**IDEEKSHA: Industrial Decarbonisation and Energy Efficiency Knowledge Sharing Platform**' has been developed in collaboration with the Bureau of Energy Efficiency (BEE) to promote and share best practices and energy-efficient technologies among large-scale industries. The IDEEKSHA platform was launched by Mr. R.K. Singh, Hon'ble Cabinet Minister for Power and New and Renewable Energy, Government of India during the 21st Foundation Day Event of BEE on March 01, 2023, in Delhi.

The IDEEKSHA platform is a one-stop shop for all energy efficiency/ decarbonisation needs of large industries covered under BEE's PAT Scheme. The IDEEKSHA platform would thus facilitate:

- Exchange of knowledge and information to enhance peer to peer learning
- Enable Designated Consumers (DCs) in adopting new and emerging IEED technologies offered by Indian and global technology suppliers including from the UK and facilitate access to tools, technologies, and technology providers present in India and globally
- Access to a database of financial institutions, policy
- Access to IEED tools, technologies & technology providers available in India and globally
- Access to data sources and knowledge repositories to support knowledge translation
- Organise sector/ industry specific workshops/ seminars to enhance EE measures
- Enable knowledge and commercial partnerships

This is the third of a series of newsletters that are being developed under the above initiative of ASPIRE programme for the 'IDEEKSHA Platform" and the Bureau of Energy Efficiency.

[1] KPMG is the implementation advisor to FCDO in relation to the ASPIRE programme. Idam Infrastructure Advisory Private Limited (India) and Carbon Trust (UK) are the key consortium members.

SECTION 1

INTERNATIONAL CASE STUDIES

1.1 Carbon Capture Technology Decarbonising the Cement Industry: Carbon8, Vicat Case Study

Introduction

In 2020, Carbon8 successfully deployed its first commercial **CO_2ntainer** to the Vicat Group cement plant in Montalieu, France. Carbon8, a UK-based cleantech company, specialises in carbon capture technology offering a viable solution for the global cement industry and other carbon intensive sectors to achieve their decarbonisation goals. The company leverages industrial residues produced onsite as raw material, employing a circular approach to tackle industrial wastes and support hard-to-abate industries in reaching net-zero and fulfilling their zero-waste ambitions.

Carbon8's award-winning technology solution is the culmination of extensive research spanning over 25 years. By effectively converting captured carbon and industrial residues into novel construction materials, the company is making significant contributions to the construction industry.

The technology is indigenously housed in a custom designed structure called the CO_2ntainer, comprising two retrofitted 40ft shipping containers installed withing the industrial sites. This innovative solution provided Vicat with a means to escalating volume of cement bypass dust (CBD) while concurrently advancing the decarbonisation efforts of their operations. Moreover, the CO_2ntainer facilitates the production of a sustainable aggregate that seamlessly integrates into Vicat's concrete production process.

> *"With the CO_2ntainer system, Vicat kills two birds with one stone. At the Montalieu-Vercieu cement plant, we are now able to upcycle chlorinated dust, with some of the CO_2 emitted during the manufacture of cement, by turning it into a new construction material."*
>
> - Laury Barnes-Davin, Scientific and R&D Director Vicat Group.

The Challenge

Vicat Group is a French multinational company that manufactures cement, concrete, and aggregates. It has spread its operations in over 12 countries. Vicat Group aims to become climate neutral by 2050, which includes using 100% Alternative Fuels. These Alternative Fuel sources include a specific blend of Refuse Derived Fuel (RDF), sewage sludge, wood, and polyurethane (PU) foam waste. However, the increased use of Alternative Fuels resulted in elevated chloride levels, leading to production of a byproduct called calcium -based residue. Vicat Group needed a solution for managing and utilising this CBD byproduct in a sustainable manner to achieve their climate goals.

Carbon8 Solution

Carbon8, an award-winning company specialising in Accelerated Carbonation Technology (ACT), developed a solution called **CO_2ntainer**. This solution serves as a compact and mobile carbon capture, utilisation and storage (CCUS) system. Its innovative Plug 'n Play system allows for seamless integration and transportation across the globe in two 40FT CO_2ntainers. The CO_2ntainer captures CO_2 at the source, and utilises it as an ingredient in the carbonisation process of industrial residue that would otherwise be sent to landfill. The solution is able to treat up to 12,000 tonnes of residues annually in the process. Housed inside the CO_2ntainer, ACT enables the production of carbonated products for the construction industry. This includes carbon-negative aggregate, which has a variety of applications including in cement blocks, road fillers and green roofing substrates.

Figure 1: CO_2ntainer at Vicat cement plant in Montalieu, France

Deployment at Vicat Group cement plant in Montalieu France

At the Vicat cement plant in Montalieu, France, deployment of the **ACT** is taking place. This innovative solution involves two stacked 40ft containers that house at the ACT system (Figure 1).The ACT technology utilises CO_2 extracted directly from the plant's flue gas, along with the calcium based residue as feedstock, to manufacture CircaBuild products onsite.

CircaBuild are sustainable, carbon negative alternatives to virgin aggregates. It is manufactured by Carbon8's Accelerated Carbonation Technology (ACT) that carbonates and treats residues from industrial plants, with captured carbon. The CO_2 is permanently and safely stored within CircaBuild, thus giving the residues a new life and making it a circular product. CircaBuild can be used in a variety of construction applications such as concrete blocks, ready-mix concrete, precast concrete, pipe bedding, road filler, green roofing substrate, etc.

CircaBuild is a carbon negative alternative to virgin aggregate, offering diverse applications in construction industry. This technology is offering Vicat a cost-effective, sustainable, and circular approach to manage CBD, thereby helping the group in reducing their carbon footprint.

How does it work?

At the Montalieu plant, the flue gas is extracted from the main flue stack, undergoes cooling, and then pass directly through the processing equipment located within the CO_2ntainer. The flue gas typically contains a CO_2 concentration of ~10 - 20%, which is adequate for the technology employed. The system can utilise CO_2 derived from the flue gas, as done at Vicat, or can utilise CO_2 obtained from bottled sources.

In case of Montalieu, the CBD is transported to the container via trucks and initially stored in a silo for batch processing. Within the container, both waste streams undergo treatment, and the carbonation process typically takes ~15-20 minutes. The carbonated products, known as CircaBuild, are then conveyed by a rear-mounted belt and directly loaded on to the trucks for transportation.

