Message

Warm greeting to industry friends and colleagues!

The past few years have been quite significant as part of our journey under Perform Achieve and Trade (PAT) scheme, with the first cycle far exceeding the expectations and next three cycles currently running concurrently with challenging targets. With initiatives like PAT, India has not only been able to reaffirm its global leadership in mitigating the impacts tackling climate change, but also demonstrated that we are willing to challenge our own success and test new limits. For realising this vision, we are currently leading a consultative effort to revisit the strategies and initiatives under the new mission ROSHANEE (Road Map of Sustainable and Holistic Approach to National Energy Efficiency).

I wish to encourage the industry leaders to join hands with BEE in realising this roadmap, wherein we recognise the importance of efforts being made at the individual industry level and are committed to support and add momentum to these efforts through forum like Knowledge Exchange Platform (KEP) initiative.

As Industry braces itself to achieve the targets under the rolling cycles of PAT there will be a need to bring in knowledge and enhance access to new and innovative technologies and services that can take them on a continuous energy saving trajectory. To realise this potential, we have initiated the process of developing technology roadmap for different sectors and mapping of best available international technologies under KEP. To compliment this process we have also created a Database for Knowledge Sharing on Technological Advancements– DaKShaTA, which is a mobile based application to help guide industry to latest technological advancements, their cost benefit analysis, CO2 mitigation potential and access to technology suppliers.

This issue of newsletter covers case studies, which have been selected from Aluminium and Cement sectors. I will encourage the industry associations and opinion leaders to provide their inputs and suggestions in making KEP more interactive and vibrant.

Abhay Bakre
The importance of the textile sector for the South Asia region cannot be overstated as it provides direct employment to more than 55 million people and indirect employment to nearly 90 million people. The importance of the sector to the region is also reflected from the share of the sector in global exports. South Asia's share in global trade is around 4.4 percent, while generating an export volume of over US$37 billion. At the national level, it constitutes around 80 per cent of total exports of Bangladesh providing direct employment to 3 million people; 45 per cent in Sri Lanka employing more than 1.8 million; 55 per cent in Pakistan employing more than 15 million and around 12 per cent in India employing more than 38 million. But all these positive aspects of the sector is overshadowed by the range of environmental and social impacts associated with its operations, impairing sustainability of very inputs on which this sector thrives. The main issues linked to textile sector are typically those associated with discharge of untreated effluents leading to water pollution, high energy and chemical use, GHG emissions and associated issues of workplace safety. Resource efficiency along the supply chain of textile sector is an effective approach to tackle these issues. The following case study provides details of various resource efficiency measures undertaken by different actors along the supply chain of textile, the impacts achieved and replication potential. The case study in based on a joint initiative of IIP and IKEA undertaken in India.

Indian Textile Sector: An Overview

India is the world's third largest producer of cotton, after China and the USA and the second largest cotton consumer after China.

Environmental Issues associated with Textile industry

Water: The textile industry uses high volumes of water throughout its operations, from cultivation to bleaching, dyeing and washing of finished products. On an average, approximately 200 litres of water are required to produce 1 kg of textiles.

Energy: High energy consumption (oil, gas & coal) and consequent GHG emissions in different stages of textile production particularly wet processing, with significant energy saving possibility.

Chemicals: The cotton production process involves extensive use of fertilizers in farm lands that causes soil depletion as well as contamination of surface and ground water resources. Similarly the wet process of textile manufacture specifically the dyeing, printing and finishing involves extensive use of chemicals, which are mostly hazardous.

Air Pollution: Apart from GHG emissions due to fossil fuel burning, various processes like dyeing, printing, fabric preparation etc. also results in emissions of hydrocarbons, formaldehyde and other volatile compounds, which are hazardous to health and environment.

Solid Waste: Solid waste includes scraps of fabric and yarn, off-specification yarn and fabric and packaging waste. There are also wastes associated with the storage and production of yarns and textiles, such as chemical storage drums, cardboard reels for storing fabric and cones used to hold yarns for dyeing and knitting.

Facts about Cotton

- 2.5% of the world's cultivated land is used to grow cotton
- Cotton accounts for up to 10% of global pesticide use
- Cotton is grown in around 80 countries around the world
- The largest producers are China, India, USA, Pakistan, Brazil and Uzbekistan
- More than 300 million people work in the cotton industry
- On average, 10,000 litres of water is used to grow one kilogram of cotton, but it can require three times as much if farming practices are poor
- Nearly half of all textile production is based on cotton

It contributes about 14 percent of industrial production, 4 per cent to GDP, 20 per cent to the foreign exchange earnings and provides direct employment to more than 38 million, making this sector the second largest provider of jobs after agriculture. The sector also creates a large volume of indirect employment, both in traditional industries (like production of cotton and other natural fibers) as well as in modern industries (like textile design and fashions).

The Textile and Apparel Supply Chain comprises raw material producers essentially covering farmers, ginning facilities, spinning processes, processing sector, weaving and knitting factories and garment manufacturing facilities. This supply chain is perhaps one of the most diverse in terms of the raw materials used, technologies deployed and end products. Cotton remains the most significant raw material for the Indian textile industry with a production of 5 billion kg making up for...
22 percent of world share next only to 30 percent of China. Cotton grows mostly in western and central India and cotton cultivation provides direct livelihood to 6 million farmers.

However, Indian cotton production relies on extensive use of hazardous pesticides and chemical fertilizers. Data reveals that Cotton cultivation in India consumes 44.5% of the total pesticides used in the country. In addition, cotton is a water intensive crop and around 6% of the water for irrigation in India is used for cotton cultivation (Figures from www.indiastat.com).

It is estimated that there are about 65,000 garment units in the organized sector, of which about 88 per cent are for woven cloth while the remaining are for knits. The weaving and knits sector lies at the heart of the industry. Weaving, using powerlooms, was traditionally done by composite mills that combined it with spinning and processing operations. Over the years, government incentives and demand for low cost, high volume, standard products moved the production towards power loom factories.

Supply Chain Intervention

Indian textile industry has suffered from inefficiency and low productivity at both ends of the supply chain – low farm yields affecting cotton production and inefficiency in garment sector leading to high environmental and social externalities. The case study focuses on how resource efficiency has been brought through low cost intervention along the entire supply chain of IKEA.

The supply chain intervention, as shown in figure 1, covers both resource efficiency issues at the level of farmers producing cotton as well as the production facilities or textile mills. At the farm level, the emphasis was on reducing water and pesticide use, while the focus at the manufacturing facilities was to enhance efficiency of the production process. For ease of understanding, the interventions have been presented in two sections – one at the level of cotton producers i.e. farmers and the other covering aspects of fabric production.

Enhancing resource efficiency for cotton growers

The IKEA initiative in India targeted the Aurangabad region of Maharashtra, where major factors responsible for low cotton yield have been inadequacy of water and pest attack. Farmers typically resort to over exploitation of available water resources and indiscriminate use of pesticides and fertilizers that have resulted in severe degradation of surface and ground water reservoirs, soil erosion and bio-diversity loss.

Approach adopted

The project adopted participatory approach to address these issues. Awareness campaigns and interactions were organized to motivate farmers to adopt sustainable approaches to cultivation that could (i) reduce the use of pesticides, fertilizers and water, (ii) enhance productivity and (iii) reduce the environmental & social impacts.

The skills and capacities on better crop management practices was developed at the local level through Farmer Training and Farmer Field Schools (FFS), where the farmers were provided practical hands on training on sustainable irrigation, cultivation and pest control practices. The farmers producing cotton by adopting such approaches were further supported to get their cotton certified as ‘Better Cotton Initiative’ product that provided them access to better market.

The result of the pilot project was very encouraging and inspired other farmers to join the initiative. More than 6000 farmers joined this project in Aurangabad, Maharashtra. This happened as a result of:

• Campaigns to create awareness among farmers about the Better Cotton Initiative (BCI) and its benefits.
• Organisation of farmers into ‘Learning Groups’ to provide practical hands on training.
• Initiation of Farmers Field Schools to enhance the skills of the farmers on sustainable crop management practices
• Guidance of expert agronomists at every stage
• Continuous monitoring and timely feedback to farmers by the experts
• Training to farmers on usage and handling of plant protection chemicals
• Facilitation to link the farmers to banking channels
• Street plays and awareness campaigns on child labour, health and safety, and employment conditions etc. was done to promote awareness about social issues

Impact of BCI

An impact assessment carried out by WWF for the project shows that:

Details of BCI

BCI exists to make global cotton production better for the people who produce it, better for the environment it grows in and better for the sector's future. It works with adverse range of stakeholders to promote measurable and continuing improvements for the environment, farming communities and the economies of cotton-producing areas. BCI aims to transform cotton production world wide by developing Better Cotton as a sustainable mainstream commodity.

• Street plays and awareness campaigns on child labour, health and safety, and employment conditions etc. was done to promote awareness about social issues
- Farmers now use 38% less pesticides reducing environment damage and harmful effect on the health of the farmers handling it.
- Efficient irrigation practices have helped the farmers use 24% less water reducing the strain on the already scare surface and ground water resources.
- Farmers now use 29% less fertilizers helping preserve soil health and preventing chemical pollution.
- Farmers benefited from reduced cost of farm inputs and increased crop yields.
- Certification of cotton through BCI helped farmers get better price for their produce.

