Message

Warm greetings for 2015 with the inaugural issue of this Newsletter!

We have increasingly come to realise the fact that ‘knowledge’ is a significant driving force for promoting growth and development. In this context, the promotion of knowledge transfer for accelerating industrial energy efficiency through the Knowledge Exchange Platform initiative assumes significance. At the heart of this initiative is promoting collaborations among industries to bring about an exchange of learning’s with their peers and build partnerships that will bring in international best practices and technologies.

We intend to use this newsletter as a tool to promote this agenda by providing a Forum for sharing industry’s experience, bringing reviews on new technologies and linking up with important stakeholders in the energy efficiency space.

Significant work has been done by the industry and we want to add momentum to this effort by teaming up with industry leaders and outstanding performers to create a knowledge community. The recently concluded National Energy Conservation Day on 14th December, 2014, where the Hon’ble Union Minister of State (Independent Charge) for Power, Coal and New & Renewable Energy, Shri Piyush Goyal, handed over prizes to the National Energy Conservation Award winners is evidence of the fact that there are large numbers of such energy leaders within our industry.

This newsletter covers success stories, which have been carefully selected from two sectors and represent the best examples of energy efficiency projects. By presenting them we hope to illustrate the potential for gains in energy efficiency and their impact over a range of applications across sectors. To accelerate the move towards an increase in energy efficiency in the country, these projects have to be scaled up and integrated into the mainstream development strategy of the industry.

This newsletter also bring to you the experience of leading industries in implementing energy management approaches under ISO 50001, as well as the voices of some industry leaders who have benefitted from it. The newsletter will also have a section carrying the opinion and voices from various industry associations. In this inaugural issue, we have covered the views of Fertiliser Association of India.

We will continue our effort to connect the industry partners with best available technologies, practices and knowledge through this newsletter, and other activities forming part of the Knowledge Exchange Platform. However, to be effective and to make this platform responsive to industry needs, we also require participation and support from industry. I am quite hopeful that KEP will develop into an influential and vibrant platform for promoting energy management system in the industry sector.

Ajay Mathur
Knowledge Exchange Platform to Accelerate Industrial Energy Efficiency in India

The Indian industry, in general, is highly energy intensive compared to other industrialized countries; however, the energy efficiency of some of the well performing units in certain sectors is comparable to their counterparts in developed countries. The major area of concern is the large bandwidth in specific energy consumption within a given sector between the better performing units and the worst ones. Further, in some sectors, although significant achievements in terms of improvements in energy efficiency & productivity have been made in the past, the improvement graph have become almost flat and the industry is desperately seeking information on innovative approaches and new opportunities to take them to the next level. This will increasingly become important in the subsequent cycles of Perform Achieve and Trade (PAT).

In order to capitalize on the above opportunities Bureau of Energy Efficiency (BEE) in Partnership with Institute for Industrial Productivity (IIP) is creating a knowledge exchange platform (KEP) for promoting energy efficiency and Energy Management System (EnMS), as a means of achieving continuous improvement in energy efficiency in the industry sector. This is proposed to be achieved through the following specific objectives:

- Facilitate exchange of knowledge and information within a particular industry sector to help the lagging industrial units (and encourage peer to peer learning) improve the efficiency of their operations and narrow down the SEC bandwidth.
- Facilitate exchange of energy management best practices across sectors in common areas like utilities, where there is a high possibility of replication.
- Facilitate sharing of information/capacity building on upcoming approaches to energy management and to new and innovative technological choices for promoting energy efficiency available at the international level.

The knowledge exchange platform (KEP) is proposed to be anchored at Bureau of Energy Efficiency (BEE) and supported by a Secretariat, Technical Expert/Resource Pool and an Advisory Group for operation and facilitating various activities. The overall aim of the project is to make it effective, vibrant and responsive to the needs of the Industry/Industry associations. KEP will support and facilitate partnership in a range of ways i.e. between industry and government at one end and collaborative work amongst the industry partners at one end. The Secretariat will be responsible for facilitating organization of various activities that may include, but not limited to:

- Technology partnership within Industry Associations. Facilitate knowledge exchange around effective technologies/tools/processes etc. in the focus PAT sectors by creating Sector Learning Groups and through the Sectoral Industry Associations (CMA, FAI etc.) for its outreach and rapid uptake.
- Create Network/Forum of Industry Associations. To promote cross sectoral knowledge transfer, a Network/Forum consisting of Sectoral Industry Associations (of targeted PAT sectors) will be created. The partner Industry associations will be able to access the information about technology/best practices of other Industry Associations that could be applicable in their sectors, improve access to new ideas and network of technology suppliers.
- Training and Capacity Building. The initiative proposes to use the existing Centers of Excellence and expert organizations to engage with the industry through effective means like (a) sensitization workshops, (b) brainstorming meetings, (c) training programs (d) webinars.
- Periodic discussion and dialogue between BEE and Industry members. The proposed platform would facilitate sustained periodic discussions and dialogue between BEE, Industry and other relevant stakeholders to seek views and feedback from the industry, raising awareness regarding policy directives and improving preparedness among the industry to implement energy efficiency targets and Energy Management Systems.