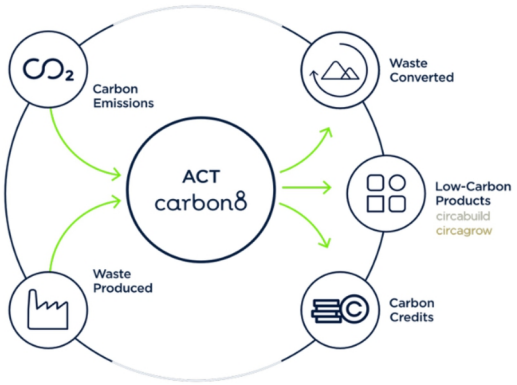


Figure 2: Input and output process for ACT Carbon8

The CO_2ntainer Overview:

Carbon capture	**Direct carbon capture from flue stack, 1,500 tonnes– 4,000 tonnes CO_2 annually**
Cloud-connected	Industry 4.0 capability
Waste utilised	Treats and utilises up to 12,000 tonnes of residue annually
Output	Manufacture up to 16,000 tonnes of CircaBuild carbon-negative aggregate annually
Integration	Seamless installation, retrofittable with minimal downtime

The Outcomes

Following the deployment of the CO_2ntainer, Vicat Group became an investor in Carbon8 in 2022, joining forces with EDF Pulse Ventures, in a co-investment of £4 million. The successful deployment of Carbon8's CO_2ntainer at Montalieu serves as a powerful demonstration of Vicat Group's commitment to achieving carbon neutrality throughout its value chain by 2050.

Following the deployment, Carbon8 and FLSmidth, a Danish OEM, signed an exclusive partnership to deploy the solution to the global cement industry, to accelerate the adoption of their technology, thereby facilitating a greener transformation of cement industry. Through this close working relationship, Vicat Group and Carbon8 are unlocking increased utilisation of alternative fuels, offering a sustainable solution for CBD while simultaneously decarbonising operations and promoting circularity within Vicat Group's activities. Together, these two companies are setting a benchmark for the cement and construction sectors.

Opportunity for Indian Cement Sector

India is the second largest producer of cement in the world, with an installed capacity of 500+ million metric tons per annum (MTPA). In this regard, Carbon8's innovative technology presents a significant opportunity for the Indian cement industry to address it's emissions and embark on a decarbonisation journey. The application of this technology enables the capture of carbon dioxide from cement plants' flue gas, subsequently utilising it to produce sustainable construction material. By harnessing Carbon8's technology, the Indian cement can effectively work towards meeting its carbon emission reduction objectives. This approach not only aids in carbon emission reduction but also aligns with India's broader goals to combat climate change.

1.2 Cambridge Electric Cement: A Zero-Emissions Breakthrough

Background

Concrete is the second most utilised material on earth, after water, and it is plays a fundamental role in our daily life, economy and the transformation of our environment. However, the production of cement through chemical and thermal combustion processes presents significant challenges due to its substantial carbon dioxide (CO_2) emissions. According to the Global Cement and Concrete Association (GCCA), more than **4 billion tonnes** of cement is produced each year, which accounts for ~**7%** of global CO_2 emissions. Replacement of the current cement poses one of the hardest challenges in achieving a climate safe future with zero emissions. Various processes exist to reduce the emissions from cement production, primarily centred around blending alternatives materials with the reactive component of cement (clinker). However, the elusive goal of producing the reactive element of cement without emissions has remained unattainable until now. A team of engineers at the University of Cambridge, Dr Cyrille Dunant, Dr Pippa Horton and Professor Julian Allwood, have recently secured research funding for their ground-breaking invention- the world's first emissions-free route to recycle Portland cement. This pioneering cement represents a remarkable milestone as a truly zero- emission Portland cement.

The inspiration behind Cambridge Electric Cement arose when the inventors recognised the striking resemblance between cement and lime-flux employed in conventional steel recycling processes. This innovative cement is thus produced withing a virtuous recycling loop, not only eradicating emissions associated with cement production but also conserving raw material while reducing emissions involved in the lime-flux manufacturing process.

The product

The Cambridge Electric Cement process commences with the utilization of concrete waste derived from the demolition of old structures. Through crushing, the stones and sand that constitute concrete are separated from the mixture of cement powder and water responsible for binding them together. Subsequently, the previously used cement powder is employed as a substitute for lime-flux in the process of steel recycling. During the melting of steel, the flux generates a protective slag that floats on the liquid steel, guarding it against exposure to oxygen in the surrounding air. Once the recycled steel is extracted, the liquid slag is rapidly cooled in the air and pulverised into a powder that closely resembles the clinker, which serves as the foundation for producing new Portland cement. In pilot-scale trials of this innovative process, the Cambridge team successfully demonstrated the integrated recycling approach, and the findings indicate that the resulting material possesses the same chemical composition as clinker produced using the present-day process.

Figure 3: Output of Electric Arc Furnace (EAF) steel recycling process to be cooled to make Portland Cement clinker through Cambridge Electric Cement' process (Source: Cambridge Electric Cement)

A problem of scale

For any solution to be effective, it must not only function properly but also possess scalability, ensuring a reasonable expectation for rapid deployment and expansion. After successfully demonstrating the product's performance at par with Portland cement, it is currently undergoing industrial-scale trials as part of the **Cement2Zero** project. The project has secured approximately €6.5 million in funding from Innovate UK, and a consortium consisting of prominent industry partners from various sectors are involved in conducting these trials. Led by the Materials Processing Institute and supported by the University of Cambridge (UoC), the Cement2Zero initiative represents a significant collaborative effort within the supply chain. It aims to address the construction industry's foremost challenge of decarbonisation in response to the global climate emergency. (Figure 4)

Industrial trial

The Cement2Zero project aims to investigate the technical and commercial aspects of scaling up the production of Cambridge Electric Cement to achieve a production volume of 20 tons, creating the world's first zero-emissions cement. The initial phase of the trial involves melting processes conducted by the Materials Processing Institute using an 800kg induction furnace, which will later be scaled up to 6 tons in an Electric Arc Furnace (EAF). Once the process has been thoroughly trialed, developed, and de-risked, large-scale melts will take place in CELSA's EAF located in Cardiff.