The success of Aurangabad provides an effective model for scale up sustainable production of cotton in India as well as other countries in South Asia facing similar issues. IKEA, which currently uses around 0.6% of the world’s cotton production every year is keen gradually switching over to sourcing 100 percent BCI cotton in its supply chain.

**Promoting resource efficiency in Textile Production**

To complement the efforts under BCI, the sustainability effort was extended up in the supply chain – i.e. textile production.

**Figure 2: Process flow diagram of the pilot unit**

Detailed investigation and technical backstopping support was provided by IIP to increase resource use efficiency in a textile production unit in Erode district of Tamil Nadu, which is one of the most important textile producing clusters in India. The vendor targeted under this initiative is one of the largest suppliers of IKEA in India and house all the important stages of textile production. They produce textile for various IKEA products and source 100 percent of their raw material requirement from farmers producing cotton under ‘Better Cotton Initiative’ in Aurangabad.

A major drawback with the textile industry in Erode is that there has been very little investment for technology up gradation and modernization. In general, the machineries installed are obsolete and outmoded, resulting in low efficiency, high energy consumption and excessive water use. Another significant challenge for the textile industry in Erode proper effluent management. Erode is in a dry, water-scarce region, and the rapid expansion of the textile industry has taken place in an unplanned manner with no associated development of supporting infrastructure or institutional capacity. This has led to the depletion of groundwater reserves and a serious deterioration in environmental quality of both surface and ground water. A large quantity of salt is used in the dyeing process and the wastewater from this process is highly saline and is contaminated with a variety of chemicals. As there is hardly any source of fresh water nearby, water is brought in by trucks from ground water sources as far as 50 Kms away at an enormous cost. Typical water consumption in Erode is around 200 to 400 litres/kg of finished product, compared with the international norm of 120 to 150 litres/kg.

Most of the bleaching and dyeing units in Erode are located in clusters along the banks of the River Cauveri & Bhavani, into which they discharge effluent. Industrial effluents stagnate in the riverbeds and percolate into the groundwater. As a result, the groundwater quality around the cluster of bleaching and dyeing units is getting polluted. The bleaching and dyeing process are the main causes of pollutants which include caustic soda, hydrochloric acid, sodium hydro sulphate, hypochlorite and peroxides. This deteriorating water quality has in turn polluted the soil, with the crop productivity falling drastically in the nearby agricultural belt. Though currently only the decline in crop productivity is observed, it would not be long before the pollutants percolate into the soil and ground water causing an irreversible environmental damage.

The approach to resource efficiency in the next stage of textile supply chain in Erode was therefore to focus on minimisation of water & energy footprint along with reduction in waste and effluent discharge. The unit chosen for pilot intervention is a medium sized wet processing mill, manufacturing a wide range of cotton and blended home textile products. The activities of the mill include sizing and warping of yarn, weaving, wet processing, printing and specialized finishing. The unit caters to both own production as well as job orders and needs of global customers such as IKEA. The products manufactured include bleached, dyed, printed fabrics and bleached and dyed yarns.

**Figure 2** depicts the process flow chart along with the input and output at each stage. Large amounts of energy is used in the unit along water both directly as well as in the form of steam for different wet processing stages of this unit.

**Energy:** Electricity, firewood and diesel are the various energy types used in the plant. Electricity is used to power equipment and machinery for drying, pumping, lighting, finishing, dyeing and bleaching.

**Figure 3:** Electricity use by different departments (KWh, %)

![Electricity use by different departments](image)
and office equipment (Figure 3). Firewood is used as a fuel for boilers to generate steam and for thermic fluid heaters. Diesel is used as a fuel for Diesel Generator sets which are used as a standby power source. The forms of energy, description and source in the plant are summarized in Table 1.

Electricity and firewood are the primary energy sources used in the mill. The plant uses around 4 million units of electricity and 18000 tonnes of wood annually.

**Water:** Since the plant is a wet processing mill, large quantities of water is used at almost every stage of the production process. Excessive water use lowers the water table and depletes water sources for future production and community use. The main source of water for the plant is open well. As per the zero discharge regulations applicable to textile industry, the plant’s treated effluent has to be diverted back to the well for recharging. The recharging is facilitated with RO system and only make-up water is drawn to replenish the water loss. Table 2 shows section/equipment wise water consumption in the plant.

The amount of water consumed varies widely depending on the following factors:

- **Type of fabric being processed -** water consumption in textile operations vary between processing different fabric types. Water used in processing woven fabric averages 50-100 m³ of water per tonne of production depending upon the operating sequences.
- **Management and work practices -** improper management and work practices also contribute to excessive water consumption. About 5-10% savings in water consumption can be achieved by applying good housekeeping measures and adopting good practices.
- **Type of process -** water consumption in textile operations vary widely between the different unit equipment for the same process. Some dyeing methods consume large quantities of water (i.e. jiggers) while others have very low water consumption (i.e. pad-batch).
- **Machine type -** water consumption in different textile processing machines depends on bath or liquor ratio (weight of bath water divided by weight of fabric).
- **Process control -** lack of adequate process controls (e.g. flow and level controls) also leads to avoidable water loss.

**Waste & Effluent discharge.** Almost all chemicals and dyes are carried over into wastewater except chemicals picked-up by fabric and yarn. Wastewater generated from the various pretreatment washing and dyeing operations contain substantial pollution loads characterized by a high biological load suspended solids (e.g. fibers and grease), dissolved solids, colours (i.e. dyes), high temperature and strong alkalinity.

The plant generated Biological Oxygen Demand (BOD) levels in the effluent varies between 1500-4000 ppm and Total Dissolved Solids (TDS) from 7000 ppm to more than 10000 ppm. In addition some chemicals released into the wastewater are highly toxic and hazardous and pose a threat to human health and aquatic life. All the wastewaters from the plant is collected in tanks and sent to primary clarifier. Aeration tank takes care of BOD and Chemical Oxygen Demand (COD). In the tertiary clarifier, turbidity is removed. This is followed by ultra-filtration and reverse Osmosis (RO) plant. TDS gets removed and permeate is collected from all three stages of RO. Final reject from RO is sent to evaporator and the resulting salt slurry is stored in a shed. The solid wastearising from the primary clarifier is separated from liquid in a filter press. The sludge is dried in open bed and packed and stored under closed roof. The sludge arising from primary treatment is about 480 kg/day.

**Towards resource efficient and cleaner production**

In order to deal with the existing resource inefficiency and environmental issues,
a thorough resource audit was carried out in the unit followed by development of a ‘greening’ action plan detailing the measures that need to be undertaken by the unit. This action plan was presented to the unit and through a consultative process involving the plant personnel and senior management, a prioritization exercise was carried out. The financial assessment in terms of investment needed for various interventions and payback period helped the Plant Management in taking investment decision. The Management also felt that such investments would help them in environmental & regulatory compliance. The plant was further provided with technical backstopping support to implement the recommended measures. An impact assessment was subsequently carried out to gauge the impacts of interventions already implemented by the unit, those under progress and proposed in near future.

**Energy Saving measures:** Details of impact of some of the short term energy saving initiatives already implemented by the unit are as follows:

<table>
<thead>
<tr>
<th>Insulation of Boiler Feed water tank</th>
<th>Variable Frequency Drive (INVERTER) for Calendaring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual reduction in firewood consumption = 134 Tons</td>
<td>Annual Electricity con. reduction = 20130 kWh</td>
</tr>
<tr>
<td>Annual savings = Rs. 0.415 Million</td>
<td>Annual savings = Rs. 0.141 million</td>
</tr>
<tr>
<td>Investment = Rs. 0.028 Million</td>
<td>Annual Investment = Rs. 0.18 Million</td>
</tr>
<tr>
<td>Simple payback = 1 month</td>
<td>Simple payback = 16 months</td>
</tr>
<tr>
<td>Annual GHG reduction = 100 Tons of CO₂</td>
<td>Annual GHG reduction = 16.9 Tons of CO₂</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Single Shot Dyeing and Printing</th>
<th>Replacement of Surface Aerator with Diffused Aerator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual thermal energy savings = 16.5 Gcal</td>
<td>Annual electricity savings = 108098 kWh</td>
</tr>
<tr>
<td>Annual electricity savings = 7015 kWh</td>
<td>Annual savings = Rs. 0.594 Million</td>
</tr>
<tr>
<td>Annual savings = Rs. 1.36 Million</td>
<td>Annual Investment = Rs. 2.1 Million</td>
</tr>
<tr>
<td>Annual Investment = Rs. 2.06 Million</td>
<td>Simple payback period = 42 months</td>
</tr>
<tr>
<td>Simple payback period = 18 months</td>
<td>Annual GHG reduction = 101 Tons of CO₂</td>
</tr>
<tr>
<td>Annual GHG reduction = 6 Tons of CO₂</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Recycling of Wash Water in Rotary Screen Printing</th>
<th>Recovery of cooling water from Hydraulic Jiggers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual water savings = 3.95 Million Litres</td>
<td>Annual water savings = 5.49 Million Litres</td>
</tr>
<tr>
<td>Annual electricity savings = 23040 kWh</td>
<td>Annual electricity savings = 32105 kWh</td>
</tr>
<tr>
<td>Annual savings = Rs. 0.161 Million</td>
<td>Annual savings = Rs. 0.224 Million</td>
</tr>
<tr>
<td>Investment = Rs. 0.025 Million</td>
<td>Annual Investment = Rs. 0.05 Million</td>
</tr>
<tr>
<td>Simple payback = 2 months</td>
<td>Simple payback = 3 months</td>
</tr>
<tr>
<td>Annual GHG reduction = 10.4 Tons of CO₂</td>
<td>Annual GHG reduction = 26.9 Tons of CO₂</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cooling Water and Condensate Recovery from Pre-shrinking Range</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual water savings = 0.86 Million Litres</td>
<td>Net annual savings = Rs. 0.146 Million</td>
</tr>
<tr>
<td>Annual savings in water cost = Rs. 0.11 Million</td>
<td>Investment = Rs. 0.05 Million</td>
</tr>
<tr>
<td>Annual savings in electricity consumption = 5005 kWh</td>
<td>Simple payback = 4 months</td>
</tr>
<tr>
<td>Annual GHG reduction = 4 Tons of CO₂</td>
<td></td>
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</tbody>
</table>

