UK Government

Accelerating Smart Power & Renewable Energy in India (ASPIRE) Programme

iDEEKSHA NEWSLETTER

Industrial Energy Efficiency/ Decarbonisation Outlook

Case studies on select global technologies and best practices

March 2023

iDeeksha

Industrial Decarbonization and Energy Efficiency Knowledge Sharing Platform

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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 decarbonization sector. To take forward this partnership to support sustainable development and inclusive growth, the UK-India bilateral Technical Assistance Programme, on **"Accelerating Smart Power and Renewable Energy" (ASPIRE)** was launched in October **2021**. ASPIRE is being implemented by the Foreign Commonwealth and Development Office, Government of UK in association with the Ministry of Power and Ministry of New and Renewable Energy, Government of India. The objective of ASPIRE is to catalyse increased investment in industrial energy efficiency and decarbonization (IEED), renewable energy, storage deployment, and electricity distribution in India. 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
(REJUVENATED KNOWLEDGE EXCHANGE PLATFORM)

Under the ASPIRE Programme, a rejuvenated Knowledge Exchange Platform (KEP) – **'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 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 Facilitate access to tools, technologies, and technology providers 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 second 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 lead delivery partner for the ASPIRE programme. Idam Infrastructure Advisory Private Limited (India) and Carbon Trust (UK) are the key consortium members.*

Section 1

CASE STUDIES:
INTERNATIONAL IEED TECHNOLOGIES

1.1 Semi-modular CDRMax™ Technology for carbon capture

Introduction

Carbon Clean patented technology significantly reduces the costs and environmental impacts of CO_2 separation, when compared to existing techniques. Headquartered in London, UK with offices in India, Spain and the US with 49 sites operating across Europe, North America and Asia capturing 1.8 million tonnes of CO_2

carbon clean
TECHNOLOGY TO ACHIEVE 'NET ZERO'

They global leader in cost-effective CO_2 capture technology and services for essential hard-to-abate industries such as cement, steel, oil & gas power plants, energy from waste and biogas

The Innovation

Carbon Clean offers a range of advanced industry leading technologies and provide all the services needed to support net zero, from technology licence and solvent supply, a full process design package (PDP) and proprietary equipment to end-to-end systems — including design, build, financing and operation.

- **CDRMax™: Semi-modular solution for Carbon Capture**

These systems modularise and containerise about 80% of a carbon capture system, giving many of the benefits of modularisation. Installation and on-site activity are dramatically reduced compared to an open-plant construction

Their semi-modular systems are proven, fully scalable solutions, currently being operated around the globe – standard sizes 10, 100, 200, 300 TPD CO_2 capture.

Some of the key benefits of their systems are mentioned below:

- Pre-fabricated semi-modular systems
- Less installation and onsite activities
- Reduced project timelines
- 30% less energy consumption
- No hazardous emissions
- 50% less solvent make-up
- 20x less corrosion

Figure 1: Carbon Clean's CDRMax™ semi-modular technology implemented at Tata Steel, Jamshedpur, India as part of pilot demonstration

Demonstration -TATA Steel Plant, Jamshedpur

Tata Steel aims to be the industry leader in sustainability by reducing its CO_2 emissions intensity and freshwater consumption, developing supply chains and contributing to the circular economy. The company wanted to implement carbon capture in order to achieve its decarbonisation goal.

Carbon Clean collaborated closely with Tata Steel to successfully design and commission a semi-modular, skid-mounted 5 tonnes per day (TPD) CDRMax™ carbon capture unit for its Jamshedpur plant. Their unit is affordable and sits within the available onsite space. They also supplied our proprietary APBS-CDRMax™ solvent.

Carbon clean also helped in contributing to the circular Carbon Economy and creating jobs in the steel Industry.

Results

The modular skid-mounted unit captures CO_2 directly from the blast furnace gas and makes it available for onsite reuse in a variety of applications. The depleted CO_2 gas is then sent back to the gas network with an increased calorific value. The 5 TPD carbon capture plant, along with the semi-commercial use of the captured CO2 within the steel value chain, makes the Tata Steel Jamshedpur plant the first-of-its-kind within the steel industry. "Following the successful demonstration, we plan to rapidly accelerate the number of carbon capture projects, says Aniruddha Sharma, Co-founder and CEO, Carbon Clean.

> **"The operational experience gathered from this 5 TPD CO_2 capture plant will give us the required data and confidence to establish larger carbon capture plants in future."**
>
> **T. V. Narendram**
> CEO & MD, Tata Steel

Opportunity for India

India's power and industrial sectors (primarily steel, cement, oil & gas, refineries, chemicals and coal gasification) contributed around 1,600 million tons per annum (mtpa) of CO_2 emissions i.e., ~60% of the total emissions in 2020. Fuelled by economic growth across sectors as well as rapid urbanisation, emissions from these sectors are expected to increase to nearly 2,300 mtpa by the year 2030. These sectors are amenable for carbon capture and offer significant potential for deployment of carbon capture utilisation and storage (CCUS) technology to aid in decarbonising the hard to electrify and hard to abate industrial sectors, due to use of fossil fuels not only as a source of energy but within the core process itself.

Further, CCUS also has an important role to play in decarbonising the power sector, given India's current reliance on coal for meeting over 70% of its electricity needs. Even if the country successfully meets its target of 500 GW installed power generation capacity from renewable sources by 2030, there would still be a need to meet the base power demand from fossil fuels (most likely coal) or other dispatchable sources.

Thus new-age low carbon technologies such as CCUS would play a critical role in India's energy transition and aid in reducing CO_2 emissions by half by 2050 to achieve the net-zero target by 2070. Hence, it is important to design and develop the framework and policy instruments (including pilot demonstration projects) for CCUS to become a reality in India and contribute to the country's efforts to decarbonise.

1.2 Waste heat-powered treatment of industrial wastewaters – LAT Water

Introduction

Globally up to **80%** of wastewater is directed back into the environment without adequate treatment. Where treatment technology is available it can be costly, inflexible, and incapable of fully treating the water, especially for highly contaminated waste streams. LAT Water's innovative solution to this problem is a bespoke engineered wastewater treatment solution, capable of treating a wider variety of input waters than traditional water treatment technologies, leading to high recovery rates of clean water for reuse.

The Technology

The LAT system has a novel approach to wastewater evaporation by condensing and recirculating water vapour through the system below the boiling point of water whilst ensuring maximum energy recovery enabling a higher percentage of clean water recovery at considerably reduced operating costs.

The **Low-temperature Ambient pressure Technology (LAT™)** process is suitable for all sectors which have highly saline effluents, and complex dissolved contaminants. It is suitable for applications such as municipal waste sites, food and drink, anaerobic digestion, chemicals, pharmaceuticals, power generation, and aquaculture. The process can operate using low-grade waste heat which has been generated from industrial processes or renewable sources. Using waste heat as a primary thermal energy source generates low operating costs, and operating at ambient pressure reduces the need for costly pressurised vessels or high-energy demand vacuum pumps delivering an attractive cost-effective solution.

Figure 2: LAT Water installation at Broadpath landfill treating leachate

The technology allows clients to reduce energy consumption and lower carbon emissions which contribute to decarbonisation goals. LAT™ is a closed system therefore, unlike conventional open-to-atmosphere evaporators, wastewater never contacts the atmosphere therefore volatile organic compounds are not released, this reduces GHG emissions and associated health and safety concerns.