Over the course of two years, the industrial trial will comprehensively test each stage of the production process, leveraging the expertise of the Materials Processing Institute, the University of Cambridge, and key partners in the supply chain, including Atkins, Balfour Beatty, CELSA, Day Aggregates, and Tarmac. The ultimate goal is to utilize the innovative product in a real construction project within the UK. Currently, the strength of the initial cement produced by the project is being tested, and the results will be shared soon.

The success of this project holds the potential to drive advancements in the cement, steel, and construction industries while influencing recycling practices, construction methods, and infrastructure maintenance, thereby shaping the future of towns and cities. Furthermore, it can boost economic development and, most importantly, contribute to the reduction of CO_2 emissions to address global warming. The adoption of Cambridge Electric Cement can have a significant impact on the country's carbon emissions and resource conservation, reducing the reliance on virgin materials.

Cambridge Electric Cement is a collaborative effort involving the Universities of Cambridge, Warwick, and Imperial College London. It is funded by the EPSRC. Led by the Materials Processing Institute and supported by the University of Cambridge, the Cement2Zero project collaborates with Atkins, Balfour Beatty, Celsa, Day Group, and Tarmac. It is funded by Innovate UK and UKRI.

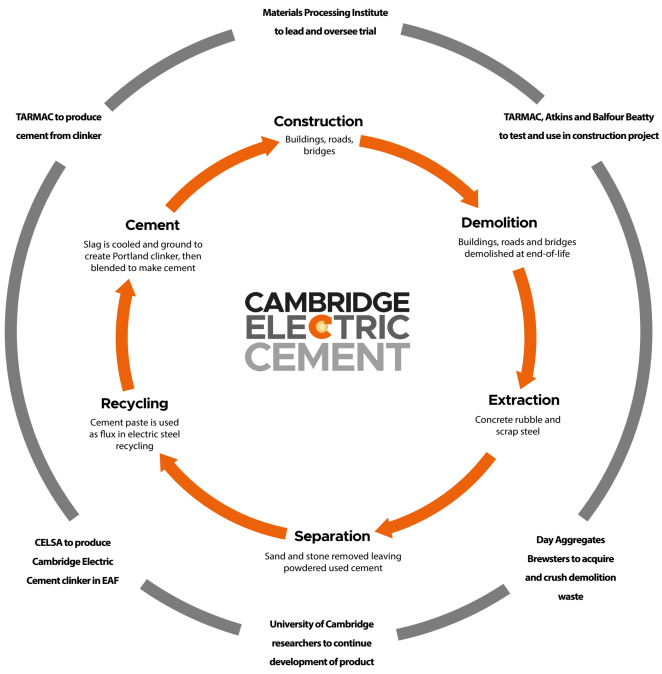


Figure 4: The Cement 2 Zero project (Source: Cambridge Electric Cement)

1.3 Decarbonising Cement Production: Carbon Re's AI-based Delta Zero Cement Platform

Carbon Re is an innovative materials company dedicated to significantly reducing carbon emissions using cutting-edge AI technology. As a joint venture between Cambridge University and University College London (UCL), their primary focus is on decarbonising vital materials like cement, steel, and glass. Their flagship product, Delta Zero Cement, leverages the latest advancements in artificial intelligence (AI) and machine learning (ML) to optimize fuel usage and enhance cement production quality.

Figure 1 showcases the key features and functions of Delta Zero. One notable feature is its ability to provide specific and quantified recommendations and predictions, which can be seamlessly integrated into expert systems or advanced process control (APC) systems without any intervention from the control room. For clients utilising manual kilns, they offer a "human-in-the-loop" system, where the control room operator manages the optimization recommendations. Another essential aspect of Delta Zero is its Application Program Interface (API) layer data integration, which enables direct connectivity to the plant through a secure API interface. This connection empowers the AI agents with real-time access to the plant's live status and data, facilitating accurate and informed decision-making. Furthermore, Delta Zero utilises the plant's existing data to create and maintain a precise digital twin, tailor-made for each specific plant. This digital twin serves as a virtual replica of the plant, enabling comprehensive analysis and optimization. Lastly, Delta Zero encompasses a powerful recommendation engine that provides specific and quantified setpoint recommendations. For instance, it offers optimal settings for kiln feed rate (tonnes/hour), fan speed (rpm), and Preheater Cyclones (PC) temperature (°C).