Some other energy saving measures like use of acrylic sheets for natural lighting in plants, power saving measures in worker’s quarters, reducing AC load, insulation of bare steam pipes yielded payback in less than 7 months with high electricity and fuel wood savings along with GHG mitigation.

**Water & Energy saving measures:** Short term initiatives with water, energy and GHG mitigation potential implemented by the plant are as follows:

Besides water and energy savings, the intervention also contributed towards...
**Scaling up Resource Conservation Measures**

The supply chain greening approach in textile sector represents a win-win situation. For the SME vendor and farmers involved in cotton growing, it means improved resource productivity, reduced wastages and higher profit margins. For socially and environmentally conscious corporate like IKEA, it means reduced carbon footprint for its operations. The additional co-benefits by way of social and environmental impacts are a bonus.

The successful demonstration has encouraged IKEA to internalise this approach with all its vendors in India and South Asia region. IKEA has already set sustainability targets for its vendors on energy, water and raw material use as well as increasing use of renewable energy. In order to motivate other vendors in India, IKEA organised a ‘Sustainability’ workshop in which all major IKEA vendors in India were encouraged to follow a similar approach by showcasing the benefits being achieved by the participating unit.

Following the success of supply chain greening model in India, IIP made effort to promote similar approach in Bangladesh in partnership with other leading brands like H&M, Raw star G, C&A and IKEA under a South-South cooperation approach through exposure visits to India, awareness generation, energy/resource audit in representative units (participating vendors supplying textile products to international brands) and workshops to showcase impacts achieved by participating vendors. The results of the project was quite successful as Bangladesh Garment Manufacturers Exporters Association (BGMEA), which is the biggest and most important textile industry association in Bangladesh, has agreed to scale up this model among their members.

The supply chain greening efforts in India and Bangladesh helped in demonstrating how Corporate Policy of global buyers can help in stimulating sustainability along their supply chain. However, successful scale up of such models will need the involvement and support of not just the farmers and textile industry but other stakeholders, specifically, the policy makers that incentivize adoption of energy/resource efficient technologies, enable access to finance, facilitate certification among other. This will be particularly important for overcoming the barriers that energy/resource efficient technologies and sustainable approaches will face in replacing conventional and deep rooted processes and methods. Experience shows that scaling up of such technologies will require both ‘supply side’ push through technology assistance, capacity building and government policies that incentivizes adoption of such technologies as well as ‘demand side’ pull through favourable Corporate and public procurement policy that promotes sourcing of resource efficient products.

Indian experience with the supply chain greening provides a lot of learning that can help in shaping of effective strategies and policies in other South Asian countries, particularly those dealing with the
### Table 3: Greening action plan under implementation and associated benefit streams

<table>
<thead>
<tr>
<th>Greening measure implemented</th>
<th>Investment (INR)</th>
<th>Annual Savings (INR)</th>
<th>Pay-back period (month)</th>
<th>Annual Fuel (thermal energy) Savings (Gcal)</th>
<th>Annual Electricity Savings ('000 KW)</th>
<th>Annual Water Saving (ML)</th>
<th>Annual CO₂ emission reduction (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medium-term projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect steam use in Jiggers (under trial)</td>
<td>525000</td>
<td>355074</td>
<td>18</td>
<td>309</td>
<td>-</td>
<td>-</td>
<td>86</td>
</tr>
<tr>
<td>VFD for ID fan of boiler (under investigation)</td>
<td>50000</td>
<td>108864</td>
<td>6</td>
<td>-</td>
<td>25.92</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td>Insulation of drying cylinders (under trial)</td>
<td>100000</td>
<td>195920</td>
<td>6</td>
<td>169</td>
<td>-</td>
<td>-</td>
<td>47</td>
</tr>
<tr>
<td>Avoiding horizontal yarn dryer and maximizing use of vertical dryer</td>
<td>100000</td>
<td>567000</td>
<td>24</td>
<td>-</td>
<td>130.2</td>
<td>-</td>
<td>109</td>
</tr>
<tr>
<td>Replacement of surface aerator with diffused aerator</td>
<td>2100000</td>
<td>594541</td>
<td>42</td>
<td>-</td>
<td>108.098</td>
<td>-</td>
<td>101</td>
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<tr>
<td><strong>Long-term projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFD for ID fan of thermic fluid heater</td>
<td>35000</td>
<td>66528</td>
<td>6</td>
<td>-</td>
<td>15.84</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>Maximizing condensate recovery</td>
<td>100000</td>
<td>219450</td>
<td>5</td>
<td>160.65</td>
<td>-</td>
<td>-</td>
<td>43</td>
</tr>
<tr>
<td>AFBC boiler with multi-fuel capability in place of existing firewood fired-boiler</td>
<td>1500000</td>
<td>7269500</td>
<td>&gt;24</td>
<td>5500</td>
<td>-</td>
<td>-</td>
<td>1700</td>
</tr>
<tr>
<td>Waste heat recovery from yarn dying machine</td>
<td>1400000</td>
<td>666500</td>
<td>24</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>156</td>
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<tr>
<td>VFD for Stenter exhaust fan</td>
<td>70000</td>
<td>26612</td>
<td>31</td>
<td>-</td>
<td>6.336</td>
<td>-</td>
<td>5</td>
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<tr>
<td>Centralized compressed air system in place of distributed system with piping size modification</td>
<td>900000</td>
<td>445560</td>
<td>24</td>
<td>-</td>
<td>111.39</td>
<td>-</td>
<td>9</td>
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<tr>
<td>VFD for thermic fluid circulation pump</td>
<td>50000</td>
<td>43788</td>
<td>14</td>
<td>-</td>
<td>10.426</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Adopting Continuous Scouring and Bleaching Range and phasing out post-mercerized activities in jiggers</td>
<td>25000000</td>
<td>12500000</td>
<td>24</td>
<td>5.9</td>
<td>1453</td>
<td>↓ 10 - 15 Litres/kg</td>
<td>1221</td>
</tr>
<tr>
<td>Rain water harvesting plan (proposed)</td>
<td>350000</td>
<td>1070550</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8.235</td>
</tr>
</tbody>
</table>

Implementation challenges that are quite similar to India, and open up opportunities for knowledge transfer to other countries along the lines of technology/expertise transfer to Bangladesh.

1. UN-COMTRADE database, World Integrated Solutions (WITS)
2. Derived from Planning Commission’s Employment estimates
3. Potential Supply Chains In The Textiles And Clothing Sector In South Asia An Exploratory Study, United Nations Conference on Trade and Development (UNCTAD)
4. Devaraja, T.S, Indian Textile and Garment Industry- An Overview, Department of Commerce, Post Graduate Centre, University of Mysore, Hassan, India
Best Practices Case Study

JK White Cement Works, Gotan (A division of JK Cement Ltd)

– Mr. Gajendra Panwar & Mr. V. S. Rathore, JK White Cement Works, Gotan

Introduction

JK White Cement is the first White Cement factory in India, which manufactured White Cement through dry process technology. The Gotan plant was commissioned in 1984 with an initial production capacity of 50,000 tons. It uses technical expertise from F.L. Smidth & Co. of Denmark and state-of-the-art technology with continuous on-line quality control by microprocessors and X-rays, ensuring the purest white cement. Over the years, continuous process improvements and modifications have increased the plant’s production capacity to 6,00,000 tons per annum. Owing to its constant R&D efforts and updated technology J.K. Wall Putty, a new, value-added product was launched in 2002.

Raw Mill-1 Specification and Introduction

Raw mill 1 is 3.2 m diameter and 5.25 m length with drying chamber and single chamber mill. There is dryer for material drying before entering in mill. Two parallel air separator for material separation. Mill feed size is 6 mm by two impact crusher which is in parallel and vibrating screen installed after two impact crushers.