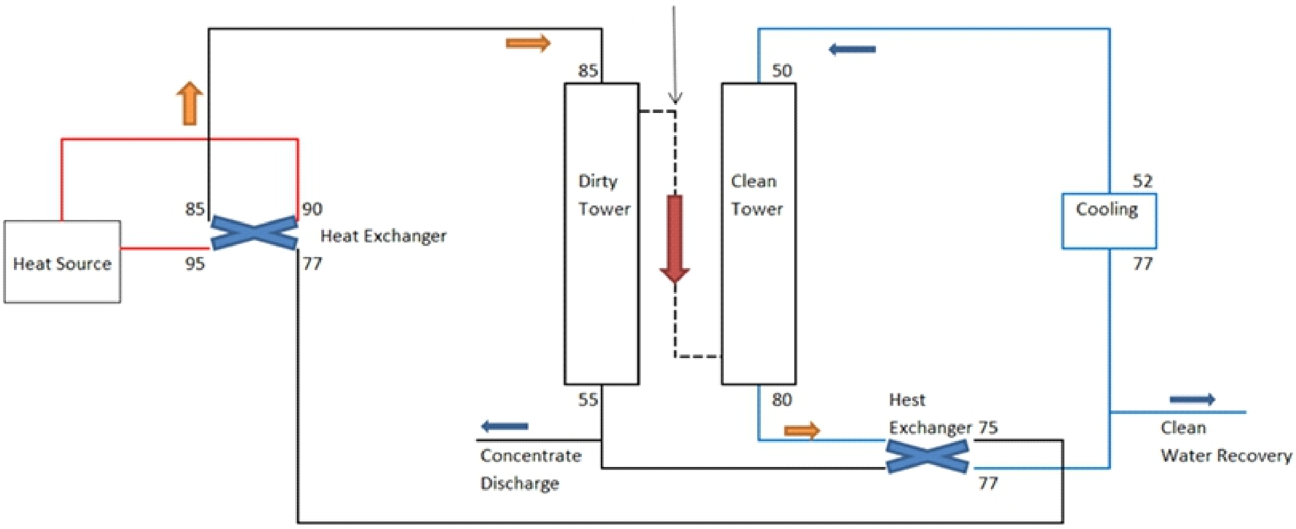

Figure 3: Simplified flow diagram of LAT process

Case Study – Waste Management

LAT Water has operational facilities at a number of landfill sites, in the UK and Shenyang, China. The installation at Shenyang has been operating successfully since **2019**, treating **120-150m3/day** with an uptime of over **95%** and low maintenance. Landfill leachate contains high levels of ammonia, organic matter, dissolved salts, and heavy metals. This mix of complex contaminants leads to high-cost treatment from traditional technologies. Figure 3 shows typical results from the Shenyang site. By using waste heat provided either as low-pressure steam or exhaust gas from CHP gas engines, high operating cost savings were achieved of over **60%**.

Industry Sector Solutions

In **2023** LAT Water is delivering a solution to the pharmaceutical sector. On-site treatment and separation of clean distillate water have helped a British manufacturer of enzymes and reagents for the global medical diagnostics industry to reduce operating costs and avoid discharging contaminated effluent into the sewer. As a heat source, LAT Water was able to use waste heat from an existing boiler, with the outflow water still hot enough to use throughout the site, providing further cost savings.

A very different application is with an inland prawn aquaculture product in eastern England. Here the LAT system is used to eliminate the effluent from the prawn grow-out tanks and recover the clean brine for recirculation back to the growing tanks. Energy is provided by ground source heat pumps and solar photo voltaic panels. In this way, the water and salt are fully recovered and recycled reducing costs and importantly delivering an environmentally sustainable solution for an industry that is notorious for negative environmental impact. Other industry applications include an installation at a coal power plant in Xinji, China. Flue gas from coal burning is passed through a desulphurisation water scrubber with LAT Water treating the sulphate and salt-rich effluent.

LAT Water has developed tailored solutions for varied industry sectors including Metals production, food & drink manufacturing, power generation, anaerobic digestion & agricultural wastewater, pulp & paper, aquaculture, textiles, and chemical production. Examples of tests run at a UK anaerobic digester are shown in Figure 4 showing the clean water recovered and input into the LAT system.

Table 1: Chemical analysis from the Shenyang landfill

Parameters	Raw Leachate	Distillate	Product Concentrate
pH	8.2	9.5	9.3
Total Dissolved Solids (mg/L)	71,800	466	183,000
Ammoniacal nitrogen (mg/L)	2	0	8
COD (mg/L)	165	48	650
Sodium (mg/L)	17,000	77	51,900
Potassium (mg/L)	11,400	40	26,900
Calcium (mg/L)	280	3	832
Magnesium (mg/L)	1,170	2	808
Chloride (mg/L)	33,900	26	88,200
Sulphate (mg/L)	116	68	0

Opportunity for India

Increasing economic activities and declining water quantity and quality are driving the demand for water and wastewater treatment systems in India's industrial sectors. Increasing globalization is affecting the quality of water being used in the process industries and encouraging adherence to wastewater disposal regulations. It is therefore anticipated that India's water and wastewater treatment market will grow by ~**60%** to **GBP 1.7** billion by **2025** from **GBP 1.05** billion in **2020**, registering a compounded annual growth rate of ~**10%**[2]. LAT™ is suitable for water treatment in a wide spectrum of industrial sectors in India and is particularly well-suited for sites where there is waste heat and high-water demand. The water recovery from LAT technology will create a virtuous circle of water and energy demand. Beyond landfills, these include textiles, paper, pharmaceuticals, power, mining, aquaculture, beverages, and chemicals. LAT Water offer multiple-sized solutions capable of treating inputs between **1-5,000 m3/day**, utilizing a wide range of heat sources such as waste heat (hot water, hot exhaust gas), geothermal, solar, or low-pressure steam, and allowing industries to reduce energy consumption and lower carbon emissions.

Figure 4: Test samples from anaerobic digestor digestate: clean water recovered, concentrate, feed input, raw unfiltered feed

[2] *Indian Water and Wastewater Treatment Industry, Frost & Sullivan 2022*

1.3 Simulation aided/digital twin control of drying process in paper production

Introduction

A collaborative project between PITA, CF Pro Sim GmbH, AutomationX GmbH, and Perceptive Engineering Ltd involved a digital twin trial for the Simulation Aided Control of Drying Process, carried out at one of Smurfit Kappa's operational Paper Mills in Kent, UK. The aim of the project was to reduce the energy required for paper drying by identifying energy losses and optimizing the transition between operational set points. The main objective of the demonstration was to reduce the average steam consumption on the paper machine at least by **5%**, this target was exceeded and an energy reduction of more than **7%** was achieved.