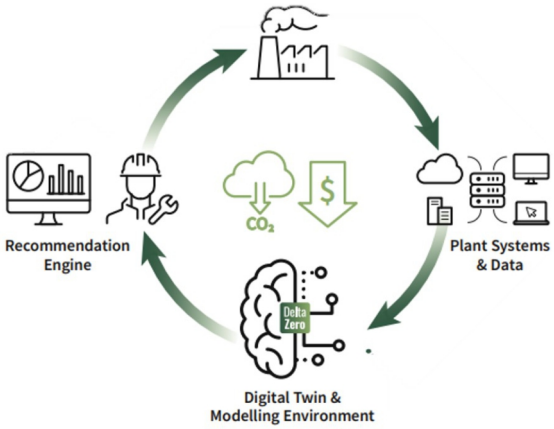


Figure 1: Key features and functions of Delta Zero

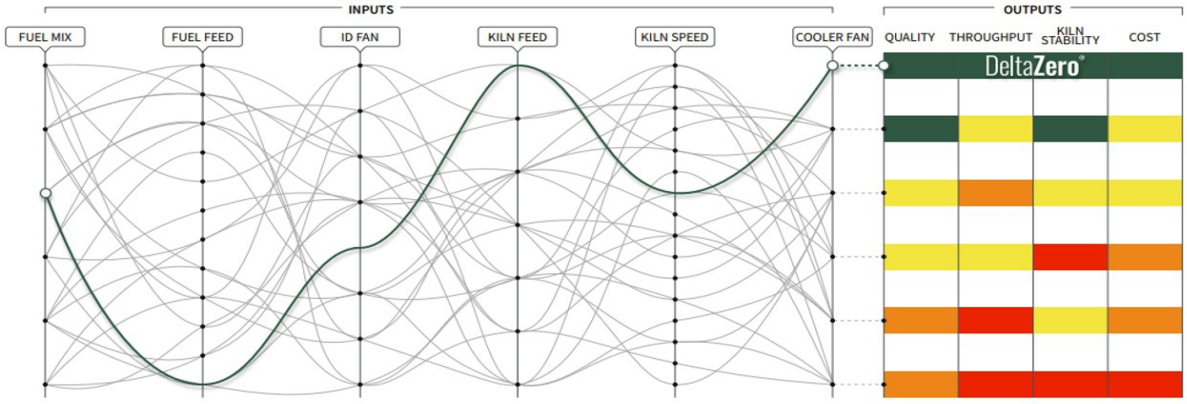


Figure 2: Illustrative input and output parameters for recommendation

Delta Zero for Cement Sector

Cement production is a highly intricate process influenced by various factors such as fuel types, raw materials, equipment conditions, and operational priorities. With Carbon Re's Delta Zero Cement, an AI and ML-based software platform, they offer a comprehensive solution that replicates and analyses the chemical and physical processes within each plant. This enables the AI agents to provide tailored solutions specific to the unique needs of each facility. Utilizing feed rates, sensor data, and control parameters, thier software platform generates precise and quantified recommendations to minimize the mass of CO_2 emitted per useful heating value (kgCO2/UHV). By harnessing the power of Deep Learning, an advanced branch of artificial intelligence, Delta Zero Cement effectively manages complex relationships and identifies optimal pathways for process optimization. Consequently, cement plant operations benefit from increased efficiency, cost savings, and emissions reduction, all achieved without requiring additional capital expenditure (CAPEX). They are actively deploying Delta Zero Cement with customers across Europe and the America, empowering cement manufacturers to achieve substantial improvements in their operations while driving environmental sustainability.

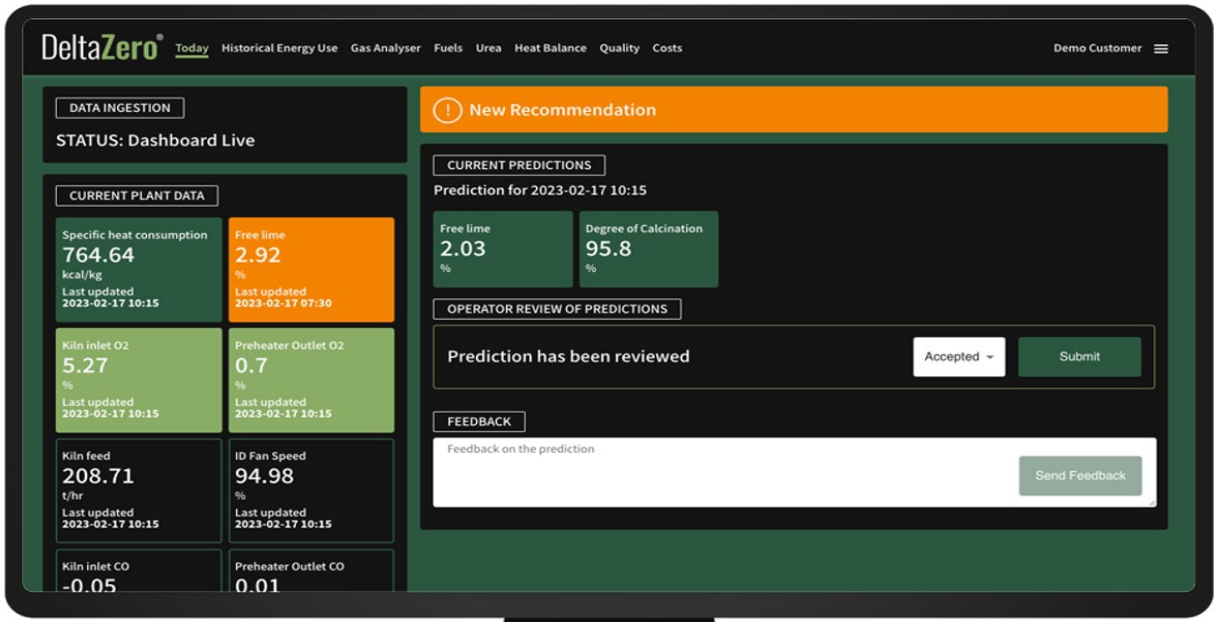


Figure 3: Illustrative Dashboard for Delta Zero

The key features of Delta Zero Cement include:

- Live forecast and quality metric predictions from the current operating parameters such as Free Lime % and heat balance.
- Adaptable outcomes to customer market conditions: Recommendations and predictions work on a live or daily basis, using the latest operating data. They are customisable to current priorities whether that is maintaining throughput or maximising cost savings.
- Regular insight into the trends and performance of plant from detailed analysis of the operating data.
- Plant controls: Ability to set control limits to keep parameters such as kiln torque and NOx emissions within desired parameters, improving kiln stability.
- Data visualisation: The platform analyses and visualises key operational data for the cement plant including Clinker production (tonnes), Specific Heat Consumption (kcal per kg clinker), Kiln Torque, actual Torque limits exceeded (%), NOx Emissions (actual), NOx limits exceeded (%), Raw Mill Chemistry, Clinker Quality, Recommendation tracking actual selections vs recommendations, etc. (Figure 3).

Delta Zero Cement is fast and easy to deploy, with no capital/ hardware instalments. As a cloud-based platform, it can easily integrate with an existing distributed control system or an 'Expert System' to set optimum efficiency parameters. Deployment of Delta Zero Cement can deliver several benefits including:

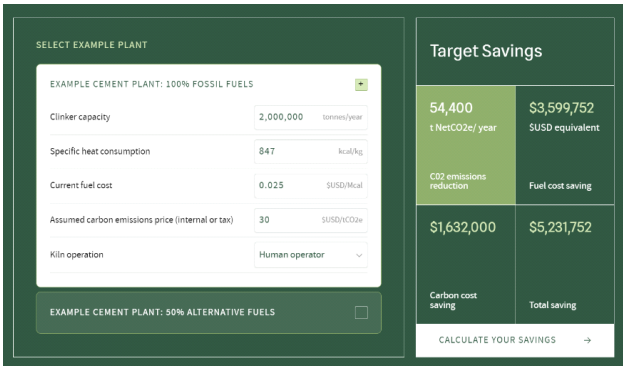


Figure 4: Delta Zero Savings Calculator

a) up to 5% reduction in carbon emissions through optimization of fuel usage, b) $3-10M savings per kiln line per year, c) up to 5% reduction in fuel costs, and d) break even on investments within year one and up to 4x returns by year 3 and beyond. Cement companies can also get a customised calculation of the potential savings in their plant through a savings calculator developed by Carbon Re (Figure 4).