Figure 1: Fishbone diagram for identifying the root cause of increase in power consumption of raw mill 1

<table>
<thead>
<tr>
<th>Action</th>
<th>Jul-13</th>
<th>Jul-13</th>
<th>Aug-13</th>
<th>Dec-13</th>
<th>May-14</th>
<th>Mar-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grinding media pattern changed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Grinding media filling level increased</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Dryer fan motor replaced from 60 Kw (DC) to 110 kw (AC) Installed VFD in dryer fan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Screen inlet belt speed increased from 46 rpm to 60rpm by change gear box</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Hopper filling conveyor belt motor kw increased from 22 kw to 30 Kw</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Air Blaster installed in clay crusher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pneumatic hammer installed for separator-2 air slide for proper distribution of material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Nibs separator installed at mill outlet for nips separation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Dryer &amp; mill inlet RAL replaced with gravity flap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Observation &amp;monitoring’s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Methodology Adopted

The talented in-house team used brainstorming sessions, departmental meetings and a root cause analysis tool to analyze the problem scientifically. A fishbone diagram (Figure 1) was prepared to understand the root cause of the problems. A detailed implementation plan was prepared by the team (Figure 2) to carry out the task as per a schedule.

Reason for low output and higher energy consumption of mill:

- Mill outlet residue was high up to 49% on 90 micron because of inadequate media pattern of mill which results in higher circulating load of mill and this results in decrement the efficiency of the separator.
- Clay nib’s formation in mills because of non-charging of large size (70 mm & 80 mm) grinding media in mill.
- Grinding media filling level is low in mill. Grinding media filling level was
25% in mill with different sizes of balls. Optimum filling level of media was not done.

- Dryer outlet temp was below 55 degree centigrade because we were unable to increase the rpm of the fan which results in frequent tripping of fan and this results in lower kW of the motor of the fan. Earlier fan of motor was DC therefore frequent load fluctuation was happened. Because of above problems of mill we were unable to get the required mill outlet temperature (>85 degree centigrade)

- Material flow distribution was not proper in separator no. 2 (351SR2). All Material from mill outlet elevator was going into separator -1 through air slide. Air slide of separator -2 was frequently jammed.

- When both raw mill 1 & raw mill 2 were run combined then hoppers of limestone & clay was not maintained by the operator because tunnel to hopper belt (311 BC2) was tripped frequently because of lower size capacity motor (22kw).

- Screen inlet belt (331BC8) was tripped frequently even after increasing the feed of raw mill 1 because of lower speed of screen inlet belt (331 BC8).

- Jamming of clay crusher due to existence of moisture in both clay (clay1 & clay2) around 7% and this results in frequent tripping of clay crusher inlet belt (331 BC4) which leads to feed cut of mill & creates process disturbance.

- Frequent Jamming of mill diaphragm due to formation of clay nibs and wear & tear of grinding media which results in increased outlet draught & increase of material filling level of mill and combination of above factors finally results in reduction of feed.

- Frequent tripping of dryer inlet (331SU1) & Mill inlet Rotary Air Lock (331SU1) because of oversize clay lumps passed through clay crusher & under capacity motors of both rotary air locks which results in feed cut of mill and creates process disturbance.

Improvements carried out:

- Grinding media pattern changed. Earlier grinding media optimization was not done. Following actions taken to optimize the size and quantity of grinding media -
  a) We have increased the quantity of 20 mm grinding media from 9.67 tonne to 17.13 tonne
  b) We have increased the quantity of 25 mm grinding media from 2.01 tonne to 6.65 tonne
  c) Quantity of 30 mm grinding media was added to 40 mm and this results in increased qty. of 40 mm grinding media (from 8.58 tonne to 14.3 tonne)
  d) Quantity of 50 mm grinding media was added to 60 mm and this results in increased qty. of 60 mm grinding media (from 9.82 tonne to 14.35 tonne)
  e) 70 mm (2 tonne) & 80 mm (1.0 tonne) grinding media was charged in the mill to avoid the formation of clay nibs in the mill.

- Increase grinding media filling level: Grinding media filling level was 25% in mill with different sizes of balls. Optimum filling level of media was not done. Media filling level was increased from 25% to 29.70%.

- Separator louvers & separator rotor rpm adjusted to take different sample to achieve maximum efficiency of both separator.

- Dryer fan DC motor (60 kw) was replaced with AC motor with VFD (110kw) to –
  a) Achieve the required flow ,
  b) Avoid the RPM fluctuation.
  c) Avoid the fan tripping.
  d) Increase the dryer outlet temperature.
  e) Achieve the optimum mill outlet temperature which also results in increasing the grinding efficiency of mill & separator.

  (f) Increase average tph of raw mill 1.
• We have replaced the gear box of screen inlet belt (331BC8) which results in increasing of belt speed from 46 rpm to 60 rpm and this results in achieving the required TPH of the mill and hurdle free operation.

• After increase speed of screen inlet belt we are able to achieve following benefits -
  a) Reduction in breakdown frequency of mill related to overloading of belt.
  b) Mill Feed was increased up to required TPH.
  c) Smooth operation.

• We have replaced the motor of belt (311 BC2) from 22 kW to 30 kW to maintain the filling level of hoppers of raw mill and this results in achieving the required TPH of the mill.

• After replacing the motor from 22KW to 30KW, we are able to achieve following benefits -
  a) Hopper level maintained of both mills.
  b) Breakdown reduced related to hopper empty.
  c) Increased average tph of raw mill 1.

• Material flow distribution was not proper in separator no. 2 (351SR2). All Material from mill outlet elevator was going into separator -1 through air slide, Air slide of separator -2 was frequently jammed. A pneumatic hammer was installed at separator -2 air slide to overcome from this problem

• After installation of pneumatic hammer we are able to achieve following benefits -
  a) Proper distribution of material in both separator.
  b) Separator efficiency improved.
  c) Increased average tph of raw mill 1.
  d) Circulating load in range.

• Pneumatic air blaster installed in clay crusher for prevent jamming of clay crusher and avoid tripping of clay crusher inlet belt (331 BC4).

• After installation of air blaster in clay crusher we are able to achieve following benefits -
  a) Reduction in breakdown frequency due to jamming of clay crusher
  b) Increased average tph of raw mill 1.
  c) Smooth operation.

• Nib’s separator installed at mill outlet for prevent jamming of mill diaphragm by worn grinding media & clay nibs.

Dryer inlet flow before and after modification

<table>
<thead>
<tr>
<th>Location</th>
<th>Diameter (mm)</th>
<th>Pdy, mmwc</th>
<th>Pstat, mmwc</th>
<th>Dry bulb temp. (deg.C)</th>
<th>Damper position</th>
<th>Density at zero deg. (kg/m3)</th>
<th>Density (kg/m3)</th>
<th>Pitot constant</th>
<th>Velocity(m/sec)</th>
<th>Vol. flow rate(m3/ Hr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dryer inlet</td>
<td>1385</td>
<td>5.96</td>
<td>3.04</td>
<td>198</td>
<td>100</td>
<td>1.41</td>
<td>0.77</td>
<td>0.869</td>
<td>10.76</td>
<td>58350</td>
</tr>
<tr>
<td>After</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Diameter (mm)</td>
<td>Pdy, mmwc</td>
<td>Pstat, mmwc</td>
<td>Dry bulb temp. (deg.C)</td>
<td>Damper position</td>
<td>Density at zero deg. (kg/m3)</td>
<td>Density (kg/m3)</td>
<td>Pitot constant</td>
<td>Velocity(m/sec)</td>
<td>Vol. flow rate(m3/ Hr.)</td>
</tr>
<tr>
<td>dryer inlet</td>
<td>1385</td>
<td>7.81</td>
<td>4.6</td>
<td>230</td>
<td>100</td>
<td>1.41</td>
<td>0.66</td>
<td>0.869</td>
<td>13.20</td>
<td>71584</td>
</tr>
</tbody>
</table>
• After installed Nib's separator at mill outlet:
  a) Efficiency of mill increased.
  b) Solved problem regarding diaphragm jamming.
  c) Increased average tph of raw mill 1.
  d) Breakdown reduced.
  e) Separator efficiency improved.
  f) Mill outlet draught maintained.
• Mill inlet and dryer inlet rotary air lock (RAL) replaced with gravity flap to prevent frequently tripping of rotary air lock.
• After replaced RAL with gravity flap we are able to achieve following benefits:
  a) Reduction in breakdown frequency due to tripping of RAL.
  b) Smooth operation.
  c) Increased average tph of raw mill 1.
  d) Direct saving of power.

**Impacts and Benefits**

- **Energy Savings**: Plant had reduced raw mill 1 specific energy consumption from 13.16 to 12.35 in first year which was further reduced to 11.41 in 2014-15.

**Financial implications**: Total cost incurred for carrying above improvements was 16 Lacs (Approx.)

- **Payback period**: The payback period is short, at 1 year, as the plant increased the production after implementation of this project.

**Box 1: Impact of the optimization on the overall performance of the plant**

- Using a step-by-step approach to solve the problem increased the team’s confidence and set an example of team work in the plant.
- ISO 50001 Energy Management System certification implementation process in the early 2014-15 also helped the team to emphasis on scientific analysis of the root cause of the problem.
- The project was instrumental in motivating other departments to reduce their energy consumption.
- Operational optimization of raw mill 1 section sets as an example for other Operation departments to run the section at optimum output to reduce the energy consumption through operational excellence.
- Project helped in reducing plant’s energy cost and achieving the Target in PAT cycle-1.