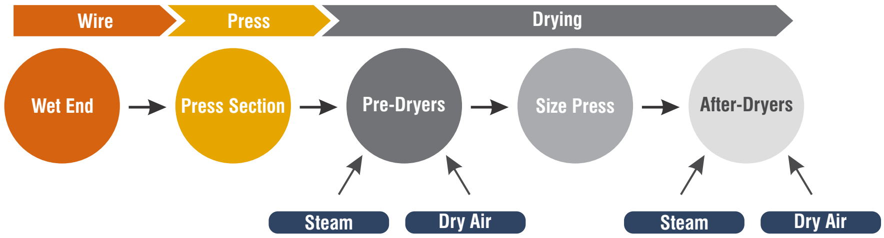

Figure 5: Production process at the Smufit Kappa demonstrator in Kent, UK

A major challenge for a paper machine's control system is the process dwelling time between a change in set point or operating conditions and the time the desired process result is achieved. For example, the duration between a measured response (e.g., final web dryness) translating to a control action (e.g., change of steam pressure in the drying section) takes several minutes. An additional factor that complicates control management is that some important process values cannot be measured due to challenging conditions such as high humidity and temperature, strong vibrations, and splash water.

In a paper machine, the two main reasons for unnecessary energy losses include a lack of data acquisition from the process to properly inform for energy efficiency control and the fact that the control loops generally work independently of each other which extends the time required for process stabilization following a change in operating conditions or set points. Simulation-aided control technology combines process values from field instrumentation with a framework of physical equations and equipment parameters creating a digital twin to model real processes. The control system does not only work with process data but also with well-known and established physical dependencies and machinery parameters. This approach optimizes process control and improves information flow and data transparency, leading to higher efficiencies and improved paper quality.

The Innovation

Simulation-aided control technology identifies energy losses and optimizes the transition from one operating set point to the next.

To create the simulation, the drying process is broken down into elementary physical processes, and models for each component are described using first principles physical formulae and produced. Individual models of each physical component, connected with energy and mass flows in the form of physical equations, are brought together to assemble a digital twin of the real process.

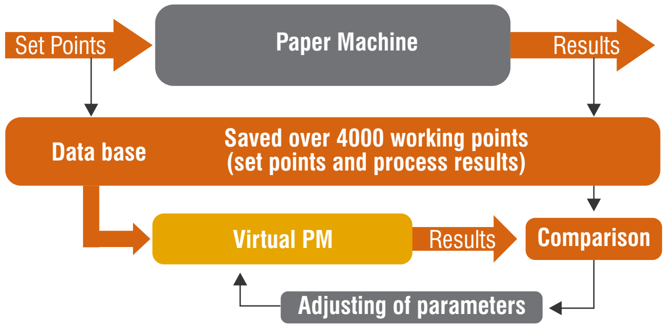

Figure 6: Validation of simulated drying process was performed offline. Identical set points must generate the same results. Deviations should be within the scope of instrumentation accuracy

The digital twin software program is a virtual process, resembling the real paper machine and running in parallel. When a process change is made, the results from the virtual machine are available much more quickly, allowing the simulation-aided controller to optimize the process and provide new set points to the paper machine's control system with improved efficiency. Additionally, a key limitation of conventional modeling and control techniques such as PID and model predictive controls (MPC) is that they rely on a data feed that is commonly collected by field instruments, therefore the efficiency of the control relies on the accuracy of the measurement devices. Moreover, many important process variables are difficult to measure or cannot be measured at all. A simulated controller overcomes these issues by utilizing physical dependencies and equipment functions to substitute for missing process data. Unmeasured drying variables are derived from a virtual process and visualized in combination with real data that is available, this improves the quantity and quality of information available to the control system.

Demonstration

This technology was proven at the Smurfit Kappa Townsend Hook mill in Kent, UK. The campaign was carried out from **February 2020** to **March 2022**. The site has a modern Paper Machine, capable of producing over **235,000 tonnes** per annum **(TPA)** of Lightweight Containerboard. The project was carried out in **7** phases varying from general fact-finding, assembling simulation, testing, and validation, the connection of the digital twin to the DCS control system, the open loop phase, and controller evaluation.

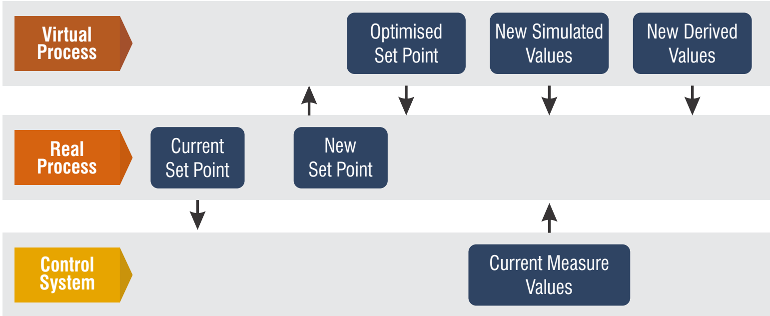

Figure 7: Open and closed loop regime during a production set-point change Deviations corrected before they occur in the real process.

Results

Following calibration of the digital twin to ensure alignment between measured and simulated values to a sufficient level of accuracy, whilst in 'production change' mode, the controller calculates the impact of new set points and makes future predictions to ensure deviations are corrected before they occur in the real process. The optimized set points from the predicted future then simulate the best process route to reach the new set point. This leads to the stabilization of new production conditions in the physically shortest time, reducing wastepaper to a minimum and resulting in a significant decrease in energy consumption.

Through this project, the control system technology has demonstrated reduced steam consumption by up to **2%** in the press section, up to **3%** in the drying section, and up to **3%** in the heat recovery area. Once the new controller was activated, the steam consumption dropped by **7.75%** (from **46.28 t/hr** to **42.69 t/hr**). The main objective of this demonstration project was to reduce the average steam consumption on the paper machine at least by **5%**, this was exceeded and an energy reduction of more than **7%** was achieved. Significant changes in the steam flow can be observed with the steam for air heating. This is also evidence of steam use reduction in the heat recovery area of the **PM9**. The technology can also reduce energy and materials losses during start-ups and grade changes, making further contributions to reducing overall energy consumption and costs.

Opportunity for India

Indian paper industry is the fifth largest in the world. According to **2019-20 data**[3], there are 526 operating units of pulp and paper spread across India, with an annual output of **20.61 million tons**. India's pulp and paper sector has exhibited a CAGR of **5.8%** from **2015-2020** and is projected to reach **30 million tons** per annum of production by **2030**, to meet this production capacity the paper industry will require **43,968,419** tons of coal equivalent. India's pulp and paper industry is highly energy intensive, carbon emissions from coal combustion are responsible for the majority of emissions from the sector.

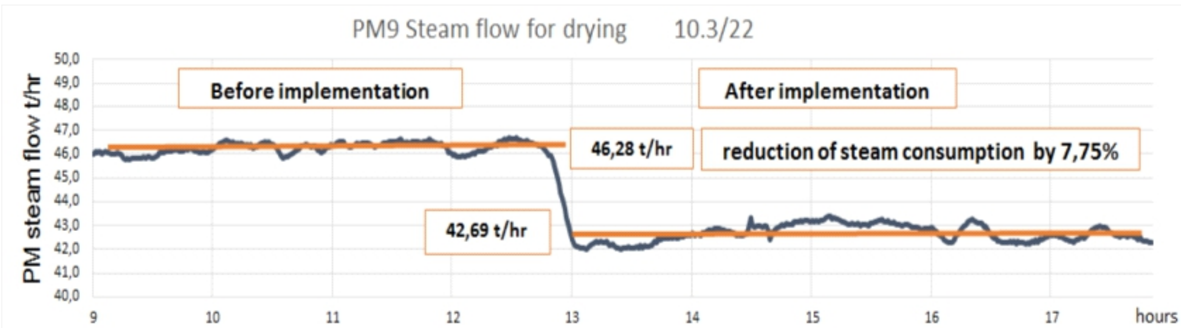

Figure 8: Demonstrator steam flow for drying controller test in March 2022 shows steam consumption fell from 46.28 t/hr to 42.69 t/hr

Many of the agro-based and recycled paper mills still use conventional process technology which is otherwise obsolete by international standards. India has a limited number of mills with the deployment of state of art technologies as compared to other global paper industries like China, Malaysia, etc. 'Simulation Aided Control of Drying Processes' control system is a proven technology that has the capability of realizing significant energy savings for India's paper industry in a short timeframe. The technology can be retrofitted to existing processes, and fitting the tool creates minimal disruption to production. The control system could also be adapted to steam production and distribution networks across a range of other sectors.