Significant work has been done by the industry in the area of energy efficiency and KEP intends to add momentum to these efforts by creating collaboration for transfer of industry experiences, best practices, experiences and technologies. KEP will facilitate capacity building and network with service providers, experts, research institutions for uptake of new technologies by industry. This will call for industry participation in SLGs, FOIA and round table discussions, willingness to share their knowledge and constant feedback and suggestion to enhance the effectiveness of the platform. The idea is also to make it self-sustaining by being relevant to the industry and providing value added service for promoting energy efficiency and energy management approaches. To this effect, this initiative will aim to devise appropriate revenue models in collaboration with the industry, in the long run, so that the platform continues to support sustainable industrial growth beyond the period of project assistance.
ISO 50001: Industry's Perspective

Experiences of ACC Limited

ACC: A brief

The journey of ACC started in 1936 when ten cement companies merged to form a single entity that was aptly named “The Associated Cement Companies Limited”. In 2006, company’s name was changed to ACC Limited. Today, ACC is a part of the Holcim group which owns 50.01% of total equity. ACC operates 17 cement factories, 47 concrete plants, 26 offices including registered, regional and sales offices across India with its corporate office in Mumbai. All ACC’s manufacturing set-ups have been ISO 9000 and ISO 14000 certified for a long time.

ISO 50001

ISO 50001 was released by the ISO in June 2011. The system is modelled after the ISO 9001 Quality Management System and the ISO 14001 Environmental Management System (EMS). It was anticipated that by implementing ISO 9001 and 14001 an organization would, in fact, improve quality and environmental performance, but the standards do not specify it as a requirement. ISO 50001, therefore, has made a major leap forward in ‘raising the bar’ by requiring an organization to demonstrate that they have improved their energy performance. There are no quantitative targets specified - an organization chooses its own, then creates an action plan to reach the target. With this structured approach, an organization is more likely to see some tangible financial benefits.

ACC’s ISO 50001 Journey

ACC started the journey towards implementing ISO 50001 in 2012, and at present, most of ACC plants are ISO 50001 certified. ACC plants were among those from the cement industry that led the initiative to implement ISO 50001. With systems and processes in place, and much experience with ISO 9000 and ISO 14000 systems, it was rather simple to implement ISO 50001, and percolated smoothly through the organization; benefits were also reaped quickly.

Salient benefits reaped by implementing ISO 50001

- People started observing day-to-day variations in energy consumption by using CUSUM charts and started predicting future energy use which strengthened the planning process
- The process of communicating with the masses was streamlined, with charts and tables capturing and displaying energy consumption according to pre-designed templates and timelines.
- Visible cultural shift towards initiatives aimed at energy conservation in line with the energy conservation policy.
- Streamlining of audits as per pre-determined timelines
- Better monitoring through better structuring of Encon projects leading to better execution and reduced implementation time. Evaluation, after implementation, helped lesson-learning for future projects.
- Quality circles on shop-floor levels motivated employees towards more energy conservation measures, not only in the plant, but also in their communities.

Organizations of all types and sizes increasingly want to reduce the amount of energy they consume. This is driven by the need or desire to:

- Reduce costs
- Reduce the impact of rising costs,
- Meet legislative or self-imposed carbon targets,
- Reduce reliance on fossil fuels, and,
- Enhance the entity’s reputation as a socially responsible organization.

In tandem, governments increasingly want to reduce the greenhouse gas emissions of their citizens and industries, and are imposing legislative mechanisms to compel greater carbon reduction.

ISO 50001 is a system which can help organizations to achieve these objectives, and also help achieve PAT targets.
UltraTech Cement’s Energy Management Journey

Cement manufacturing is an energy intensive process. Hence, it makes good business sense to have a structured energy management program. UltraTech Cement Limited (UTCL) had adopted the ISO 14001 at all its 12 integrated cement manufacturing units in India and also had energy review committees at these locations. A detailed structured process to measure, review and manage energy consumption was required to strengthen its focus. Since UTCL has been proactive in adopting global systems and benchmarking against them, it was decided to implement ISO 50001 in 2011.

For UltraTech, ISO 50001 provided a platform to develop and implement an energy policy, establish objectives, targets and action plans, which take into account legal requirements and information related to significant energy use.

The process involved developing a cross functional energy team, with members from all energy intensive/non-intensive areas in a plant. It helped to:

- Define energy baselines for different areas in the plant so as to present a clear and comprehensive picture of energy consumption type wise – power, fuel type, etc.
- Define an energy review, that is define all energy consuming equipment with specifications.
- Provide energy metering, wherever not available, for effective and efficient monitoring.

The energy team was responsible for conducting energy audits, identifying losses, finding solutions and improving energy efficiency. The team also had to define an energy baseline, that is energy intensity (area/section level), followed by an initial energy review, area wise and at equipment level (even for offices).

All these steps compelled the team to consider all possible angles, for example, new equipment purchase, modification of existing layouts, change of design, etc.

The road was not always smooth: one major challenge was training the entire energy team on the application of ISO 50001 (EnMS). An in-house training program was conducted using experts from outside the factory. Another complex task was establishing an accurate energy baseline which required time, knowledge, dedication and motivation. Support and commitment from the leadership team helped tide over these challenges.

The exercise had multiple benefits, the most significant being a change in the approach of all employees towards energy management. It also improved the carbon footprint of the organization. UTCL is improving and marching forward on a green and sustainable path to growth, with four units already certified to ISO 50001, and more on their way.