**Figure 3: Raw Mill TPH (year 12-13 to year 16-17)**

**Figure 4: Raw Mill-kWh/ton of raw mix (year 12-13 to year 16-17)**
Best Practices Case Study

M/s. Winsome Yarns Limited

About the Plant
M/s. Winsome Yarns Limited, Derabassi, Punjab, is a part of the Winsome Group of Industries engaged in spinning, knitting, and hydropower. Winsome Yarns Limited was the first textile unit to produce cotton melange yarn in India. Progressing continuously, its production capacity has now reached 110,000 spindles. Winsome Yarns Limited has a product profile which includes speciality yarns such as slub yarns, nippy yarns, streaky yarns, blended yarns (cotton blend with nylon, modal, wool, silk, soya, bamboo, etc.).

PGS Energy Services Pvt. Ltd., identified energy conservation opportunities after a PAT audit. Energy conservation schemes worth Rs 160 lacs were implemented in different parts of the plant described below.

Energy Consumption

Innovative Project: Compressed Air System Optimization & Total Reduction in Electricity Consumption: 1221 MWh/Annnum (approximate reduction in kW/CFM: 15%)

Compressed air is a major energy consuming utility in textile units, accounting for about 7% of the power consumed. The cost of compressed air is one of the largest components of a textile utility’s cost. Air compressors are considered the lifeline of textile units, because most of the machinery is pneumatically operated. In the Winsome Yarns Ltd., Derabassi Unit, the compressed air network has three main units.

Problems necessitating innovation
- The system’s efficiency was low in the centralized compressed air system.
- The specific power consumption was 0.20 kW per CFM, which was considerably high.
- The centrifugal compressor dryer was running inefficiently (demand higher than capacity) because of air leakages in machines.
- Losses in productivity and quality were observed.
- Air leakage audits found leakages amounting to 800 CFM.
- Analysis suggested that the compressed air system could be made more energy efficient if air leakages were arrested and maintenance carried out in the recommended time frame.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Unit</th>
<th>2014-15</th>
<th>2015-16</th>
<th>2016-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Production</td>
<td>Tonne</td>
<td>9330.03</td>
<td>13068</td>
<td>10690</td>
</tr>
<tr>
<td>Electrical Energy Consumption</td>
<td>Lakh kWh</td>
<td>599</td>
<td>685</td>
<td>625.7</td>
</tr>
</tbody>
</table>

Images before and after optimization of the Compressed Air System

Before Implementation

After Implementation

Compressed Air Consumption Comparison

<table>
<thead>
<tr>
<th>Process</th>
<th>Before Implementation</th>
<th>After Implementation</th>
<th>% of Compressed Air used in different sections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compressed Air Consumption (CFM)</td>
<td>Compressed Air Consumption (CFM)</td>
<td></td>
</tr>
<tr>
<td>1 Winding</td>
<td>43560</td>
<td>31,680</td>
<td>60</td>
</tr>
<tr>
<td>2 Spinning</td>
<td>18150</td>
<td>13200</td>
<td>25</td>
</tr>
<tr>
<td>3 Blow Room &amp; Carding</td>
<td>7260</td>
<td>5280</td>
<td>10</td>
</tr>
<tr>
<td>4 Preparatory Machine</td>
<td>3630</td>
<td>2640</td>
<td>5</td>
</tr>
</tbody>
</table>
Replacement of T8 lamps with LED lamps

- Total Reduction in Electricity Consumption: 1727 MWh/annum

<table>
<thead>
<tr>
<th>Plant no</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Colonies</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of T8 lamps</td>
<td>1897</td>
<td>1704</td>
<td>2741</td>
<td>1000</td>
<td>7342</td>
</tr>
<tr>
<td>Power consumption (LkWh/annum)</td>
<td>6.94</td>
<td>6.24</td>
<td>10.03</td>
<td>3.66</td>
<td>26.86</td>
</tr>
<tr>
<td>Number of LED Tube Lamps</td>
<td>1897</td>
<td>1704</td>
<td>2741</td>
<td>1000</td>
<td>7342</td>
</tr>
<tr>
<td>Power consumption per month after installation</td>
<td>2.48</td>
<td>2.23</td>
<td>3.58</td>
<td>1.31</td>
<td>9.59</td>
</tr>
<tr>
<td>Power saving (LkWh/annum)</td>
<td>4.46</td>
<td>4.01</td>
<td>6.45</td>
<td>2.35</td>
<td>17.27</td>
</tr>
<tr>
<td>Investment (in Rs. Lac)</td>
<td>12.33</td>
<td>11.08</td>
<td>17.82</td>
<td>6.5</td>
<td>47.72</td>
</tr>
<tr>
<td>Monetary Saving (Rs. Lac/annum)</td>
<td>33.47</td>
<td>30.06</td>
<td>48.36</td>
<td>17.64</td>
<td>129.53</td>
</tr>
<tr>
<td>Pay Back (in months)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Images showing energy conservation measures in lighting before and after implementation.

Before Implementation

After Implementation

Initiatives Taken

1. Meetings were conducted with the plant’s management to apprise them of air leakages in plant and take approval for the following:

- Forming a dedicated team to arrest air leakages
- Stopping production till air leakages were rectified
- Funds to arrange spare parts required to arrest the leakages.

2. Formation of a dedicated team with the mission, ‘Save power, arrest air leakage’.
3. Daily monitoring of air leakages in the machines, followed by rectification work.
4. Formation of a separate team for M&V (measurement & verification) which would help to quantify energy savings.

After arresting air leakages the specific power consumption was reduced to 0.173 kW per CFM, from 0.20 kW per CFM,a saving of 14%.

Energy Savings in terms of MTOE

After modification the usage of electricity has been reduced to around 0.275 MWh/ton of yarn.

The environmental impact of implementing the ENCON measures results in terms of savings of MTOE

MTOE savings

Savings in production process= 0.253 MTOEb

Mr. B.S. Sharma
Plant Head
Winsome Yarns Ltd
Derabassi, Mohali, Punjab

It is a matter of pride that our team at Winsome Yarns Ltd. has put tremendous efforts for sustainability and energy conservation. We have a strong belive in environment conservation and our manufacturing process are in coherence with Eco system. We practice Eco friendly means for energy generation from renewable resources adopt, rain water harvesting, zero waste generation & producing & promoting responsible fashion which help to save environment. Kudos to our engineering head Mr. D.S. Pandey & Energy saving team.
RDF Production for Cement Plants

Further to the earlier article ‘Increasing Energy Efficiency in Indian Cement Manufacturing’ published in KEP issue 8 2017; this article will outline a state of the art, patented and UK Government proven technology for production of high-quality Solid Refined Fuel (SRF) fraction for producing alternative fuels (AF) from Municipal Solid Waste (MSW) and Commercial and Industrial waste streams.

Increasing use of waste-derived alternative fuels (AF) in cement plants has been a major global success story of the past few decades. With substitution rates of 70% or higher, millions of tonnes of waste have been diverted from landfill and likewise millions of tonnes of fossil fuels saved from being burnt, providing benefit to the environment. Furthermore, the global cement industry has seen significant financial benefits as AF will generally be available at lower cost than fossil fuels. However, this global best practice has proven slow in spreading to some parts of the world.

For an existing cement plant to use AF it is true that capital investment is required, which in some cases can be a barrier to entry. In particular, new or modified fuel handling systems and burners will generally be required, due to the properties of the AF differing from coal. Use of multiple burners at different locations in the cement kiln is also becoming increasingly the standard to enable use of multiple different fuels and the most energy efficient heating of the raw material. Modification of the plant emissions control equipment may also be required. Shutting down the plant to make the required changes is liable to interrupt the continuous production that is of key importance, particularly to individually owned cement plants. However this should be considered part of the long-term plant investment strategy and can be incorporated into the existing plant maintenance/upgrade schedule. For all new-build cement plants it should now be considered standard & best practise to design for use of AF to supplement fossil fuels from day one.

The state-of-the-art AF handling and burner systems developed to date are generally flexible and can handle a variety of materials (including fossil fuels), however for best performance they can be optimised for specific types of AF. The type of AF available is a key consideration because a vast array of such fuels have been used, with significant differences in CV and handling properties. Transporting the AF long distances can compromise the financial and environmental benefits significantly, so it is important to consider local sources of AF whenever possible. Furthermore not all AF are created equal, and there may be competition for the best. For example used rubber tyres are an excellent AF, with lower moisture and ash contents and a significantly higher CV than coal. Nowadays in Europe there is a seller’s market in such tyres with not enough supply to meet the demand. Some early adopters have even been priced out of the market – long-term security of supply must be considered as part of the AF selection!

There is one particular AF that is available in almost limitless quantities and in practically every location – refuse derived fuel (RDF). Sometimes also referred to as solid recovered fuel (SRF), as its name suggests this fuel is obtained by processing refuse obtained from a great variety of sources, including domestic households and commercial premises, typically supermarkets, offices, hotels and so forth. As such it can also be understood that in the long-term RDF should be considered a secure supply of AF -the increasing population and wealth of developing nations resulting in ever-increasing production of such refuse, the majority of which is currently not being safely treated or optimally disposed of.