Note: This article was contributed by Carbon Re. For more information on Cement Decarbonisation & Sustainable Alternatives, please visit: Delta Zero - AI decarbonization Technology - Carbon Re

SECTION 2

NATIONAL CASE STUDIES

2.1 Co-processing of Spent Pot Lining (SPL) Mixed Fines in Cement Plants - A Sustainable Solution

Dr. Alka Mishra, Rajiv Sadavarti and G V Ramakrishna, *Dalmia Cement (Bharat) Limited · New Delhi · India*

Introduction

The disposal of waste presents significant financial and logistical challenges. Particularly, in the current context, effectively utilizing hazardous waste generated in industries such as Iron and Steel, Petroleum, Aluminium, Power, and others is a pressing issue.

Dalmia Bharat Group adheres to the business philosophy 'Clean & Green is Profitable and Sustainable,' aiming to create positive environmental and social impacts by substituting traditional fuels and raw materials with alternative solutions. The group collaborates with sectors such as Iron and Steel, Petroleum, Aluminium, Power, and others to leverage their waste materials.

In India, the aluminium smelting industry holds great importance in the metallurgical sector, producing a hazardous waste called SPL Mixed Fines (SPL-MF). Dalmia Cement (Bharat) Limited obtained permission from the State Pollution Control Board (SPCB-Odisha) to accept SPL-MF from one of Odisha's largest aluminium industries for co-processing in the Clinkerization Unit's cement kiln in Odisha. This permission is documented under reference number 10943/IND-IV-HW-1361, dated 24-06-2022. To comply with the guidelines set by SPCB-Odisha, a trial run was conducted at a cement plant to assess the co-processing of SPL-MF. Environmental monitoring during the trial run was conducted by a team from a National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory.

The Innovation

One of the primary challenges faced by the Aluminium Industry today revolves around effectively managing the hazardous waste generated during the production of primary aluminium from Alumina Smelting Industries. This waste comprises fines obtained by segregating the carbon and refractory portions of Spent Pot Lining (SPL). These fines, known as SPL Mixed Fines (SPL-MF), fall under the category of Hazardous waste (S. No. 11.2 of Schedule-I of HOWM Rules 2016). As per the authorization conditions, when not utilized for energy/resource recovery, SPL-MF must be disposed of in an authorized facility.

Although SPL-MF lacks energy value, it contains valuable components and can be repurposed for specific applications. Dalmia Cement (Bharat) Limited Odisha Unit takes pride in being the first cement plant in India to conduct a trial run for co-processing SPL-MF. This initiative aligns with the guidelines provided by the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB)-Odisha, ensuring compliance with proper waste management practices.

The trial run has been executed successfully, demonstrating an absorption rate of up to 1.0% of SPL-MF in clinker production. Nevertheless, it is essential to carry out appropriate pre-processing of SPL-MF before its co-processing in a cement kiln. Co-processing necessitates the implementation of a dedicated controlled feeding system, ensuring a smooth feed into the kiln inlet while upholding clinker quality. Achieving this task while maintaining the rated production posed a significant challenge.

Demonstration

Generation: SPL-MF, a byproduct of primary aluminium smelting industries, is generated through the separation of fines from carbon and refractory portions of Spent Pot Lining (SPL). Typically, SPL-MF is produced at a rate of approximately 16-18 kg per metric ton of Aluminium metal. During the operation of pots, the carbon lining gradually deteriorates due to the gradual penetration of molten melt. Consequently, continuous operation necessitates the replacement of pot lining, resulting

in the generation of SPL-MF, which comprises fines mixed with carbon and refractory lumps. SPL-MF falls under the category of Hazardous waste and must be disposed of in an authorized facility when not utilized for energy or resource recovery.

Storage and Handling: The transportation of SPL-MF from the aluminium industry generator to the cement plant co-processor requires dedicated and authorized vehicles. These vehicles must be completely covered with tarpaulin, adhering to the necessary safeguards as outlined in the Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016, to prevent waste spillage.

Both the storage facilities at the aluminium industry and the cement plant should consist of well-ventilated covered sheds with impervious Reinforced Cement Concrete (RCC) flooring to prevent rainwater intrusion. Additionally, garland drains surrounding the storage shed should be in place, connecting to an Effluent Treatment Plant (ETP) for further treatment and recycling. Dalmia Cement (Bharat) Limited, Odisha Unit, and the aluminium industry in Odisha have established storage facilities in accordance with the guidelines outlined in HWM Rules-2016.

Testing: Multiple samples of SPL-MF obtained from the aluminium industry in Odisha were systematically analysed in the Dalmia Cement laboratory in Odisha. These samples underwent rigorous testing using sophisticated equipment available in the plant laboratory. The testing revealed significant variations in major components. The storage conditions and chemical composition range of SPL-MF are presented in Table-1, adhering to the guidelines of HWM Rules-2016.

Table-1 Chemical composition of SPL-MF

Storage Condition	Chemical Composition	
	LOI [%]	10 - 12
	SiO^2 [%]	**30 - 50**
	$Al2O^3$ [%]	**20 - 35**
	$Fe2O^3$ [%]	2 - 5
	CaO [%]	2 - 6
	MgO [%]	3 - 6
	K^2O [%]	1 - 4
	Na^2O [%]	2 - 6
	SO^3 [%]	0.20 -1.0

In accordance with the guidelines set by the Central Pollution Control Board (CPCB), it is imperative for the SPL-MF to adhere to the concentration limits for Cyanide, determined through the Toxicity Characteristic Leaching Procedure (TCLP), and Fluoride, established by the Soluble Threshold Limit Concentration (STLC), as specified in Schedule II of the Hazardous Waste (Management and Handling) Rules, 2016. Notably, comprehensive tests were performed on composite samples in a laboratory accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL), and the results indicate that the concentration levels for both Cyanide and Fluoride are well within the recommended limits, as indicated in Table-2.