Note: This demonstration project was funded through, and the case study has been adapted from, the UK BEIS (Department for Business Energy and Industrial Strategy) Industrial Energy Efficiency Accelerator Programme 2018-2021

[3] *Indian Pulp & Paper Sector An insight for an energy efficient tomorrow – GIZ July 2021 (tuewas-asia.org)*

1.4 Total Dissolved Solids detection and control in industrial steam boilers

Introduction

Spirax Sarco has developed a microwave total dissolved solids (TDS) sensor to overcome the traditional limitations of electrical conductivity-based TDS sensors in steam boilers. The innovative TDS control system (ITCS) improves the control of TDS to avoid poor-quality steam, scaling, and excessive boiler water blowdown. Spirax Sarco's demonstrator resulted in a significant increase in boiler blowdown efficiency, energy savings, and a reduction in the boiler's carbon emissions in comparison to systems that use conventional electrical conductivity TDS sensors.

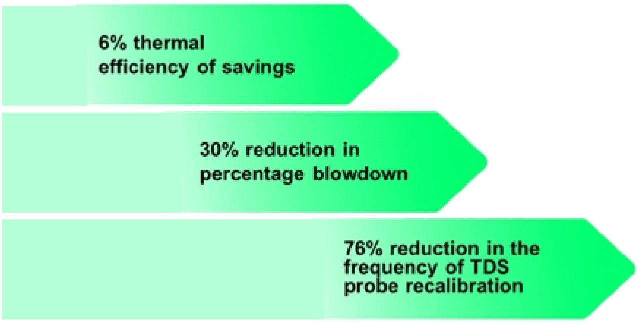

Figure 9: Performance improvement of the demonstrator fitted with the ITCS

When a steam boiler generates steam, impurities dissolved in the feedwater accumulate in the boiler. Over time, the dissolved solids become more concentrated, causing bubbles and foam to enter the steam line. This ultimately results in low-quality, excessively wet steam and can lead to a reduction in boiler efficiency and contamination of components such as valves, heat exchangers, and steam traps.

Conventionally, when the TDS rises above a maximum allowable value the control system automatically activates a side blowdown (discharge) of boiler water. Since a blowdown causes a loss of energy and mass from the boiler water, it is important that the discharge only occurs when it is necessary to avoid excessive TDS levels. Electrical conductivity probes used for detecting TDS levels in steam boilers are prone to scale build-up and measurement drifts and therefore need frequent recalibration; the severity of these problems increases with boiler size, pressure, and steam load. The team is also developing an advanced self-calibration technique that will no longer require operators to manually recalibrate the probe.

The Innovation

Spirax Sarco's microwave TDS sensor overcomes the traditional limitations of electrical conductivity TDS sensors. The new technology relies on electromagnetic interactions between electromagnetic waves which are propagated into the boiler water via the microwave TDS probe. A complex relationship between the intensity and phase of the electromagnetic interaction is proportional to TDS concentrations in the boiler water.

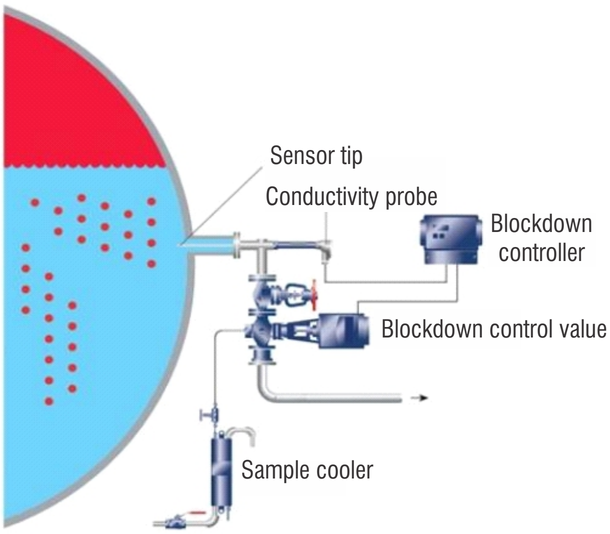

Figure 10: A closed loop TDS control system based on an electrical conductivity probe

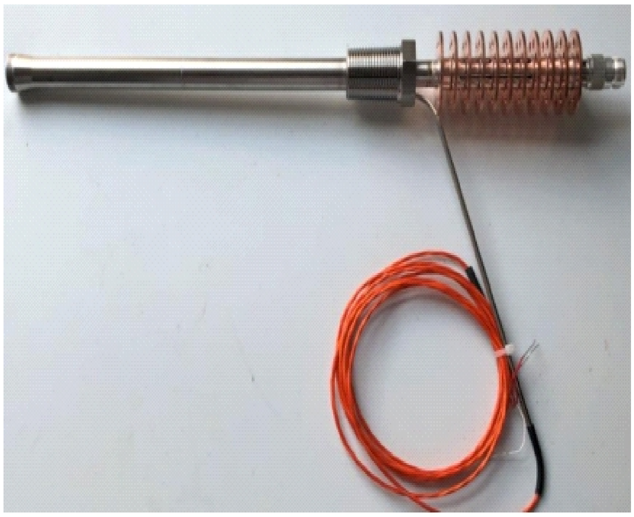

Figure 11: Microwave TDS demonstrator probe was designed to fit the boiler as well as on-head sensor electronics

In-line TDS measurement and control are crucial to efficient and safe industrial steam boilers. A typical automatic TDS control system tends to use electrical conductivity sensors to detect TDS levels in a boiler (Figure 8). The microwave TDS prototype probe can operate in boilers with pressures and temperatures up to **100 Bar and 300°C**. On-head electronics are connected directly at the end of the probe. The device incorporates a temperature probe that compensates for the effects of boiler temperature on the probe measurements. The TDS sensor processes measurements from the TDS probe before feeding them back in real-time to a blowdown controller. The blowdown controller compares the TDS measurement to a setpoint value and then sends a signal to open or close the blowdown control valve accordingly.

Demonstration

An industrial prototype of the ITCS was demonstrated on a **2,500kg/h** natural gas-fuelled steam boiler at Bakkavor Meals Wigan, UK; Bakkavor Meals is part of the Bakkavor Group, a leading provider of freshly prepared food. The trial compared the performance of the microwave TDS sensor with the existing electrical conductivity TDS probes.

The goal was to demonstrate the energy savings and potential greenhouse gas reductions of the blowdown control. This was carried out by comparing the performance of the microwave TDS sensor with the installed electrical conductivity TDS probes. A monitoring system with various sensors within the boiler collected gas flow, steam flow, feedwater flow, and blowdown flow data over **10 months** to benchmark the boiler's energy performance and produce a baseline energy report.