“Implementation of ISO 50001:2011 (EnMS) has given a structure to the energy consumption activities. The implementation helped to identify and prioritize the main energy consuming activities and equipments. It has helped to devise a system for close monitoring of such processes and take informed decisions regarding any change in pattern of energy consumption. It also helped to improve operational efficiencies and brought about a change in maintenance as well as procurement procedure. The implementation of EnMS also improved the awareness of employees and associates about energy consumption. Overall the implementation has helped the brand image of the company by giving a positive impetus and increased its credibility among all stakeholders.” - Mr. Rajendra Nandi, Project Director, Dahanu Thermal Power Station, Reliance Infrastructure Limited

“By maintaining and improving the energy management system in accordance with ISO 50001:2011 reaps the benefits of Increase Energy Cost Savings by Reducing Energy Costs via a Structured Approach to manage our Energy Consumption thereby achieving Energy Conservation…; Improved Operational Efficiencies, Energy Efficiencies and Maintenance practices; Enhanced Energy Performance throughout the Supply Chain with Energy Efficient Procurement & Services.” - Mr. R Jayakumar, Executive Vice President (Works), DCW Limited, Sahupuram
Introduction
India is the second largest consumer of aluminium in Asia with an aluminium usage (primary plus secondary) of around 2.5 million tonnes (mt) in 2012. The largest users of aluminium are the electrical and electronics sector followed by the automotive sector and transportation; building and construction; packaging; consumer durables; and other applications, including defence.

The primary aluminium demand in India is expected to reach 6 million tonnes, from the current demand of 1.8 million tonnes, by 2025. This equates to a consumption of about 4.1 kg per capita compared to 1.5 kg per capita today, indicating a large growth in demand.

Process
Commercially, bauxite is the most important ore of aluminium as it has the highest content of the base metal. The primary aluminium production process consists of three stages: the first is mining of bauxite, followed by refining to alumina and, finally, smelting of alumina to aluminium.

India has the world’s fifth largest bauxite reserves with deposits of about 3 billion tonnes, or 5% of the world’s deposits. India’s share in the overall production of aluminium is about 3%. Producing one tonne of aluminium requires 2 tonnes of alumina, and producing one tonne of alumina requires 2 to 3 tonnes of bauxite.

Energy Intensity
The cost of power is about the largest component of cost in aluminium manufacture because electrolysis is used in the process. The amount of energy typically used in different sub-processes is shown in Figure 1.

Smelting consumes about 72% of the all energy used during the manufacture of aluminium, in the form of electricity; 13,000 to 14,500 kWh/t of electrical energy are required for smelting, depending on the amperage of operating pots. In India, aluminium smelter units have cell amperages ranging from 65,000 to 360,000. Most smelters have shifted from the less energy efficient Soderberg technology to prebaked cell technology. (Source: PAT Booklet)

Perform, Achieve and Trade (PAT) Scheme
The aluminium industry is a Designated Energy Consumer and covered by the Perform, Achieve and Trade (PAT) scheme of the Bureau of Energy Efficiency. The key goal of the PAT scheme is to mandate specific energy efficiency improvements for the most energy-intensive industries.

Ten Designated Consumers (four smelters, four alumina refineries, one integrated plant and one sheet roll plant) covered in the PAT Scheme are expected to achieve energy savings of 0.456 million tonnes of oil equivalent, which is 7% of the total energy savings potential that 478 Designated Consumers aim to achieve by 2014-15; measures have already been taken by these consumers to achieve the notified targets. (Source: PAT Booklet)

The Sesa Sterlite Limited, Aluminium Smelter Plant in Jharsuguda employs the latest, one-of-its-kind technology. It operates at the pot line current level of 327 kA, which is above design current of 325 kA. Notwithstanding its adoption of the latest technology, Sesa Sterlite Ltd. has also undertaken in-house programs to improve its specific energy consumption performance and has shown continuous improvement in its energy performance indicators. The plant has also received National Energy Conservation Awards by BEE, MoP, and the Excellent Energy Efficient Unit Award given by CII in 2013, and 2014, for its efforts to conserve energy and for its innovative best practices. In view of its significant efforts in the aluminium sector, this plant makes an apt case for study.

Success Story: Sesa Sterlite Limited (Aluminium Smelter Plant), Jharsuguda

Sesa Sterlite Limited (SSL), Jharsuguda, is a leading producer of aluminium products such as ingots, wire rods and billets, which cater to a wide spectrum of industries. The firm operates a 0.5 mtpa (million tonne per annum) aluminium smelter and a 1215 MW captive power plant supported by highly modern infrastructure. In addition to this, a 1.25 mtpa aluminium smelter expansion project at Jharsuguda is going to be commissioned shortly.

The operational areas of the plant include the green anode, bake oven, rodding...
A snapshot of energy consumption in the plant from 2011-2014 is given in **Table 1**.

A total of 35 energy saving projects have been implemented by Sesa Sterlite Limited in the last four years generating savings of nearly 200 kWh/t of aluminium produced. An independent external agency, First Climate, carried out a carbon footprint study of the unit and it has now taken on the challenge of reducing CO₂ emissions by 5% from the baseline year FY 12-13, by FY 2014-15. Of this 5%, it has already achieved a 2.3% reduction in CO₂ emissions from the baseline 2013-14.

Of the different in-house programs implemented in this plant, the use of slotted anodes led it to win the National Energy Conservation Award in 2013 given by the Bureau of Energy Efficiency, Ministry of Power, Government of India and ‘Best Energy Efficient project realized abroad’ in ENE’S’ 2014 organized by the Ministry of Energy, Government of Russia. This project was designed, conceived and implemented in-house and helped a large reduction in the consumption of power and non-renewable resources with a relatively small investment. In view of these achievements, it will be helpful to document the company’s approach and the benefits accruing to it.

The production of aluminium is highly energy intensive and the expense on energy accounts for nearly 40% of the total production cost. This energy is in the form of electricity used in the electrolysis of alumina to produce aluminium metal and to maintain a thermal balance in the pot. The reduction of alumina to aluminium consumes about 14.5 MWh/t of aluminium produced.