Table-2 Mandatory test results - CPCB March 2021

Mandatory Requirement (mg/l)		Value	Method of Analysis
4500-CN: C/D	180 (max)	< 5.5 mg/l	EPA 1311, APHA 23 Rd edn. 4500, F:D
Fluoride (STLC)	180 (max)	< 5.5 mg/l	EPA 1311, APHA 23 Rd edn. 4500, F:D

Result – Plant Trial

For the cement manufacturing industry, the utilization of industrial waste as a partial substitute for raw materials has emerged as a viable solution to safeguard the environment while simultaneously enhancing clinker production. The Aluminium Industry, based in Odisha, possesses a substantial quantity of waste materials within their plant premises, and they are seeking appropriate disposal methods for these by-products. Recognizing the potential value of these waste materials, Dalmia Cement has identified the suitability of the SPL-MF to effectively incorporate their valuable components into the clinkerization process.

Utilization of industrial waste to partially replace raw material is one of the solutions to protect the environment and enhance clinker production in the cement manufacturing process. Aluminium Industry has enough quantity of waste materials in their plant located in Odisha and wants to dispose of it. Dalmia Cement found the usability of SPL-MF to utilize its valuable components in clinkerization.

Methodology: The primary application of SPL-MF in this study was to address the deficiency of silica and alumina in the cement raw mix. By incorporating SPL-MF as a raw mix component, improved control could be achieved through enhanced homogenization and greater dilution. However, due to the specific characteristics of SPL-MF, it was not suitable for grinding in a raw mill. Instead, a separate controlled feeding system was employed to introduce SPL-MF into the kiln inlet.

The addition of SPL-MF commenced at a starting concentration of 0.25% and gradually increased up to 1.5%. The introduction of SPL-MF posed challenges in maintaining optimal kiln performance, including the quality of clinker produced and the rated production capacity, primarily due to the larger particle size and significant variation in the composition of SPL-MF.

Throughout the trial run, environmental monitoring was conducted in accordance with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2018, following the guidelines provided by the Odisha State Pollution Control Board (OSPCB) or the Pollution Control Committee (PCC) for cement co-processing. The monitoring was carried out by a team from an NABL-accredited laboratory. The results demonstrated compliance with the specified standards both at the stack (connected to the rotary kiln, followed by the Bag filter) and within the work zone, as depicted in Table-3.

Table-3 Compliance to Standards - CPCB March 2021

Fugitive Emission in the Work Zone		
Mandatory Requirement (mg/l)		**Value**
PM10	5.0 mg/m^3 TWA (Note-1)	<5 mg/m^3 TWA
Cyanide as CN	5.0 mg/m^3 TWA	<5 mg/m^3 TWA
Fluoride as F	2.5 mg/m^3 TWA	<2.5 mg/m^3 TWA
Ammonia	25 ppm (18 mg/m^3) TWA	< 25 ppm TWA
	35 ppm (27 mg/m^3) STEL (Note-2)	< 35 ppm STEL
Emission from Stack connected to Rotary kiln followed by Bag filter		
PM	50 mg/Nm^3	< 50 mg/Nm^3
Total Fluoride	25 mg/Nm^3	< 25 mg/Nm^3
Hydrogen Fluoride	4 mg/Nm^3	< 4 mg/Nm^3
Ammonia	75 mg/Nm^3	< 75 mg/Nm^3
Hydrogen Cyanide	10 mg/Nm^3	< 10 mg/Nm^3
Note-1 TWA = Time Weighted Average (8 hours, Max)		
Note-2 STEL = Short-Term Exposure Limit (15 minutes, Max)		
Reference: Occupational Safety and Health Standard 1910: 1000		

Challenges and Mitigation: As SPL-MF is categorized as a hazardous waste as per Schedule 1 (11.2) of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, there are few operational challenges to co-process SPL-MF in cement kiln.

Some of the major challenges included the below:

- Failure of the grinding process in the Raw Mill,
- Restriction in production, due to larger size and wide variation in the composition of SPL-MF.

The key requirements to mitigate the above challenges include the following:

- Proper pre-processing of SPL-MF to segregate contaminants and to reduce size <10 mm,
- Separate feeding system with controlled dosing at kiln inlet,
- Appropriate sampling of SPL-MF during operation,
- Additional requirement of additives to maintain clinker quality,
- Replacement of existing Hazardous Waste to maintain the mandatory Norms specified by SPCB / CPCB.

Conclusion – Opportunity for India

The circular economy presents a significant opportunity for India, particularly when it comes to the careful utilisation of hazardous waste in the production of valuable products. Considering that aluminium smelting ranks as the second most vital metallurgical industry in India, and India itself being the world's second-largest cement producer, there is a clear opportunity for both the aluminium and cement sectors to embrace the principles of the circular economy.

By judiciously incorporating SPL-MF as a raw mix component in cement kilns, the challenges can be mitigated, provided that the usage adheres to the guidelines established by the CPCB or the SPCB. Fulfilling the prime requirements outlined by these regulatory bodies will ensure responsible and sustainable co-processing of SPL-MF in cement production, thus fostering a circular economy approach in India.

2.2 Energy Savings & Greenhouse Gases Mitigation to Manage Climate Change- Raymond Ltd, Vapi

Introduction

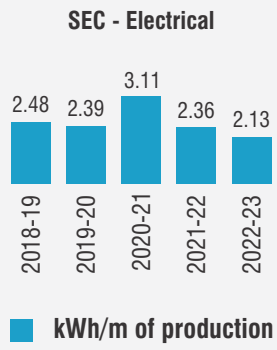
Raymond Ltd's Vapi Unit is a prominent manufacturing facility within the Textile Division, specializing in the production of worsted suiting fabrics. Equipped with state-of-the-art machinery, the plant possesses exceptional efficiency and productivity. Its workforce consists of highly skilled and well-trained individuals who demonstrate remarkable competence. The unit commenced operations in 2006.

Recognising the urgent need to conserve energy, Raymond Limited, being a widely renowned brand in the country, takes great pride in its commitment to sustainability and greenhouse gas reduction. To achieve these goals, the Vapi Unit has successfully implemented an energy management system (EnMS) that complies with all ISO 50001 requirements.