In addition to the variety between different types of AF, there can also be significant variation in the properties of RDF. In Europe, a technical standard EN 15359:2011 has been introduced to assess the quality of RDF which if sufficiently high can be certified as SRF. The variation in RDF quality is largely attributable to two factors:

1. The RDF production process
2. The composition of the refuse feed into the process

For example, paper/card and plastics will generally make a very good RDF whereas waste food and glass will not. In this respect the best and most reliable RDF production must be considered as a combination of obtaining the most suitable refuse available and having the right process. Similar to the AF handling systems for cement plants, a great deal of investment of time and money worldwide has by now established state-of-the-art RDF production technology which is generally ready to be used worldwide, however it will require some adaptation to best suit the local economic factors and refuse sector.
RDF production facilities can include a wide variety of process operations, typically including:

1. Policing of incoming waste to remove bulky and/or hazardous objects. This is normally carried out manually.

2. Removal of organic materials, generally by screening. The removed organic material will normally be suitable for anaerobic digestion or animal feed.

3. Removal of ferrous and non-ferrous metals. In Europe these are typically removed by magnets and eddy current separators respectively but hand-picking may be preferred. These non-fuel materials can provide a significant additional revenue stream for the RDF production facility.

4. Removal of glass, ceramics and other dense materials. The most common methods involve use of low pressure air systems which will divert the lighter fuel materials. Dependent on the available markets this may be suitable for use as a recycled aggregate.

5. Shredding of the RDF to the correct specification for the cement plant. The basic form of RDF is generally a shredded ‘floc’ material around 25mm-50mm nominal size.

In the case of more advanced RDF production, additional process operations may be involved, such as:

6. Thermal treatment to reduce the moisture content of the RDF. This will have a major benefit to the RDF quality and the performance of the AF handling systems at the cement plant. This may be especially important during monsoon season depending on how the refuse is collected and stored. As part of integrated facilities, it may be possible to use waste heat from the cement plant and/or bio-methane generated from the organic fraction.

7. In some markets, it may be financially viable to remove certain plastics using an optical sorter, or as with the metals hand-picking may be preferred in India.

Although this will tend to reduce the CV of the RDF, the plastics can achieve a good price in the recycling market.

8. Forming the RDF, for example into pellets, briquettes, or bales. This can make the RDF more suitable for transportation and handling in some cement plants. It can also open up the RDF for use in other markets such as advanced conversion technologies like gasification or pyrolysis.

In terms of assessing the quality of the RDF/SRF, the key parameters are generally as follows:

1. Calorific Value (CV) – often the single headline figure that grabs attention. The energy density of RDF/SRF (CV/bulk density) is generally significantly lower than coal so will require larger volumetric feed rates to supply the kiln energy demand. This will in turn have a knock-on effect on the size of storage and conveying systems as well as the burner itself.

2. Moisture Content – as well as affecting the CV, the moisture content will have a major effect on the reliability of the handling equipment as well as moisture control within the mill and emissions treatment systems. Wet, sticky, low-quality RDF with poor particle size control is particularly prone to sticking and bridging.

3. Ash Content – in cement plants this is not generally as significant as some other applications, since the ash can normally be safely contained in the clinker without compromising quality. However it is still generally wise to avoid fuels with excessive ash content.

4. Sulphur Content – the sulphur content of RDF/SRF will generally be significantly lower than coal. This can have a beneficial effect on flue gas desulphuration systems and the emission of oxides of Sulphur.

5. Nitrogen Content – the nitrogen content of RDF/SRF will generally be slightly lower than coal. This can have a beneficial effect on SCR/SNCR systems and NOx emissions.

6. Chlorine Content –the chlorine content of RDF/SRF will generally be significantly higher than coal. This can have a negative effect on corrosion and dioxin formation within the kiln so generally requires monitoring. This is currently a topic of some attention in the RDF/SRF production industry with studies of the origin of the chlorine and how it can be controlled. At present much work is focussing on PVC (which can be removed by optical sorter) and sodium chloride (salt) in the organic fraction of the refuse.

7. Heavy Metal Content –the heavy metal content of RDF/SRF varies significantly but is generally slightly higher than coal. As with the chlorine there is current investigation on how to reduce heavy metal content which is moving towards feed policing, in particular removal of waste electronics and electrical equipment (WEEE), and efficient metal removal by overb and magnets, optical sorters and more modern technology such as induction sorters, X-Ray and laser technology.

In addition to the average values of the above parameters it is important to consider the variation. Successful cement kiln operation requires a consistent fuel, which can be an issue with some RDF, particularly from lower end processes. Blending of RDF/SRF with coal will also help improve consistency.

As can be inferred from the above discussion, higher end production technology will generally produce a more consistent, cleaner, higher CV fuel, albeit at

---

**Graph**

- **Waste Streams:**
  - Paper and Cardboard
  - Metal
  - Glass
  - Plastic
  - Organics

**Composition:**

- **Waste Stream Distribution:**
  - Mixed waste: 22.7%
  - Paper and Cardboard: 7.6%
  - Metal: 4.6%
  - Glass: 6.0%
  - Plastic: 3.1%
  - Organics: 60.0%

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**Image:**

- Various images related to recycling and waste management.
a higher investment. However conversely it will generally reduce the investment required in the cement plant fuel handling systems, burners and emissions control systems. To optimise the overall balance of benefits to expenditure for RDF production for cement plants in India it will be necessary to carry out a local audit of the available refuse, locations, markets and transport networks, as well as the cement plants themselves. This expertise is typically best provided by a single consultant company that has knowledge of all aspects of the RDF process, from collection and processing to final use in the cement plant. They will be able to ensure that the entire process from RDF production, transport to and storage at the cement plant, handling and introduction to the cement kilns is integrated and considered holistically. Likewise, when considering all that has been discussed above, an integrated RDF production facility potentially including an anaerobic digestion facility, nearby to the cement plant can be seen as an ideal scenario. Although this would require a significant investment it will maximise the benefits and the security of production.

Orchid Environmental was established in 2003 by Fairport Engineering to develop RDF production technology, as part of the competition by the UK Government’s Department of the Environment, Food, and Rural Affairs (DEFRA). Their Recycling and Recovery Centre (RRC) at Liverpool, UK successfully produced RDF for use in cement plants for several years. With steady plant operation and quality control the RDF achieved the necessary standard and consistency to be classified as the higher quality SRF according to the European Standard. Key to this success was the parent company Fairport Engineering having over 30 years of experience in the bulk materials handling industry including specific experience working on the AF handling systems at a number of UK cement plants.

The Orchid process includes all of the processing stages described in the previous section and as such represents a state-of-the-art SRF production facility. The mass balance (based on UK waste) from the Orchid process is shown below. With 60% recovery of SRF, 22% evaporated moisture, and in total 13.4% of value-added products (metals, plastic and aggregate), only 4.5% of the incoming refuse remained as residual material requiring disposal to landfill.

One key aspect of the Orchid technology is the patented thermal process drum, as shown in the photo below. Whilst the majority of the process equipment is relatively standard and can be sourced from a variety of reputable suppliers, the thermal processing is unique to the Orchid process. Although some similar equipment has been used in RDF production, the majority of RDF production facilities do not employ thermal processing. This means that the RDF and value-added products are generally lower quality. As mentioned previously, moisture content of the RDF in particular can lead to handling problems at the cement plant and will certainly result in a lower CV.

The low carbon fuel produced by the Orchid process is shown in the photo below. With moisture content typically around 16.5% it is suitable for mechanical and pneumatic conveying, and consistently sized to avoid burner blockages. With low organic, metals, glass and ceramics content, abrasion and corrosion are significantly reduced. Experience in the UK has demonstrated that compromises on RDF quality will almost inevitably lead to problems at the cement plant. By taking direct control of RDF production, cement companies can ensure that they get the quality fuel that they need.

In conclusion, RDF/ SRF is not the only AF available but in the long-term may be the most easy to obtain in sufficient quantities to make a major impact on the considerable energy requirements of the Indian cement industry. Furthermore, the benefits of diversion of refuse from landfill and burning must be factored into the overall impact assessment. Cement plants should incorporate introduction of AF into their operational and maintenance strategy at the earliest opportunity and could also benefit from taking control further back down the AF supply chain to improve fuel security and quality control. Grants from the World Business Council for Sustainable Development may be available to contribute towards the upfront costs of AF implementation, and furthermore the Perform Achieve and Trade scheme will recompense businesses that successfully substitute fossil fuels with AF, on their future fuel bills and on an ongoing basis. The equipment and knowhow required to implement all stages of this process is well-established and ready to bring to India, however a responsible consultant, (such as Fairport Engineering Ltd) should be brought on board to consider all relevant local factors before deciding on the specific technology to be introduced. In this way Indian cement plants can ensure that they implement the solution that is best for them and maximise the proven benefits of fossil fuel substitution for AF.
DaKShaTA- Database for Knowledge Sharing on Technological Advancements

Institute for Industrial Productivity (IIP), a mobile application DaKShaTA - Database for Knowledge Sharing on Technological Advancements, which is a one stop repository of all the information needs of the industry such as technological advancements in different processes and applications, their performance on different parameters and other relevant information such as benchmarks, international standards etc.