Spirax Sarco designed and developed an industrial prototype of the microwave TDS probe and sensor. Various iterations of the probe were simulated, and an advanced microwave TDS probe calibration and sensor algorithm was developed to overcome challenges associated with calibrating the probe in a boiler. The existing electrical conductivity TDS probe and control system was replaced with the ITCS which automatically controlled the TDS blowdown based on continuous TDS measurement.

Results

During the ITCS trial, the process operators mirrored the conditions of the project's benchmark stage, this allowed Spirax Sarco to evaluate the energy and greenhouse gas emission performances of the boiler. Spirax Sarco collected data over a period of two months, before analyzing and comparing the ITCS demonstration stage data to the baseline data.

The trial showed that blowdown energy was significantly lower during the trial. Lower boiler losses mean that heat is conserved in the boiler therefore less gas is consumed to generate steam – which results in higher boiler efficiency. The efficiency results showed that thermal efficiency was improved during the trial, this was mainly due to a reduction in energy loss during blowdown.

Table 2: Steam boiler trial ITCS energy performance results

	Boiler Thermal Efficiency	Boiler Blowdown Losses	Calibration Frequency
pH	83	0.66	1.58
Electrical Conductivity [m/S/cm]	88	0.39	0.375
Total Dissolved Solids [mg/L]	5	-0.2	-1.21
Suspended Solids [mg/L]	6%	-30%	-76%

Boiler efficiency improvements were achieved by optimizing the controller's blowdown 'dead band' from ten to two percent. The improved accuracy and stability of the microwave TDS probe enabled a tighter control 'dead band'. It is expected that a one percent reduction in blowdown could lead to between **0.2-0.8%** in energy savings. The energy performance of the boiler with the ITCS showed a) **6%** thermal efficiency of savings, b) a 3**0%** reduction in percentage blowdown, and c) a **76%** reduction in the frequency of TDS probe recalibration. In addition, the system demonstrated improved reliability by reducing the frequency of probe recalibration. The Spirax Sarco team is currently working on an advanced self-calibration technique that will allow no longer require operators to manually recalibrate the probe.

Opportunity for India

Industrial steam boilers are commonplace in India and are an essential component in many key industries such as food and beverage manufacturing, thermal power plants, textiles, and paper and pulp mills. The boiler systems market in India is driven by rapid urbanization and growing industrialization, ongoing upgradation, and replacement of conventional boilers. Favorable government initiatives and incentives in the form of subsidies for the usage of steam boilers systems are fuelling market growth; the market size is expected to reach nearly **$22.56 billion** by **2027** with a compound annual growth rate of **4.63[3]%**

The ITCS is applicable for steam boiler and boiler house control systems and is not limited to any industrial sector. The ITCS optimizes control and minimizes blowdown, leading to significant savings, a reduction in carbon footprint, and an improvement in steam quality. The energy savings and corresponding greenhouse gas emissions of a boiler fitted with the ITCS will depend on the existing method of TDS control. Steam boilers with manual or fixed blowdown control will see the highest savings. Boilers that are equipped with modulating control for feedwater, burner, gas, and load can take advantage of the ability to reduce the TDS control band to around **1.5%**. The demonstrator boiler with a baseline use of **8.9MWh** per annum experienced 6 percent energy savings, resulting in an annual greenhouse gas emission saving for the demonstrator of **120 tonnes** of **CO_2e**, and a six-month payback period for the control system and probe. These savings are solely due to reduced fuel and maintenance costs, they do not consider additional potential savings from reduced chemical and water use.

Note: This demonstration project was funded through, and the case study has been adapted from, the UK BEIS (Department for Business Energy and Industrial Strategy) Industrial Energy Efficiency Accelerator Programme 2018-2021

Section 2

CASE STUDIES
INTERNATIONAL BEST PRACTICES IN IEED

2.1 Industrial Heat Recovery

Introduction

Industrial heat recovery is the collection and re-use of heat arising from an industrial process that would otherwise be lost. Waste heat can be reused in diverse ways, including the same industrial facility for heat or cooling, another end-user such as a heat network, or by converting the waste heat to power. Industrial heat recovery has the potential to realize significant savings on energy bills and carbon for industry, through a reduction in primary fuel use. It can help achieve a low-cost, clean, and secure energy system, and can also provide competitiveness and productivity gains. Globally, over 33% of energy consumption comes from the industrial sector, with up to half ultimately wasted as heat. In Europe, the potential for heat recovery in many industries is around or over 10%, The potential in India, where industrial energy efficiency is still developing, is even greater. Developing a bespoke waste heat recovery framework can help manufacturers identify the sources and sinks of energy, along with identifying the right recovery technologies to fit their industry and set up and make decisions based on the economic benefits.

Process Heating and heat sources

The delivery of heat to industrial processes has two key aspects: the release of heat from fuel and the transfer of heat to the process. In combination, these arrangements are known as 'heat sources'. Low-temperature heat recovery media include steam, hot air, and hot water. Steam is the most widespread process heat delivery medium. Higher-temperature heat can take different forms depending on the industrial process, for example, the thermal oil is usually used where temperatures higher than those which can be readily achieved with water are required. High-temperature gases are also a common heat source as loss of heat through hot waste gases is inevitable in all high-temperature processes. The energy efficiency of the process can be improved by recovering heat from the waste gas stream or the waste heat can be used elsewhere to reduce primary energy use.

Potential applications for heat recovery – Low-temperature process

Air compressors

Most of the electricity supplied to an air compressor (which can be up to **90%**) is converted to heat. It is possible to recover anywhere from **50%** to **90%** of this thermal energy and use it to heat other air or water. Air-cooled and water-cooled packaged rotary screw compressors are typically enclosed in cabinets and include heat exchangers and fans, but the waste heat discharged can be recovered.

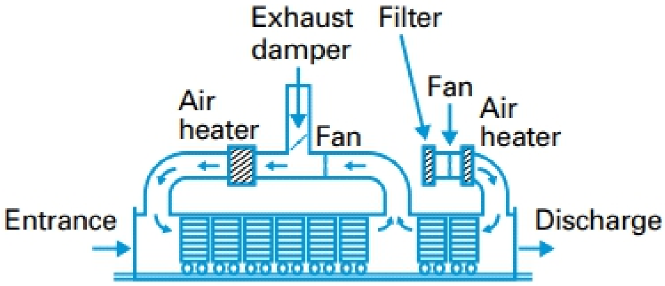

Figure 12: Tunnel dryer with recirculation to direct exhaust gases back to the inlet of the process

Drying

Dryers are widely used in several industrial sectors. Rotary dryers are the principal energy consumers, with spray and band dryers also being significant consumers. Heat is normally discharged as warm humid air.

Washing

In the fabric care industries typically in laundering, large amounts of heat are used for washing. The warm effluents that are normally drained can be a source of heat for pre-heating incoming cold water.

Dyeing and finishing

Dyeing and finishing processes in the textile and fabric care sector provide good opportunities for waste heat recovery (see figure 1). Warm effluents can be a source for pre-heating incoming cold water and heat exchangers can be used on effluent-containing fibers

Potential applications for heat recovery – High-temperature process

Furnaces

In any industrial furnace, the combustion products leave the furnace at a temperature higher than the stock temperature. Loss of heat through hot waste gases is inevitable and the energy efficiency of the process can be improved by recovering heat from the waste gas stream or the waste heat can be used elsewhere to reduce primary energy use.