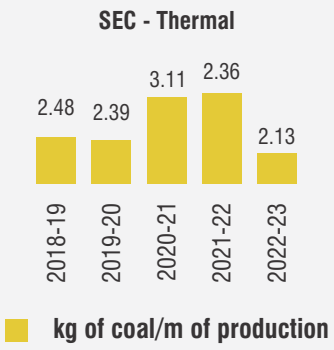
Raymond Ltd's Vapi Unit has been consistently recognised and honored for its exemplary efforts in environmental and energy management. The plant has received several prestigious accolades, including the esteemed National Energy Conservation Award (NECA) Certificate of Merit in 2019. Furthermore, the unit was bestowed with the Apex India Green Leaf Platinum Award in 2021 for its outstanding energy efficiency practices. Most recently, Raymond Ltd's Vapi Unit was honored with the Green Gujarat Award 2023 by News 18 Network, further highlighting its commitment to environmental stewardship.

Energy Review

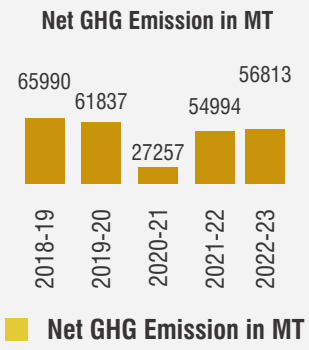
The textile plant operations heavily rely on energy consumption, with Raymond Ltd's Vapi Unit experiencing energy costs that constitute approximately 25-30% of the total production expenses. Through meticulous planning and effective implementation of energy-saving initiatives, Raymond, Vapi has achieved significant reductions in specific energy consumption (SEC) for both thermal and electrical sources on a year-on-year basis. The plant's performance in these areas over the past five years is illustrated below:



Graph 1: Specific Energy Consumption – Electrical



Graph 2: Specific Energy Consumption – Thermal



Graph 3: Net GHG Emission

Raymond Limited's Vapi plant has been designated as a Designated Consumer (DC) in accordance with the guidelines set by the Ministry of Power under the Perform Achieve Trade (PAT) Scheme. Within the framework of this scheme, the organisation was assigned a target to reduce its specific energy consumption (SEC) by 6% during PAT Cycle III. Impressively, the plant surpassed this target by achieving an 11% reduction in SEC.

Presently, the Vapi plant is operating under PAT Cycle VII, with a new target set for a 6.8% reduction in SEC by the year 2025.

In addition to diligently meeting these targets, the organisation recognises its responsibility towards the environment. Through the implementation of energy conservation projects and sustainable development initiatives, Raymond Limited has made a remarkable impact on reducing greenhouse gas emissions and mitigating CO_2 emissions.

Energy Conservation Initiatives in FY22-23

The organisation diligently identifies and categorises all energy units within the plant, employing trend analysis of historical data to define Significant Energy Users (SEUs) at various levels, including process, system, and equipment. Baselines for these SEUs are established using historical data, taking into account the influence of relevant variables. This process enables the organization to identify improvement opportunities and establish corresponding objectives and targets.

Recognising the paramount importance of energy conservation, the organisation makes substantial investments in projects, carefully considering factors such as payback period and overall environmental impact. Projects aimed at reducing greenhouse gas emissions primarily fall into two categories: the utilization of energy-saving products and the exploration of alternative and sustainable (renewable) energy sources.

ENERGY SAVING INITIATIVES

The senior management of Raymond Limited has consistently embraced the idea that energy conservation is not only beneficial for business but also a crucial step towards achieving sustainable development. As part of their commitment, the organisation actively seeks out advanced and state-of-the-art energy-saving products.Notable projects in this endeavour include:

Low Pressure Compressor with Heat Recovery Unit

In a textile unit, the compressed air system is one of the key energy consumers, attributing 12-13% of the total plant consumption. An opportunity of energy conservation was identified through the installation of a low-pressure compressor with a heat recovery unit. The Specific power consumption of a low-pressure compressor is 0.125 kWh/cfm against 0.18 kWh/cfm of existing compressors. The heat recovery unit is used to generate hot water through waste heat recovered from the compressor oil.

With an investment of Rs 66 lakhs, this project resulted in an annual saving of Rs 66 lakhs. The annual electrical and thermal savings are 4.7 lakh units and 985 MT of steam respectively.

Figure 6: Low-Pressure Compressor

Replacement of TFO Chiller (Steam- Based to Electrical- Based)

The existing VAM chiller in TFO has been replaced with a centrifugal electrical chiller due to wear and tear of the existing TFO Chiller.

With the increase in coal cost from Rs 6000-7000/ MT on May-21 to Rs 13000-14000/ MT in FY 23, it became imperative to replace the existing VAM- based chiller with an electrical chiller. Electrical chillers are beneficial from both environmental and carbon emission point as the emissions are significantly less than VAM chillers as the plant VAM chiller was operational on steam generated through coal.

With an investment of Rs 180 lakhs, this project provided an annual saving of Rs 54 lakhs.

Figure 7: Centrifugal Electrical Chiller

Flash Stream Recovery Pump

The recent global increase in coal prices has underscored the significance of thermal energy conservation in industrial units. Raymond Ltd's Vapi plant, which relies on coal for its thermal equipment, has successfully implemented an energy-saving initiative during the fiscal year 2022-2023. This initiative involves the installation of a flash steam recovery pump to optimize steam usage. The project serves two primary purposes:

- Recovery of flash steam.
- Recovery of condensate at higher temperatures.

As a result of this project, the plant now recovers approximately 5 metric tons of flash steam per day. With an investment of Rs 20 lakhs, the annual savings amount to around Rs 50 lakhs, equivalent to conserving 2000 metric tons of steam. This initiative demonstrates the plant's commitment to energy efficiency and cost savings.

Figure 8: Flash Stream Recovery Pump

Other Projects

Raymond has consistently taken a leading role in energy conservation by embracing technological advancements and adopting new energy-saving equipment. As part of this commitment, the organisation has recently replaced a total of 11 pumps in chillers with energy-efficient alternatives. This upgrade has resulted in an annual electrical saving of 4.6 lakh kilowatt-hours (kWh). Furthermore, variable frequency drives (VFDs) have been installed across various types of machinery such as fabric dyeing machines, FM machines, and low-pressure compressors. These VFDs have contributed to savings of nearly 2 lakh units of energy annually.

During the fiscal year 2022-2023, Raymond achieved cumulative savings of Rs. 10 lakhs through two significant initiatives. Firstly, conventional lights were replaced with energy-efficient LEDs, resulting in reduced electricity consumption. Secondly, standard efficiency motors were replaced with more efficient IE3 motors, further enhancing energy savings. These measures exemplify Raymond's dedication to energy conservation and its continuous efforts to embrace sustainable practices and technologies.