SSL wanted to reduce its consumption of DC energy which would help strengthen its position among aluminium producers in India. As shown in **Figure 2**, one major consumer of DC energy in the electrolytic process is the bath drop, the voltage drop across the electrolyte (bath), which is 36.9%. This large drop occurs because bubbles gather under the surface of the anodes and increase resistance to the flow of current.

The specific production of CO₂ gas was 1.3 to 1.6 t/t-Al covering 50 to 90% of the anode bottom which leads to high bubble resistance and directly impacts Specific Power Consumption. If the anode gas bubble voltage drop could be minimized, the energy consumption would be reduced while maintaining optimal current efficiency (**Figure 3**).

A modified anode surface would effectively reduce both the bubble voltage drop and anode over voltage by facilitating gas release to reduce the gas bubble coverage: a larger surface would be available for electrolytic reactions at the anode.

### Designing of anodes
- Anode surface slots were not part of the technology provider’s original design. So, in-house design engineers calculated the slot height and slope appropriate for the modified anode. These anode surface slots would become a channel for release of bubbles.

### Innovative Project: Implementation of Slotted Anode in Aluminium Reduction Cell

The production of aluminium is highly energy intensive and the expense on energy accounts for nearly 40% of the total production cost. This energy is in the form of electricity used in the electrolysis of alumina to produce aluminium metal and to maintain a thermal balance in the pot. The reduction of alumina to aluminium consumes about 14.5 MWh/t of aluminium produced.

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• Straight slots may be a problem in gas evacuation and increasing the slot height would make the green anode fragile. Experiments and data analysis suggested that slanted slots would work better.

• Formation of a low density green anode would lead to excess coke dusting inside the pot, so the recipe of green anode formation was studied. Trials runs were made using different recipes and finally the one with optimum density and minimum coke dusting was finalized. The design of the vibro-compactor, used to form the anode, was modified and a slot height of 36% of anode height was finalized. A slot height of 210 mm on one side of the anode and 200 mm on the other side was provided, with tapering thicknesses of 20 mm and 19 mm respectively, as shown in Figure 4.

• If packing coke (used as the heat transfer mode in the bake oven when green anodes are heated to form baked anodes), is not removed, excess coke dusting occurs in pots. It was observed that after baking, packing coke was being deposited inside the slots, thus creating problems. Cleaning the slots was another problem which had to be addressed so as to stop the packing coke used in baking furnace from reaching the inside of the pot. To overcome this problem, a slot cleaning machine was installed in the bake oven which would remove this packing coke and clean the slots. These modifications led to clean slots and better reduction in the pot room (Figure 5).

The project was carried out in two phases. Initially, one section of a potline was selected out of 16 sections. Slotted anodes were put into the pots of the selected section and performance parameters monitored for three cycles. Promising results were obtained in this trial, so slotted anodes were placed throughout the potline. The entire project was done in-house with an investment of ₹1.5 lakh. The Figure 6 below illustrates the anode without slots, with slots and a slotted anode in a pot.

**Figure 4: Slotted anode configuration**

<table>
<thead>
<tr>
<th>Original anode</th>
<th>Slotted anode</th>
</tr>
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• Finalization of recipe for raw material
• Difficulty cleaning of slots
• Wastage of anode during trial
• Inspection of slots during initial design to optimize anode properties, as increasing slot height would make the green anode fragile
• Scrap generation increase in GAP and bake oven
• Training pot operators and crane operators to place anode slots correctly in the beginning.

**Table 2: Challenges in implementing this project**

**Figure 5: Impact of reducing bubble resistance**

**Figure 6: Normal and slotted anodes**

**Contribution of ISO 50001 Certification**

ISO 50001 guides the unit to plan any initiative with the PDCA (Plan-Do-Check-Act) approach. The same approach was used in implementing the project and refining of the findings.
there is no doubt that creativity is the most important human resource of all. without creativity, there would be no progress and we would be forever repeating the same patterns" these were the words of edward de bono. as a responsible Corporate Citizen, sesa sterlite Jharsuguda has always focused on reduction in energy consumption & emission of GHGs. Our young team has always strived to innovate and do something creative & new. the slotted anode project implementation has been one of the unique initiatives in that direction. My appreciations to the whole smelter team, who have designed and implemented the slotted anode project in-house without the involvement of any external expertise.

Mr. D. N. Behera,
Head, Smelter 1,
Sesa Sterlite Limited,
Jharsuguda

The implementation of slotted anodes in pots has resulted in bringing in more stability of pots, resulting in decrease in voltage drop across the pot and hence reducing the specific power consumption of pots. The projects was developed and delivered in-house and I feel very proud to have been associated with such a marvellous team. My heartfelt congratulations to the whole team on achieving such a milestone and for such a tremendous team effort and focus.

Mr. Abhijit Pati
President & COO,
Sesa Sterlite Limited,
Aluminium & Power Business Jharsuguda

“There is no doubt that creativity is the most important human resource of all. Without creativity, there would be no progress and we would be forever repeating the same patterns” these were the words of Edward de Bono. As a responsible Corporate Citizen, Sesa Sterlite Jharsuguda has always focused on reduction in energy consumption & emission of GHGs. Our young team has always strived to innovate and do something creative & new. The slotted anode project implementation has been one of the unique initiatives in that direction. My appreciations to the whole smelter team, who have designed and implemented the slotted anode project in-house without the involvement of any external expertise.