Convection type: In these recuperators, the heat transfer between the primary and secondary fluids is done by convection. The hot air out is ducted to the furnace burner combustion air inlet. These are especially suitable when the working temperature is lower than **1000°C** or the gas streams are fairly clean (with no particles) and without especially corrosive components.

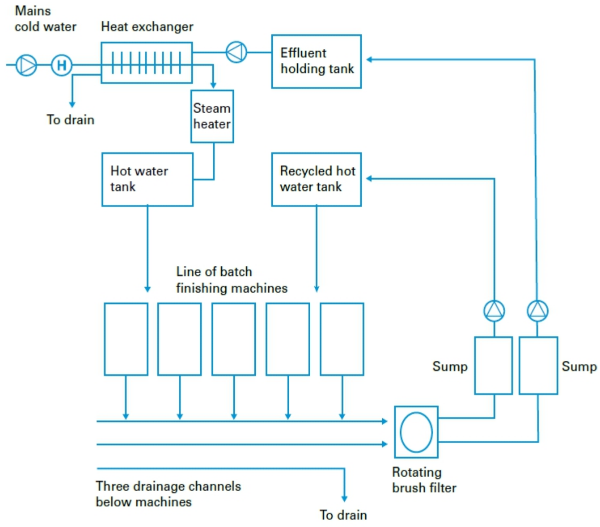

Figure 13: A sketch of a typical finishing plant with heat recovery from the effluent discharge

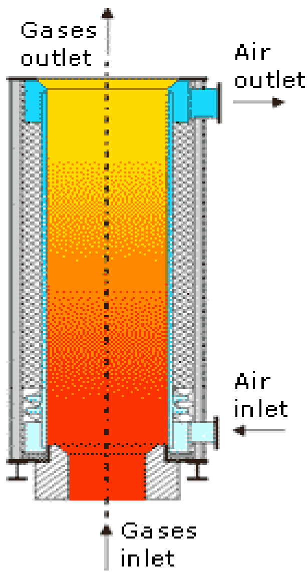

Figure 14: Radiation Recuperator

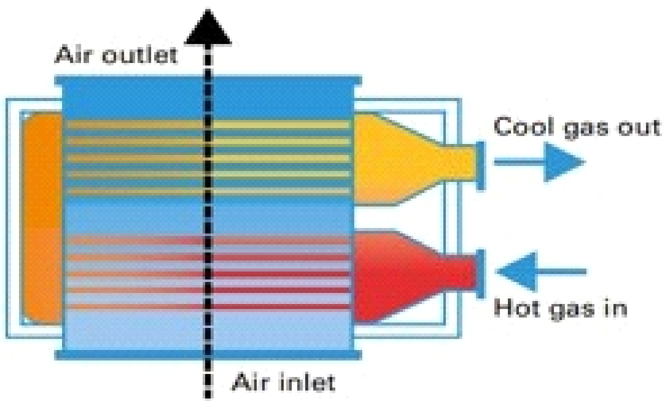

Figure 15: Convection recuperators

Charge pre-heating

When raw materials are pre-heated by exhaust gases before being placed in a heating furnace, the amount of fuel necessary to heat them in the furnace is reduced. As raw materials are usually at room temperature, they can be heated sufficiently using high-temperature flue gases, which noticeably reduces the fuel consumption rate.

With furnace pre-heating, gases from the furnace or kiln are directed to the incoming stock using ducting, or by extending the furnace. In certain industries, for example, aluminium copper foundries, stock pre-heating has the additional advantage of removing the hazard of the explosion caused by entrapped water vapor. Estimates of the fuel savings possible with this technique vary from **10%-30%**.

Steam generation

Waste heat boilers have been used for steam generation for many years in the UK chemical, copper, iron, and steel industries. Steam generation using waste heat is only economically viable if there is a continuous supply of heat and a definite requirement for process steam and paybacks on investments of around three years can be achieved.

CASE STUDIES

2.2 Waste heat recovery from kiln and cooler stacks at Hanson Cement plant, UK

About the plant

Hanson Cement is a UK-based cement production company, owned by Heidelberg Cement. The Padeswood Kiln (owned and operated by Hanson) was commissioned in **2005** and was uniquely designed to burn alternative fuels for the clinker production process making it one of the most modern Kilns in the UK. The Kiln can produce **2,650 tonnes per day** of cement clinker and consumes an average of **10 MWh per hour** of electricity. Due to the modern design, the plant currently recovers surplus heat to dry the coal used to fire the kiln and preheat the raw meal mix.

Waste heat recovery feasibility study

Through UK government funding program support, a feasibility study for waste heat recovery was undertaken. The study findings verified that a larger amount of heat could be recovered for onsite electricity generation. With the potential to reduce the site's electrical load from the grid by **45 %** and associated CO_2e savings of **11,341 Tonnes per year**, Hanson Cement intends to progress to the next stage of preliminary engineering with continued support under the UK government program.

Impacts and benefits realized

At the outset of the project, it was expected that the existing equipment would be replaced with a more modern thermal oxidizer, which would be coupled with a heat recovery solution, evaluated through this feasibility project. As work proceeded, it has become apparent that an alternate technology, namely solvent recovery equipment driven by a small-scale Combined Heat and Power (CHP) plant, has the potential to further reduce the environmental footprint and provide an improved commercial proposition compared to all of the thermal oxidizer/heat recovery options. Such potential could not be ignored and so, alongside regenerative thermal oxidation and heat capture, Hanson evaluated the technology in parallel and it has become the anticipated preferred option after the feasibility study.

Figure 16: Padeswood Kiln and Cement Plant

Note: This best practices overview has been adapted from, and the case study has been funded through, the UK Department for Business, Energy, and Industrial Strategy's (BEIS) Industrial Heat Recovery Support (IHRS) pro.

Section 3

CASE STUDY:
NATIONAL BEST PRACTICES IN IEED

3.1 Energy Analytic Platform using Power BI & AI deployed by Aditya Aluminium

Introduction

Aditya Aluminium Smelter is a flagship unit of Hindalco Industries Ltd., located at Lapanga, Sambalpur, Odisha, with a capacity of **380,000 TPA** and a **900 MW** captive power plant (CPP). The Smelter plant is put up with AP-36S technology (RTA) from Aluminum Pechiney, France involving numerous processes, quality parameters, and safety aspects at different levels. The process is quite intricate in nature as it handles very high currents gram to the tune of **368 kA** and new generation controls. Aditya Aluminium outstands amongst all twenty-two, AP-36 smelters across the Globe in terms of metal quality producing the best grades of Aluminium i.e., P0404, P0405 & P0406. Aditya Aluminium's product is recognized as 'Good Western Metal' among global customers.

The Innovation

Electrical energy is a key input to produce aluminium and the process requires extensive and flawless monitoring to minimize consumption, reduce wastage and achieve operational efficiencies both in smelter as well as CPP. Both processes require monitoring and analysis of consumption data at the substation, feeders, and equipment level with demand and consumption analysis. One of the bottlenecks that Aditya Aluminium faced is that, as the quantity of data grew larger the monitoring of energy consumption and other process parameters became cumbersome. This called for a process innovation not only to handle large sets of data but also to model and generate useful insights in a show time for time decision-making.