RENEWABLE ENERGY

Renewable energy stands as a crucial source of clean and sustainable power. Distinguished by their wide range, ample availability, and global applicability, renewable energy sources offer a significant advantage over fossil fuels: they do not generate greenhouse gases that contribute to climate change, and they are free from polluting emissions. Moreover, as the cost of renewable sources dramatically decreases, fossil fuel prices continue to rise, despite their current volatility.

Recognising the urgency of combatting climate change and mitigating its detrimental consequences, the organisation is fully aware of its responsibility. As a result, it has implemented the following initiatives in the realm of renewable energy:

Solar Rooftop Power Plant

Solar energy presents a versatile and environmentally friendly solution for heating, lighting, electricity generation, and various commercial and industrial applications. Harnessing the power of the sun, solar energy offers self-sufficiency and installing solar panels on rooftops represents a safe and accessible pathway towards a sustainable future.

Considering the potential for solar energy utilization, Raymond's Vapi plant proactively sought opportunities for installing a solar power plant on its roof. After careful analysis, the preferred roof location, maximizing sunlight exposure, were identified. Consequently, a 640 kW solar rooftop power plant was proposed and implemented with the steadfast support of Raymond Limited's top management.

In December 2017, the 640 kW solar rooftop power plant was successfully installed, enabling the plant to directly utilise the power generated through solar energy. This initiative required a significant investment of Rs. 259 lakhs but has proven to be a worthwhile endeavor. On average, the solar power plant generates approximately 8.3 lakh units of electricity annually, contributing to sustainable energy consumption within the plant.

Wind Energy & Hybrid Energy

Wind power presents numerous advantages, contributing to its rapid growth as the world's fastest-growing energy source. Raymond Ltd's Vapi plant has taken proactive steps towards harnessing renewable energy by initiating two significant projects through bilateral agreements in Virvav, Gujarat. These projects are as follows:

- Power through bilateral from a 3.15 MW hybrid power generator. (May-22)
- Power through bilateral from 3 MW wind turbine generator. (May-19)

RENEWABLE ENERGY PORTFOLIO (FY 2022-23)

Through the implementation of the aforementioned projects, the Vapi plant has successfully built a renewable energy portfolio, accounting for 32% of its energy consumption by the end of the fiscal year 2022-2023. As part of their ongoing efforts, the plant aims to further increase this renewable energy portfolio to 52% in the upcoming fiscal year. These initiatives reflect the plant's commitment to sustainable practices and their proactive approach in transitioning towards a greener energy mix.

Table-4 Renewable Energy Portfolio (22-23)

S.NO.	Particulars	Units (million kWh)
1	Solar	0.7
2	Wind	7.5
3	Hybrid	5.1
4	Renewable Total	13.3
5	Total Plant Consumption	41.3
Share of RE in total energy portfolio		**32**

CONCLUSION

In today's world, the utilities such as power, air, and water play a significant role, constituting approximately 25-30% of the plant's budget. Given the rising global temperatures and the depletion of fossil fuel resources, it is imperative for organisations to make a commitment to renewable and sustainable development.

Raymond Ltd's Vapi plant has consistently pursued this objective, continuously striving towards achieving it. Each year, the plant implements new and innovative projects that promote energy conservation and facilitate sustainability. Novel concepts are introduced to drive progress in this regard.

The organisation actively encourages initiatives such as tree sapling plantations and water conservation through rainwater harvesting systems, fostering awareness through dedicated campaigns. These efforts highlight the plant's dedication to environmental stewardship.

Having already reduced carbon emissions by 14% over the past five financial years, the Vapi unit remains committed to making further contributions in energy conservation. The unit aims to continue innovating and implementing measures to mitigate climate change and foster a greener future.

SECTION 3

FROM THE ARCHIVES

3.1 From the Archives: Timeless Gems to Revive Your Reading List!

A. Iron & Steel Sectoral Workshop

A one-day sectoral workshop on "Best Practices in Energy Efficiency & Decarbonisation in Iron & Steel Sector" was jointly organised by FCDO and BEE at Hotel Babylon Capital, Raipur, Chhattisgarh on 19th April 2023 with the support of Godawari Power & Ispat Limited (GPIL). The workshop was attended by 110+ delegates from 30+ industries and technology providers. The workshop deliberated on some innovative measures adopted by Indian Iron & Steel manufacturers and new-age technologies and solutions required to accelerate the decarbonisation of the Iron & Steel sector. During the workshop, technology suppliers from UK and India presented new and innovative technologies to enhance industrial energy efficiency and decarbonisation (IEED) measures including CCUS, transforming waste carbon & residues into new links in a circular value chain, AI and IoT-based platforms in decarbonisation, etc.

Figure 11: Participants of Sectoral Workshop on Best Practices in Energy Efficiency for Iron & Steel Sector

To access the background note, presentation delivered by energy-intensive industries, national and international technology/solutions providers and proceeding report, please visit the following:

Link: Knowledge Sharing Platform | Sectoral Workshop on Best Practices in Energy Efficiency in Iron & Steel Sector: A Path for Decarbonisation (ideeksha.in)

Figure 12: Participants of Study Tour for Iron & Steel sector

B. Iron & Steel Sectoral Study Tour

A domestic study tour of Godawari Power & Ispat Limited (GPIL) was organised under ASPIRE Programme on 20th April 2023. The purpose of the study tour was to demonstrate and disseminate the various best practices and innovative Industrial Energy Efficiency and Decarbonization (IEED) technologies adopted by GPIL to enhance its energy efficiency and efforts to decarbonize its operations. The study tour witnessed participation from 40+ delegates from 15+ industries and technology providers. The study tour was jointly organized by FCDO and BEE with the support of GPIL. To access the proceeding report, please visit the following:

Link: Knowledge Sharing Platform | A Domestic Study Tour-Visit of Iron & Steel Plant (ideeksha.in)

For more information please contact:

Bureau of Energy Efficiency
Ministry of Power, Govt. of India
4th Floor, Sewa Bhawan
R. K. Puram, New Delhi - 110066 (INDIA)
Phone : 011 – 26766700
Fax: +91 11 26178352

ASPIRE Programme Team
In-fmaspire@kpmg.com