Mr. Abhay Bakre, Director General, Bureau of Energy Efficiency, released the mobile application DaKShaTA on 8th March, 2018 at the 2nd ‘National Workshop cum Technology Exhibition for Promoting Energy Efficient and Cleaner Production’: DaKShaTA is an app that aims to help industry identify technologies and measures for enhancing energy efficiency, improving productivity and reducing CO₂ emissions, while assessing the cost-effectiveness of energy efficiency investment options.

It is estimated that energy efficiency in the industrial sector can be improved tremendously through adoption of proven and commercially available technologies. However, industry leaders often cite (i) the lack of information on relevant options and benchmarks, and (ii) difficulties in building a clear-cut financial case for energy efficiency investments, as the two main barriers to adoption of energy efficiency technologies and measures. This database aims to help decision makers realise this potential by providing comprehensive and easily accessible information that can help in overcoming information and financial barriers.

DaKShaTA app provides a dashboard approach to guide the industry to the right technology, data, information and experts for their needs. The app currently covers information on the cement sector, which has been primarily compiled from a wide array of publicly available sources and published literature. In some cases, this information is supplemented by the knowledge and opinions of IIP’s expert network.

The app contains sector-specific information, which includes an introduction to the most relevant characteristics of the sector including its size, its importance in terms of its energy consumption and GHG emissions, as well as estimated potential for technical improvements for improved energy and carbon efficiency. A typical flow diagram with the main production processes is designed to allow users quickly access some of the information, as well as understand major industrial processes for non-technical experts.

The information under the app is classified under six key tabs as following:

(i) Technologies & Resources

(a) Cement Technologies

Technologies cover technical and/or operational practices that can be used to improve productivity and reduce energy consumption and emissions. A wide range of options are included such as:

• Operational practices, that can be implemented without any major changes in the physical setting of the plant;
• Retrofit components or systems refer to technical elements that are added to the existing plant infrastructure to enable an improvement;
• New equipment or system refers to substitution of one or more equipment used within a process
• Material substitution includes partial or complete substitution of conventional inputs with better performing alternatives
• New processes includes a new set of technologies/activities the output of which is either the same as, or can be a substitute to, the output of an incumbent process.

For each technology/measure, the following types of information is provided:

Technology/Measures Description

This is a description of the key and distinct characteristics of the technology or measure that can help reduce energy consumption and CO₂ emissions. Co-benefits or non-energy benefits, such as enhanced productivity, reduced maintenance costs, improved product quality, and reduced environmental impact offered by the technology or measure are also included in the description, whenever possible.
Energy Savings

Information is provided on the reductions in different forms of energy use (e.g., electricity, heat, fuel) that can be enabled by the technology or measure. These values are primarily extracted from literature and are often reported in the form of specific energy savings – such as GJ/t-clinker or kWh/t-hot metal. In some cases, saving potentials are also reported as cumulative annual savings achieved in a plant with a particular size or as the total saving that can be achieved with the application of this technology at different scales (e.g., national or global). In order to maintain consistency and allow comparisons, unit conversions are performed on the values reported in the literature.

CO₂ Reductions

In this section, information on the potential reductions in CO₂ emissions that can be achieved with the implementation of the technology or measure is provided. In the majority of the cases, these figures have been extracted from various literature sources. In a limited number of cases, CO₂ reduction potentials are calculated based on the energy saving potentials and country and sector specific emission factors are reported. As the CO₂ emissions may differ depending on the context specific factors – such as the characteristics of dominant raw materials and fuels and prevailing electricity supply system characteristics – whenever possible, the country for which the CO₂ saving potentials are realized/estimated is also reported.

Costs

In this section, available information on the implementation and operational costs of the technology or measure is reported. Whenever possible, additional information on cost savings, payback times, and other financial indicators such as internal rate of return (IRR) or Return on Investment (ROI) are also included. In the majority of the cases, these figures are reported as they appear in literature, without any further processing (other than basic unit conversion).

It should be noted that technology/measure specific information is offered as guidance. Gains and costs that can be realized in individual sites will require site-specific assessments. It should also be noted that a large majority of the technologies/measures included in the database will also enable facilities to realize additional co-benefits or non-energy benefits such as improved product quality, enhanced productivity, reduced input and maintenance costs. These benefits are not quantified in the current version of the database but instead mentioned qualitatively.

(b) Processes

Processes are a distinct set of activities necessary for the production of an intermediate or final product, or inputs into another process. A brief description of the main processes commonly used in the sector is provided.

(c) Products, Publications and Tools

A wide range of resources that provide further information on the technology/measure is provided in the database. These include reports, guidelines, standards, reference documents, peer reviewed publications, websites, presentations, animations, case studies and company experiences.
(ii) Key Data
Detailed data is presented on areas such as trends and current levels of production, the sector’s position in the overall industrial energy use and CO₂ emissions, energy savings and GHG mitigation potential, and key countries and/or players in the sector.

(iii) Benchmarks
Benchmarks include information on best performance levels reported in the literature, broken to the level of main processes employed within a sector.

(iv) Organizations
In the organizations section, information is provided on the main organizations, whose work and/or objectives focus on improving energy efficiency and productivity in the sectors and areas covered in this database. Here both global and national organizations and programs are included.

(v) Programs
In the programs section, major global programs and schemes with the objective of improving energy efficiency and productivity in the sectors have been covered.

(vi) Service Providers
This section provides the list of service providers listed with Bureau of Energy Efficiency for the Sector

Currently the database covers information on the cement sector but we shortly plan to include other sectors. The information contained in the database is primarily compiled from a wide array of publicly available sources and published literature.

This database is an initial step towards creating a platform for easy access to relevant and reliable information. Currently this app is available on android operating system and has been developed for the Cement sector, but there is a plan to extend it for other industry sectors and iOS platform in due course.

The App can be downloaded from Google Play store by following the link: https://play.google.com/store/apps/details?id=com.iipnet
The 2nd ‘National Workshop cum Technology Exhibition for Promoting Energy Efficient and Cleaner Production for Sustainable Industrial Growth’ was organized by Knowledge Exchange Platform (KEP) initiative on 8th and 9th March, 2018 at India Habitat Centre, New Delhi. This workshop is second in series to be organized under the Knowledge Exchange Platform (KEP) initiative (http://knowledgeplatform.in/events/cross-sectoral-workshop-cum-exhibition/), for promoting cross-sectoral exchange of best practices, technologies and approaches on energy efficiency in the industries covered under the PAT scheme. This event was organized with a focus on creating awareness, building capacity and to facilitate access of the industry to reliable and efficient technologies, service providers and financing opportunities for enhancing energy efficiency in the industry and the building sectors. The theme and objective of this workshop cum technology exhibition was particularly important for the industries covered under the 2nd and 3rd PAT cycle as well as those proposed to be covered in future PAT cycles with the following specific objectives:

- **Catalyse cross sectoral exchange of best practices, tools, techniques and experiences** in energy management practices/approaches along with their impact that have high possibility of replication across sectors.
- **Create exposure to nationally and internationally available innovative and cutting edge technologies and practices** that can support industry in meeting the future energy efficiency targets.
- **Facilitate Technology transfer and B2B interaction** with technology suppliers to assess their applicability, cost and performance parameters in the Indian context.
- **Creating awareness on the provisions of PAT** to help the industry in meeting the requirements under the scheme.
- **Creating awareness about the new financing and business models** for promoting energy efficiency.

The workshop was inaugurated by Mr. Abhay Bakre, Director General, Bureau of Energy Efficiency. In his inaugural address, he mentioned that he is enthused with the proactive participation of the industry in the event and also felt that an initiative like KEP can help the industry improve their performance on a continuous basis which was particularly important under the rolling cycle of PAT. He said that it was good to note that KEP has been able to catalyse the transfer of best practices and technologies within and across the industry sector. Cross-sectoral knowledge transfer and peer-to-peer learning has been high on BEE’s agenda and he hoped that KEP would continue to leverage the platform to promote exchange of best practices and enhance access of Indian industry to national as well as international best practices and technologies. He mentioned that BEE is currently organizing technical committee meetings for different PAT sectors and he would encourage the industry participants to provide their input to BEE so that the committee can come up with robust target setting, normalization and M&V parameters.

Mr. Abhay Bakre, Director General, Bureau of Energy Efficiency, also released the mobile application DaKShaTA, which is a Database for Knowledge Sharing on Technological Advancements. DaKShaTA is an app (available on google playstore) that aims to help industry identify technologies and measures for enhancing energy efficiency, improving productivity and reducing CO₂ emissions, while assessing the cost-effectiveness of energy efficiency investment options. Currently this app is available on android operating system and has been developed for the Cement sector, but there is a plan to extend it for other industry sectors and iOS platform in due course.