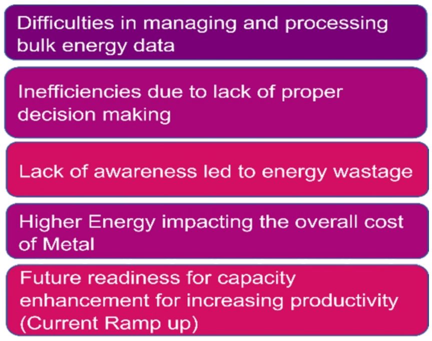

Figure 17: Challenges Faced

To achieve this goal cost-effectively, Microsoft Power BI with AI platform was employed. Smart meters capable of transferring data on a real-time basis were installed across substations at the Power Control Centre (PCC) and Motor Control Centre (MCC) levels and integrated with the energy server. This data so derived was loaded into Microsoft Power BI to get deeper insights into AI analytics for sustainable decision-making. A similar approach also was initiated for monitoring data related to PHR, GCV, and Boiler efficiency with drill-down analysis for proactive decision-making. This process innovation has resulted in the transformation of the reactive decision to predictive and preventive strategies in managing energy consumption of critical equipment of Smelters.

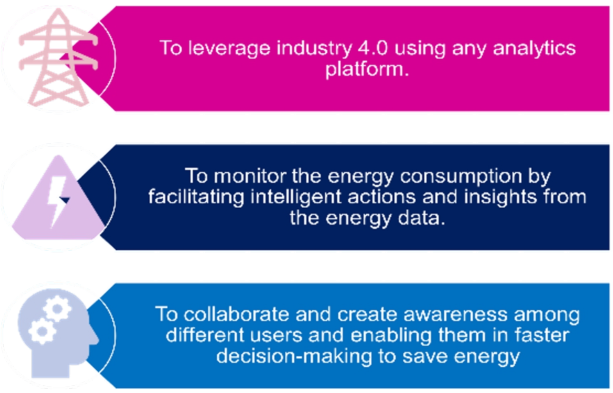

Figure 18: Approach

To achieve the above-mentioned objectives and to mitigate the problem of handling huge data, a dedicated team was constituted, and a four-pronged approach was taken to address the problem:

- Smart energy meters with **0.2s** class accuracy were installed across different substations
- Meters were connected through a fibre-optic network
- Meters were connected to the server for data pulling with an Energy Management System (EMS) software from Schneider Electric
- Microsoft Power BI with AI was used for deep data analytics

The uniqueness of the project was Microsoft Power BI with AI tool. The complete configuration was conceived and developed in-house in three stages.

1. Data Acquisition and cleansing.
2. Data Modelling.
3. Data visualization and analysis using Data Analysis Expressions (DAX).

Demonstration

The foremost step was to create a blueprint of the action to be taken. A digital stack consisting of digital threads or subunits was arranged in an orderly manner that would replicate the sequences of steps to be taken (Figure 17). The outcome of the stack was to concisely develop indicators for monitoring and decision-making. The outcome of such an exercise led to the generation of pre-processed data in a systematic manner which was then ready for further action. The acquisition of energy and process data so derived was loaded in Power BI for data modelling.

The use of Data Analysis Expressions (DAX) helps in creating new parameters within the dataset for ease of visualization. Ultimately with Power BI's dynamic charts and other visualization tools, data can be observed cleanly with drill-down options, allowing the user to gain deeper insights. The software also has a powerful AI tool that works like Google, providing easy answers to specific questions about the data (E.g. Total consumption in a particular section, date, etc).

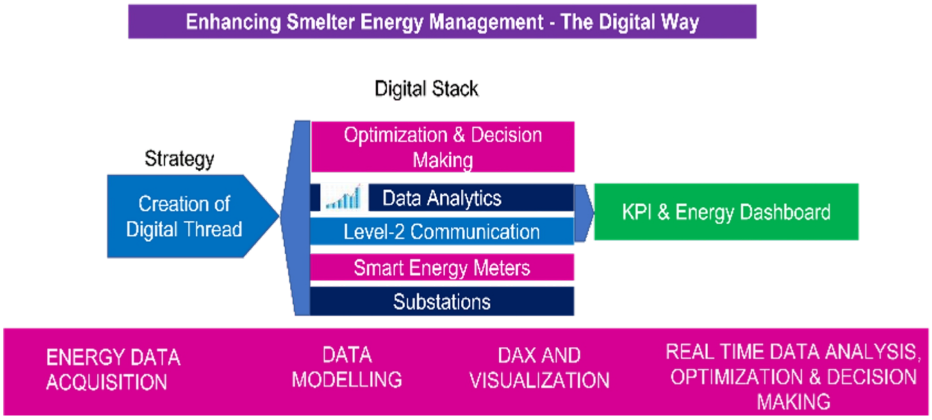

Figure 19: Solution

Results

After the implementation of Power BI in data analytics, the inefficiencies mentioned above were successfully mitigated. There was a reduction in auxiliary energy consumption in the smelter to the tune of **11.07 kWh/T** in the Gas Treatment Centre IDa Fan (depicted in Figure 18). Apart from this, there is a reduction in energy consumption in the areas of the compressed air system.

- BI helped in predicting the excess energy usage among the running ID fans with different combinations **(3 W + 1 S)**
- Insights helped in saving Auxiliary energy consumption in GTC – **10 kWh/t***

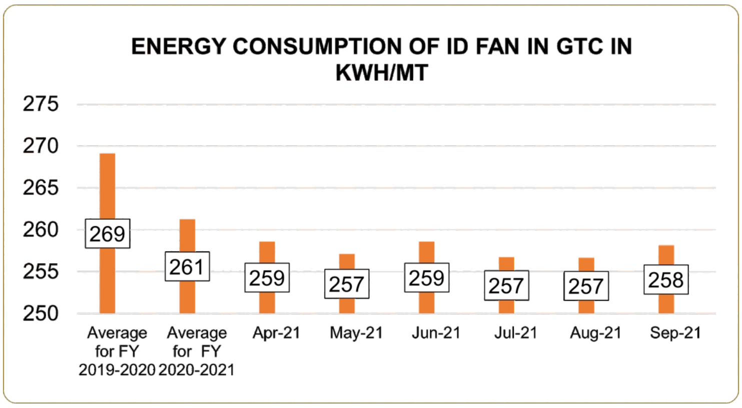

Figure 20: Energy Savings

Opportunity for scale up

The Indian Aluminium industry **is the second largest producer** in the world with a share of **~5.3%** of the global output. Indian aluminium industry is thriving at an enviable growth rate of **7%** per annum, which is one of the highest in the world. The aluminium sector is one of the designated sectors covered under the Bureau of Energy Efficiency's (BEE) Perform, Achieve, Trade (PAT) scheme. The fourteen industries from the aluminium sector, covered under the PAT scheme, cumulatively consume **10.85 MTOE** and emit **37.13 MTCO$_2$e** annually. These industries offer an energy-saving potential of **1.06 MTOE decarbonization** station potential of **3.63 MTCO$_2$e**.