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Trial period 19 Oct 212 to 16 Jan 2013</th>
<th>Implementation period 17 Jan to 8 Jun 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net reduction in pot voltage</td>
<td>11 mV</td>
<td>21 mV</td>
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<tr>
<td>Net reduction in AEF</td>
<td>0.19 no./pot day</td>
<td>0.09 no./pot day</td>
</tr>
<tr>
<td>Net reduction in noise</td>
<td>1.66 mV</td>
<td>3.9 mV</td>
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<td>Net savings in power consumption</td>
<td>35.2 kWh/t (19.1 MU/year)</td>
<td>67.3 kWh/t (36.4 MU/year)</td>
</tr>
<tr>
<td>Net reduction in per fluorocarbon and CO₂ emissions</td>
<td>50% in trial section</td>
<td>30% in whole pot line</td>
</tr>
</tbody>
</table>
Best Practice Case Studies

National Fertilizers Limited, Vijaipur I & II

– Mr. A.K. Lahiri & Mr. S.N. Sinha, NFL, Vijaipur

Introduction

The fertilizer industry sector produces primary and secondary soil nutrients which are compounds of nitrogen, phosphorus, and potassium. In India, the fertilizer industry has undergone a revival in the last two decades or so, in terms of technology used, operating practices, efficiency and economy of operation. India is the world's third largest producer of fertilizers and, as of 2013-14, it had an installed capacity of 127.67 lakh tonnes of nitrogen, and 62.08 lakh tonnes of phosphate nutrient. The actual quantities produced were 123.78 lakh tonnes of nitrogen and 37.14 lakh tonnes of phosphate. Production of nitrogen and phosphate fertilizers grew by 1.5% and 4.9%, respectively (against a production of 121.94 lakh tonnes and 35.41 lakh tonnes, respectively, in 2012-13).

The capacity utilization during 2012-13 was 101.2% of nitrogen and 62.9% of phosphate, while corresponding figures for 2013-14 were 97.0% and 59.8%. The capacity utilization for urea plants was 108.8% in 2012-13, and 105.2% in 2013-14.

Process

The process followed for synthesis of ammonia is hydro-de-sulphurisation-primary reforming-secondary reforming-CO shift conversion-CO₂ removal-methanation-ammonia synthesis.

The urea synthesis process follows high pressure CO₂ compression & liquid ammonia pumping- high pressure synthesis & stripping- medium & low pressure ammonium carbamate decomposition- ammonium recovery & recycle- two stage vacuum concentration of urea solution-prilling.

The effluents generated in the system are treated in the waste water treatment section and the treated process condensate is sent to the demineralized water plant for recycling after polishing.

Energy Intensity

Urea is a major nitrogenous fertilizer alongside ammonium sulphate, ammonium chloride and ammonium nitrate. Ammonia and carbon dioxide combine to form urea. About 80% of the energy required to produce urea goes into the manufacture of ammonia. The feedstock used for ammonia production are natural gas, naphtha, and fuel oil. Natural gas is used both, as a fuel and raw material in fertilizer production. The fertilizer sector was the second largest consumer of natural gas in 2011-12, accounting for 25% of the country’s total consumption. The sector wise consumption of natural gas is shown in Figure 1.

The energy consumed by this sector has been estimated at 150.09 million Gcal annually. The specific energy consumption per tonne of urea varied between 5.16 Gcal/t, for the efficiently operating plant, to 12.51 Gcal/t for the most inefficient plant, during 2007-08. The fertilizer sector has made continuous efforts to improve the energy performance, and reduced the specific energy consumption from 8.24 Gcal/t in urea in 1990-91 to 6.00 Gcal/t in 2013-14. Most fertilizer manufacturing facilities have energy consumptions ranging between 5.25 and 6.0 Gcal/t. In terms of feedstock, natural gas-based fertilizer production is the most energy efficient, followed by naphtha-based fertilizers.

The sector is expected to achieve energy savings of 0.478 million tonnes of oil equivalent (toe) by the end of the first cycle of the Perform, Achieve and Trade (PAT) scheme of the Bureau of Energy Efficiency. The energy savings target for the fertilizer sector will contribute 7.15% to the total national target assessed under the PAT scheme.

Success Story: National Fertilizers Limited, Vijaipur

The National Fertilizers Limited (NFL) plant in Vijaipur, (District Guna, Madhya Pradesh), is one of four fertilizer manufacturing facilities of the NFL and started operating in July 1988; it currently has two 1520 tonnes per day (tpd) ammonia streams revamped to 1750 tpd and 1864 tpd feeding Urea I of 3030 tpd and Urea II of 3231 tpd capacity. The raw materials used include natural gas, naphtha, water and power; a captive

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1. Annual Report 2013-14, Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India
2. Practical Guide to Energy Conservation, PCRA
The raw materials for urea synthesis are ammonia (NH₃) and carbon dioxide (CO₂) both which are obtained in the process of the ammonia synthesis. The CO₂ stream from ammonia synthesis also contains small quantities of H₂, N₂, CH₄ and Ar gases. A small quantity of air is also introduced along with CO₂ during urea synthesis; oxygen in the air forms a layer over the stainless steel surface of the reactor vessel making it passive to corrosion.

The excess air, along with N₂, CH₄, H₂ and Ar, do not take part in any reaction and have to be vented out continuously. These off gases are vented out from the Medium Pressure (MP) section Inert Washing Column (C-3) to maintain the MP loop pressure. The actual layout of the entire scheme is shown in Figure 2. The characteristics and composition of the off gases are presented in Table 2.

The heat value of C-3 off gases can be recovered and used. A comprehensive study identified two potential application areas for this heat value: one, as a fuel in the ammonia plant, and, two, as a supplementary fuel in the HRSG boiler of the captive power plant. Further analysis by the technical services group led to a decision to use the gases as fuel in the HRSG boiler of the captive power plant because choking of burners and high NOx emissions were expected to result from usage as a fuel in the ammonia plant.