Welcome address and introduction to the workshop was given by Mr. Somnath Bhattacherjee, Director, Institute for Industrial Productivity. He mentioned that KEP has always endeavored to come up with new and innovative solutions and technology features to remain responsive to industry’s needs particularly as new challenges and issues are emerging under the rolling cycle of PAT. Mr. Harish Chatterjee, Vice President (Manufacturing), Raymond Limited, delivered the Special Address at the...
Inaugural ceremony. He mentioned that with an increasing role of Indian Industry in the global market, it was important that the industries adopted the best available global technologies and standards to enhance their competitiveness and platform like KEP can help industries achieve this. Mr. S.K. Wali, Whole Time Director, J K Lakshmi Cement Limited, delivered the Special Address at the inaugural ceremony. He mentioned that the only way forward for the Indian Industry was to adopt a more energy efficient and sustainable pathway to remain competitive in the global market. He also said that there is no such concept as rock bottom when it comes to improving energy performance in an industry and corroborated his statement by giving example of the Cement industry where he mentioned that a decade ago, the current level of energy performance (SEC) of the cement industry was unthinkable, but the industry made it happen. He mentioned that the Industry needs to continue with this drive and explore new options for enhancing their energy productivity and resource conservation.

Special address was delivered by Ms. Sandy Sheard, Counsellor for Energy, Climate & Growth Unit, British High Commission (BHC). She mentioned that the UK Government supports Indian Government’s actions for enhancing energy efficiency through initiatives like PAT and feel that knowledge sharing and UK-India technology/best practice transfer can play a major role in promoting this agenda. She mentioned that the UK Government has launched industrial de-carbonization and energy efficiency action plans setting out Government and Industry commitments to reduce GHG emissions and improve energy efficiency. The action plans under this initiative are the result of joint working between Government and Industry to identify voluntary commitments from all parties to enable different industry sectors decarbonize till 2050. She mentioned that BHC would continue to work alongside BEE to enhance energy efficiency of the Indian Industry in line with their mandate for promoting energy security.

The Technology and Poster Exhibition was inaugurated by the Hon'ble Chief Guest, Mr. Abhay Bakre, Director General, Bureau of Energy Efficiency. The technology exhibition had participation from ARMEC Cooling Tower Private Limited, Arvind Envisol Private Limited, Arvind Limited, Atlas Copco (India) Limited, Bristol BlueGreen Ltd, Delta Power Solutions (India) Pvt Ltd., Energy Efficiency Services Limited, IKN Engineering India Pvt Ltd, Invotech Solutions and Systems, JK Lakshmi Cement Limited, Mechwell Industries Ltd, Power Star, Raymond Limited and SEAe Energy. The Poster exhibition showcased 40 posters that represented the best practice examples and technologies. This exhibition provided an exposure to the participants...
on the new technologies and practices and their impacts in the form of payback, energy savings, resource conservation benefits etc.

The inaugural event was followed by three technical sessions. The first technical session was chaired by Dr. Anupam Agnihotri, Director, Jawaharlal Nehru Aluminium Research Development and Design Centre. The discussion in the session focused on achievements and learnings from PAT Cycle 1 and creating opportunity for energy efficient industrial growth under the 2nd and 3rd PAT cycle.

Dr. Ashok Kumar, Director, Bureau of Energy Efficiency, in his presentation mentioned about India’s commitment under NDCs is to reduce emission intensity by 33-35% by 2030 compared to 2005 level and PAT scheme is expected to contribute a substantial proportion of this target. While explaining, why it is important for Indian Industries to adopt energy efficient practices/technologies, he also presented the benefits and the impact achieved under the 1st PAT Cycle. The presentation by Ms. Ritu Bharadwaj, Chief of Program, Institute for Industrial Productivity, focused on the actions taken so far under KEP and plans for enhancing the scope and effectiveness of KEP to become more responsive to industry needs particularly as they are moving into subsequent cycles of PAT.

The second technical session was focused on Scope of International Technology Transfer to facilitate Industry in achieving PAT Targets, which was chaired by Mr. Paul Silcock, Chief Technical Officer, Bristol BlueGreen Limited. This session was planned in a manner that it brought together the international technology providers and industry representatives with a view to promote interactions between the two stakeholder groups that can help in facilitating adoption of cleaner technologies. The session had presentations on technologies available for various operating areas viz. electrical saving through voltage management, solutions to improve upon energy efficiency in compressed air system by Atlas Copco, Flexibuster™ technology that turns organic waste into energy exactly at the point where the waste is produced and the energy is required by SEAb Energy Limited, enhanced Waste Heat Recovery (WHR) generation from IKN Cooler by IKN Engineering India Private Limited and opportunities of saving energy via Automatic voltage controller/optimisation system by Power Star.

The third technical session was focused on Small Group Activity (SGA), which is an in-house approach to achieving Continuous Energy Efficiency Improvement, which was chaired by Mr. K. K. Chakarvarti, Expert Consultant & Senior Advisor- KEP. The industries that shared their experience in this session included JK Lakshmi Cement Limited, Sirohi&Durg plant, Vedanta

The second day of the workshop focused on exchanging the best practices adopted to enhance the energy efficiency index in electrical and thermal utilities and technology solutions to enhance the energy efficiency index by technology suppliers. The fourth technical session was focused on sharing of best practices in energy efficiency in electrical utilities. This session was chaired by Mr. K. N. Rao, Director (Energy & Environment), ACC Limited and had presentations from Energy Efficiency Services Limited, UltraTech Cement Limited Unit - Rawan Cement Works, ACC Limited, Arvind Limited, Nabha Power Limited, Raymond Limited and Bhushan Steel Limited.

The fifth technical session (Part 1) was focused on technology solutions to enhance the energy efficiency index in process and thermal utility, was chaired by Mr. Harish Chatterjee, Vice President (Manufacturing), Raymond Limited.

The session had presentations on technologies available for various process areas viz., applications of Computational Fluid Dynamics (CFD) and heat pumps in industries by Mechwell Industries Limited, energy efficient cooling system by Armech Cooling Towers, energy efficient evaporation technology by Arvind Envisol Limited, energy savings that can be achieved through false air reduction by Invotech Solutions and Systems and enhancing the power quality by Delta Power Solutions (India) Private Limited. The Part 2 of this session was chaired by Dr. Ashwani Pahuja, Executive Director, Dalmia Cement (Bharat) Limited. This session had presentations on electrifying power generation solutions by GE Power, efficient steam utilization systems in Pulp & Paper industry by Central Pulp & Paper Research Institute (CPPRI) and Spent Pot Liner (SPL) utilization in cement & steel industry by Vedanta Limited.

The sixth technical session was focused on best practices in energy efficiency in thermal utilities, process & cross sectoral application, was chaired by Mr. S.P. Garnaik, Chief General Manager, Energy Efficiency Services Limited. The session had presentations on Technological interventions in low temperature heating and cooling by SEE-Tech Solutions, benchmarking to accelerate energy efficiency in cement, thermal power plant and pulp & paper industry by Confederation of Indian Industry (CII) and energy efficiency opportunities in dairy industry by Umgang Dairies Limited, best practices pertaining to cross –sector application by Seshasayee Paper and Boards Limited, alternate operation of aerators fans in sewage and effluent plants by Ankur Textiles, A Division of Arvind Limited and energy conservation measures in refinery and process industry by Engineers India Limited (EIL).

The technical sessions was followed by a Concluding session which was presided over by Mr. Pankaj Kumar, Secretary, Bureau of Energy Efficiency. He mentioned that BEE has initiated the KEP program with the view to promote energy efficiency and energy management systems approach as means of achieving continuous improvement in energy performance of the industry sector in partnership with IIP. Given the success of the initiative so far, BEE has recently extended its MoU with IIP. He mentioned that BEE through the PAT scheme aims to enhance productivity and also contribute to India’s Nationally Determined Contributions (NDCs).

The two day workshop had participation from over 280 distinguished speakers, eminent industry leaders, representatives of aluminium, automobile, cement, chemical, chlor-alkali, dairy, DISCOMs fertilizer, glass, hospital, hotels, pulp & paper, iron & steel, ordnance factory, railway, refineries, sugar, textile, thermal power sectors, energy auditors and energy managers, Government agencies, State Designated Agencies, Industry associations, technology and service providers, and senior industry professionals amongst many others. Various industries and organizations from United Kingdom(UK) also participated in the event, viz, British Electro technical and Allied Manufacturers Association (BEAMA), Bristol BlueGreen Limited, Uniper, Orxa Grid, Kigg Limited, Department for International Trade -UK, British High Commission, Power Star, SeAB Energy, Clarke Energy and UK India Business Council.
Awards for Outstanding Contribution

The workshop also recognized the contribution of the participating speakers, technology exhibition and poster exhibition through an award ceremony. The awards to the technology & poster exhibition were given based on the feedback of the participants. A jury comprising of senior industry representatives was formed to adjudge the speakers of technical sessions. The ceremony also recognized the contribution of the Small Group Activity team members for their efforts towards enhancing the Industrial Energy Efficiency. The winners under these categories are as follows:

Technology Exhibition:

- 1st Prize - JK Lakshmi Cement Limited
- 2nd Prize - Delta Power Solutions
- 2nd Prize - Atlas Copco (India) Limited
Comments and feedback welcome:
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