Aditya aluminium demonstrated utilization of an energy analytics platform based on power BI and AI in identifying inefficiencies in their energy usage and taking corrective action to reduce consumption and associated costs. The use of Power BI enabled them to gather and analyse data from various sources, including energy usage data from meters, sensors, and other devices. This also allowed them to monitor energy consumption in real time and identify patterns and trends that would have been difficult to detect otherwise.

Other Aluminum industries in India may also consider the implementation of an energy analytics platform for real-time monitoring to minimize consumption, reduce wastage and achieve operational efficiencies. Implementation of such innovative measures not only helps the organization in improving its bottom line, but also helped to reduce its carbon footprint and contribute to a more sustainable future.

Section 4

HIGHLIGHTS OF RECENT IDEEKSHA EVENTS UNDER ASPIRE PROGRAMME

4.1 Launch of IDEEKSHA platform by Shri R.K. Singh, Hon'ble Cabinet Minister (Power, New & Renewable Energy)

Figure 21: Launch of IDEEKSHA platform by Hon'ble Cabinet Minister of Power and New & Renewable Energy in the august presence of Secretary, Ministry of Power, Director General, BEE, Additional Secretary, Ministry of Power, and CEO, EESL

The IDEEKSHA platform was launched by the Hon'ble Cabinet Minister for Power, New and Renewable Energy Shri R.K. Singh during the 21st Foundation Day Event of BEE on **1st March 2023 in Delhi**.

IDEEKSHA platform (http://www.ideeksha.in/) has been developed in collaboration with BEE under the ASPIRE Technical Assistance Programme. ASPIRE is a bilateral programme implemented by the Foreign Commonwealth and Development Office, Government of UK in association with the Ministry of Power and Ministry of New and Renewable Energy, Government of India.

4.2 Release of IDEEKSHA Newsletter (First Edition)

ASPIRE team developed the first IDEEKSHA Newsletter covering case studies of new and innovative IEED technologies implemented in the UK as well as best practices implemented by UK and Indian stakeholders which can help accelerate the decarbonization in hard to abate sectors such as Pulp and Paper, Textile, Aluminium, Cement, Textile. The first Newsletter was released by the Hon'ble Cabinet Minister for Power, New and Renewable Energy Shri R.K. Singh during the 21st Foundation Day Event of BEE on **1st March 2023 in Delhi**.

Key Contents of Newsletter:

- Message from Director General, BEE
- Message from FCDO
- Global IEED Technologies:
  - Textile Sector: UK's Waterless Smart Dyeing Technology
  - Cement Sector: Low carbon multi-component cement for UK concrete applications
  - Cross-sectoral: Industry 4.0 Wireless Energy Solutions for Net Zero and Energy Productivity from the UK
  - Pulp & Paper: Novel Dewatering Solutions within Corrugated Case Medium Manufacture
- International Best Practices in IEED:
  - UK Aluminium Sector: Industry Best Practices
- Expert views on emerging low-carbon IEED technologies
  - Importance of Inert Anode technology for the Aluminium Sector
- Initiatives by industries to promote GESI (Gender Equality and Social Inclusion)

Link to access the Newsletter: Click Here

4.3 Aluminium Sectoral Workshop

A one-day sectoral workshop on "Best Practices in Energy Efficiency & Decarbonisation in Aluminium Sector" was jointly organized by FCDO and BEE at Aditya Aluminium, Odisha on **21st November 2022**. The workshop covered various aspects of the aluminium sector such as the impact of the PAT scheme, aluminium smelting, alumina refinery, captive power generation, circular economy, and new emerging technologies (e.g., inert anode). The workshop was attended by **100+** delegates from **21+** industries and technology providers. During the workshop, the stakeholders deliberated on best practices, technologies, and policy interventions required to accelerate the decarbonization of the aluminium sector, which is not only energy-intensive but energy sensitive as well.

To access the background note, presentation delivered by energy-intensive industries, national and international technology/solutions providers, and event summary report, please click on the following link:

Link to access workshop details: Click Here

"Best Practices in Energy Efficiency in Aluminium Sector"
under ASPIRE programme
ADITYA ALUMINIUM
21-22nd November, 2022

ADITYA BIRLA
HINDALCO

Figure 22: Sectoral Workshop on Best Practices in Energy Efficiency in Aluminium Sector

4.4 Aluminium Sectoral Study Tour

The workshop was followed by a domestic study tour of Aditya Aluminium, Lapanga unit in Odisha was organised on **22nd November 2022** under ASPIRE programme. The study tour witnessed participation from **50+** delegates from **11+** industries and technology providers. The purpose of the study tour was to demonstrate and disseminate the various best practices, new and innovative industrial energy efficiency and decarbonisation (IEED) technologies adopted by the above-mentioned aluminium unit. The study tour was jointly organised by FCDO and BEE with the support of Aditya Aluminium and Hindalco Industries Ltd. (part of Aditya Birla Group).

Figure 23: Sectoral Workshop on Best Practices in Energy Efficiency in Textile Sector

4.5 Textile Sectoral Workshop

A one-day sectoral workshop was jointly organized by FCDO and the BEE with the support of Raymond Ltd. Chhindwara, Madhya Pradesh on **8th December 2022**. The workshop covered various aspects of the PAT scheme and new emerging technologies (e.g., waterless dyeing) in Energy Efficiency and Decarbonization. The workshop was attended by **70+** delegates from **32** industries and technology providers. During the workshop, the stakeholders deliberated on best practices, technologies, and policy interventions required to accelerate the decarbonization of the textile sector which is both resource and energy intensive.

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

Link to access workshop details: Click Here

4.6 Textile Sectoral Study Tour

A domestic study tour of Raymond Ltd.'s unit in Chhindwara, Madhya Pradesh was organised on 9th December 2022 under ASPIRE programme. The study tour was jointly organised by FCDO and BEE with the support of Raymond Limited. The study tour witnessed participation from **50+** delegates from **20** industries and technology providers. The purpose of the study tour was to demonstrate and disseminate the various best practices and innovative IEED technologies adopted by the above-mentioned Raymond Unit to enhance it energy efficiency and efforts to decarbonise its operations.

4.7 Cement Sectoral Workshop

A one-day sectoral workshop was organised in Udaipur, Rajasthan (India) on **14th March 2023** under ASPIRE programme. The workshop was jointly organised by FCDO and BEE. The theme of the workshop was - "Best Practices in Energy Efficiency & Decarbonisation in Cement Sector".

The workshop was attended by **72** delegates from **30+** industries and technology providers. During the workshop, the stakeholders deliberated on best practices, technologies, and policy interventions required to accelerate decarbonisation of the cement sector. In the workshop, some key organisations from the UK Cement sector

presented various leading best practices and technologies adopted in the UK.

To access the background note, presentation delivered by energy-intensive industries, national and international technology/ solutions providers, and event summary report, please click on the following link:

Link to access workshop details: Click Here

4.8 Cement Sectoral Study Tour

A domestic study tour of Udaipur Cement Works Ltd's unit in Udaipur, Rajasthan was organized on 15th March 2023 under Accelerating Smart Power and Renewable Energy in India (ASPIRE) programme . 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 the above mentioned UCWL Unit to enhance its energy efficiency and efforts to decarbonize its operations. The study tour witnessed participation from **50+** delegates from **18+** industries and technology providers. The study tour was jointly organized by FCDO and BEE with the support of UCWL.

For more information please contact:

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