An in-house HAZOP (Hazard and Operatability) study recommended injecting around 100 Nm³/h of natural gas upstream of the MP condenser (E-7) in each of four streams of the urea plants. This would eliminate the formation of an explosive mixture by increasing the percentage of CH₄ in the C-3 off gas.

The following major modifications/installations were made:
- Separate line for introducing NG upstream of the MP condenser in the urea plant.
- Uninterrupted Supply Valve (USV)-cum-flow control valve fitted on the NG line, interlocking closure of the USV on closure of the CO₂ inlet valve to the reactor of a particular stream.
- Small separator provided on the C-3 off gas line to the CPP (at the CPP end) to prevent carryover of moisture and subsequent carbamate formation in the pipeline.
- Flow meter provided with flow indication in the CPP.
- Pressure control valve provided at the inlet of the separator to reduce pressure of C-3 off gas from 6 kg/cm² to 3.5 kg/cm².
- Pressure safety valve provided on pressure control valve downstream line.
- USVs provided on the off gas line and incorporation into trip interlock.

**Methodology adopted**

The steps followed were: initiation-planning, and design-execution–monitoring, and, control and closure. The project was implemented in phases and depended on in-house facilities to cut down the time taken and cost of implementation. In keeping with these considerations, two surplus separators were modified to meet the process requirement. All design calculations were carried out by the Process Engineering Section of the Technical Services Department.

**Challenges in implementation**

1. The oxygen content in off gas ranges between 6 and 10% making it possible for an explosive mixture to form. To eliminate any chance of this happening, it was proposed to inject around 100 Nm³/h of natural gas upstream of each MP condenser (E-7) in all the four streams of the urea plant. After continuous analysis of the gas mixture, the rate of injection of natural gas was later modified and reduced to 20 Nm³/h.

2. The second problem encountered was the disposal of ammonia condensate formed. For Vijaipur-I urea plant, a condensate separator was installed at the chemical handling and sludge removal (CP&O) plant and its separator outlet connected to the closed drain in the urea-I plant. An additional separator was proposed within the battery limits of the VP-II Urea plant and the condensate drain connected to the nearby CD header.

3. The third challenge was identifying an appropriate system for combustion of off gases. The technical group had two options, either using a dedicated burner or connecting the off gas line to the common header for NG. The composition of gas, turn down ratio of the burner and carbamate formation were three criteria considered to determine the most appropriate system. A detailed study suggested connecting the off gas to the common NG header near the burner would shorten the residence time and also avoid carbamate formation.

**Impacts and benefits**

1. **Specific energy consumed:** The consumption of natural gas decreased by 360 Sm³/h @ NCV of 8200 kcal/Sm³. This corresponds to a saving in specific energy consumption of 0.012 Gcal/t of urea at Vijaipur-I as well as Vijaipur-II, each.

2. **Greenhouse gas emissions:** Implementing the project avoided the release of 23500 tonnes of CO₂ annually, and comparatively lower NOx emissions than if off gases had been used in the primary reformer (ammonia synthesis).

A greater reduction in GHG emissions achieved because methane in the off gas is now no longer being directly vented to the atmosphere.

3. **Financial implications:** The total amount of money invested in implementing the project was about ₹70 lakhs. The monetary benefits achieved were Rs 5.12 crores/annum, assuming 330 on-stream days, and an energy cost of ₹2200/Gcal.

4. **Payback period:** The payback period is short, at 1.6 months, which makes the project attractive for replication and upscaling.

**Contribution of the project to PAT targets**

The PAT scheme targets for reducing specific energy consumption for Vijaipur-I and Vijaipur-II were, 0.088 Gcal/t urea and 0.03 Gcal/t urea, respectively. The savings realized contributed 15% and 43% to these targets.
A short interview:

**Shift In-charge Urea-I Plant**

Q. What is your opinion about the scheme of C3-off gas as supplementary fuel in HRSG boilers in Captive Power Plant?

Ans. The scheme is working fine and off gases are totally diverted to line going to CPP. No gas is being vented to atmosphere.

Q. What is your opinion about the safety inter locks provided and explosive triangle?

We are fully conversant with the safety interlocks and explosive triangle. Initially around 100 Nm$^3$/hr. NG was injected to keep the off-gas mixture out of explosive range/triangle. Now with experience and looking into the C-3 off gas analysis the NG flow rate has been reduced around 30 Nm$^3$/hr.

**Shift In charge, CPP**

Q. What is your opinion about benefit accrued on implementing the scheme?

A. We have been benefitted after implementing the scheme and total savings of NG are 350 Nm$^3$/hr. Also, it has resulted in environmental benefits.

Q. Are you aware of the safety interlocks provided?

A. Yes, we are fully conversant with the safety interlocks provided. In case of any interruption in Urea Plant operators are conversant with the action to be taken.

**Operator, Urea-II**

Q. Are you aware of the scheme and benefits?

A. Yes, we are aware of the scheme and its benefit from energy saving and environmental point of view.
Introduction

Industrial energy efficiency sits high on India’s policy agenda as an area to improve competitiveness and support green growth. To help realise this aim, in the light of important decisions on the Perform Achieve Trade (PAT) system, India is keen to learn lessons from the UK, where a number of measures have already been implemented to promote non-domestic energy efficiency.

Leading UK consultancy, Ricardo-AEA shares its insights on two central planks of industrial energy efficiency and emissions policy at work in the UK: Climate Change Agreements (CCAs) and the EU Emissions Trading System (EU ETS).

Climate Change Agreements

CCAs are voluntary agreements between industry sectors and UK government in which the industries receive a rebate on the UK energy tax in return for meeting energy efficiency targets. The agreements currently cover ~9,000 facilities across 51 sectors.

Engagement with industry throughout the setting of CCA targets has been critical to the success of the agreements. Targets are the result of negotiations between government and sector trade associations, a process that Ricardo-AEA has facilitated since the start of the scheme. Ricardo-AEA proposes targets based on knowledge of the sectors’ savings potential, other drivers for change and their historic performance. Sector trade associations either agree with the proposed targets or suggest revisions supported with evidence, which then informs the final negotiation and target agreement.

Once the target has been set, trade associations distribute allocations for meeting the target amongst individual facilities or groups of facilities within its membership. Importantly, the distribution of targets is within the sector’s own hands and can account for the differing levels of plant efficiency and improvement potential if it chooses.

Prior to 2013, the CCA targets were tested at the sector level and were connected with the UK Emissions Trading scheme (UKETS) with any underachievement being bought from the UKETS. However, to the uncertainty that surrounded the cost of underachievement and that this cost could be low, facilities now face a fixed charge of £12 per tonne of carbon produced over target. This provides facilities with certainty over costs and can underpin business plans for investment in energy saving measures.

EU Emissions Trading System (EU ETS)

The EU ETS is the world’s largest cap and trade system for industry and energy sector carbon emissions. The EU ETS has operated in three phases: Phase 1 (2005 – 2007), Phase 2 (2008 – 2012) and Phase 3 (2013 – 2020). Emissions caps in the first two phases were set by Member States subject to EU approval. Sectors received a free allocation of allowances based on estimated projections of future emissions, which were then allocated to installations based on their own historic emissions. A concern with this approach was that less efficient facilities were rewarded with larger free allowances, relative to those that were more efficient. Also, in Phase 1 the allowance allocation was too generous, as a result of inaccurate baselines used to form the policy. In Phase 2, the economic downturn led to reduced industrial activity that created an over-supply of units and also resulted in a carbon price crash.

To address these problems, the scheme was updated in Phase 3 to help the system encourage cost effective emissions reduction and improvements in energy efficiency. Emissions caps were set at EU rather than Member State level and free allocations were based on emissions intensity benchmarks related to over 50 specific activities, which were developed on close consultation with industry. Further measures are being implemented to address market oversupply.

Conclusion

So what do we take from these experiences? Both the CCAs and the EU ETS have been improved over the years, with experience in earlier phases informing the design of the later ones. These measures have helped UK industries become more energy efficient and more competitive internationally. For example in CCAs alone sectors with specific energy targets have made improvements against 2001 baselines of 10-40% in many cases. This progress is underpinned by UK technological capabilities. Early savings included high efficiency lighting, motors and drives, and improved pipework insulation. Later savings were made through more capital intensive measures such as improved heat recovery (e.g. ceramic kilns), Combined Heat and Power (e.g. in paper and chemicals sectors) and recuperative and regenerative burners (iron and steel sector).

Standardised target setting approaches are aimed at ensuring additional action that covers the sectors’ full technical, cost effective and realistic potential for energy savings. The close interaction between government and industry for CCAs helps underpin these targets and further encourages industry engagement with the system. The use of standardised performance benchmarks in EU ETS, or the CCA’s sector association administrated distribution of its target to its member enterprises, provide models for setting targets that recognise enterprises’ past action. These experiences will be increasingly important for India as the PAT system matures.
National Energy Conservation Day has been observed in India on 14th December every year since 1991. This day highlights the important role that citizens of India can play in ensuring energy security. It provides an opportunity to reach out to homes, offices and industries with the message of energy conservation and an attempt to influence their energy-consumption behavior.

The National Energy Conservation Awards instituted by the Bureau of Energy Efficiency, Ministry of Power, Government of India, recognize innovation and achievements in energy conservation by the industry, buildings, zonal railways, state designated agencies, manufacturers of BEE star-labelled appliances and municipalities, and raise awareness that energy conservation plays a big part in India’s effort to reduce global warming through energy savings. These awards have been the mainstay of the function ever since its inception in 1991. Awardees are presented a certificate and a trophy. There are four levels of trophies: first prize, second prize, top-rank award (to a unit that wins the first prize for three consecutive years), and excellence award (to a unit that wins a top rank award for two consecutive years).

The specific energy consumption of an applicant (or of the appliances sold by an applicant) compared to that of other applicants and the energy savings achieved due to implementation of energy efficiency project, in percentage of absolute energy consumption of the previous year are the two major parameters on which the award is based. Establishments having ISO 50001 Energy Management Systems are given extra weightage.

The President or the Prime Minister of India have been chief guests at past functions of the National Energy Conservation Day. In 2014, Awards were presented by Hon’ble Minister of State (Independent Charge) for Power, Coal and New & Renewable Energy, Shri Piyush Goyal. A total of 1,010 units had applied for the awards (compared to 829 last year); these applications were scrutinized and verified, and the awards were finalized by the Awards Committee. A total of 78 awards have been finalized by the jury, 41 first prizes and 37 second prizes which were presented to winning establishments on 14th December, 2014. Certificates of merit will be awarded to 44 other organizations in a separate function.

“India now produces 1 lakh crore units of electricity: if a 10% saving is made that can save 10,000 crore units, which is equivalent to Rs 50,000 crore savings which can be utilized for lighting the homes of 5 crore people of the country who are deprived of electricity” - Hon’ble Minister of State (Independent Charge) for Power, Coal and New & Renewable Energy, Shri Piyush Goyal
Introduction

The production of nitrogenous fertilizers is highly energy intensive. The raw materials for these fertilizers include hydrocarbons such as natural gas, naphtha, fuel oil or coal, and ammonia. Most of the energy required to produce fertilizers goes into the production of ammonia. Therefore, most efforts to conserve energy are focused upon making the production of ammonia energy efficient.

In India, there are 34 ammonia plants operating in the capacity range of 450 to 2000 metric tonnes per day (tpd) and which are between 16 and 49 years old. The modernization of ammonia plants by way of retrofitting and revamping has been a taking place continuously, over the years.

During the 1980s and early 1990s most old plants changed over configuration of the synthesis convertors from axial to radial or axial-radial; added units for hydrogen recovery from purge gas; installed reformer tubes of better metallurgy with thinner walls; used more efficient absorbents in the carbon dioxide removal section; replaced packing in absorption and regeneration towers to allow higher mass transfer; improved the recovery of waste heat in the convection sections of reformer furnaces; and changed from analog to digital instrumentation.

Some old plants were shut down for technoeconomic reasons and more efficient, large-scale plants were constructed.

The average energy efficiency of ammonia plants improved from 12.48 Gcal/t in 1987-88 to 9.30 Gcal/t ammonia in the year 2002-03. (Nand and Goswami 2009 and 2011)

Methodology for Measurement

The Fertiliser Association of India (FAI) has been monitoring the energy efficiency of each ammonia plant in the country since 1987-88. A favorable regulatory environment after 2002-03 encouraged the ammonia industry to invest in measures for improving energy efficiency and increasing production capacity.

The energy consumption in ammonia plant is the sum of three components: energy taken as feed (raw material) and fuel to the reformer; import/export of steam on the basis of its enthalpy; and import of power (conversion factor used, 1kWh = 2520 kcal). The consumption of power in utilities and offsite facilities such as water treatment, cooling towers, effluent treatment plants, is also added when estimating the energy consumption of an ammonia plant. All energy figures are on a Net Calorific Value (NCV) basis.

Recent Efforts In Energy Conservation

Over the past ten years, a large number of plants were revamped to increase higher capacity and improve energy efficiency. Typically, ammonia plants with a capacity of 1500 tpd were de-bottle necked to a capacity of 1800-2000 tpd. Measures to conserve energy included replacing heating coils with better heat transfer coils in the convection zone of reformer furnaces; adding one more shift converter to further reduce CO slip from the shift section; two-stage regeneration of solution in the CO₂ removal section; additional purification of synthesis gas by molecular sieve drying and ammonia wash; and replacement of heat exchangers in synthesis section.

A number of plants also refurbished and retrofitted the compressors and turbines. Synthesis gas and process air at the inlet of compressors were chilled by vapour absorption refrigeration (VAR) using low grade waste heat available in the plant. Some other important retrofits aimed at increasing the production capacity also led to savings in energy consumption; these included installation of reformer heat exchanger and additional synthesis converter.

Efforts to conserve energy were simultaneously made in urea plants. These included the use of high efficiency trays in the urea reactor, additional decomposers and two-stage concentration of urea solutions.

The operating philosophy was also changed to make operations more efficient; for example, small steam turbine driven compressors and pumps were changed to energy efficient electric motor drives. In addition to changes in the hardware, operations in fertilizer plants were optimized with advanced process control (APC) systems.

Results

All these measures reduced the weighted average energy consumption of the entire ammonia production process from 9.30 Gcal/t in 2002-03 to 8.45 Gcal/t ammonia in 2013-14 (Figure 1). The energy consumption of Indian ammonia plants for the year 2010-11 compared well with the average energy consumption of 8.75 Gcal/t determined during a survey of...
76 ammonia plants by the International Fertilizer Industry Association (IFa). The gas-based ammonia plants in India fared better than European plants and those in some other countries (Figure 2).

The energy consumed in producing urea came down from 6.59 Gcal/t of urea in 2002-03, to 6.00 Gcal/t of urea in 2013-14 (Figure 1).

Prospects for Improving Energy Efficiency

The industry has already explored and implemented energy saving measures with a payback period of up to five years. Now major capital investments are required to replace old equipment which have long pay back periods. The financial position of almost all urea plants is precarious with more than half reporting net losses in the last two years. Reasons include the under recovery of costs under various heads under present pricing policies, and higher interest costs due to undue delays in payment of industry dues by the government. Moreover, subsidies (which can be seen as a reimbursement of the production cost) amounting to about 75% of the cost of production result in a huge subsidy bill which the Government finds it difficult to allocate funds for. Urea is sold at highly subsidized prices which lead to urea overuse by farmers and also to diversion to non-agricultural use. Therefore, policy reforms in the sector are essential. The fertilizer industry is internationally competitive and if it is allowed to operate in a market-driven environment, funds for capital investment in upgradation and replacement of old equipment can be generated, whose use will lead to better operational efficiency.

Conclusion

The Indian fertilizer industry consists of old to very old plants. No new ammonia or urea plants have been constructed since 1999 but the industry has been keeping pace with technological developments through investments in revamping/retrofitting projects. Such investments have helped improve the energy efficiency and increase capacity and also improve the reliability and safety of plants.

The average efficiency of Indian ammonia plants has improved with a change in feedstock from fuel oil to natural gas in four plants early in 2013. Major revamping projects were completed in a few plants in 2012-13. As a result, the energy efficiency of production of both ammonia and urea improved by 9.0% over the last 10 years.

There is a need for policy reforms in the fertilizer sector which will allow the industry to operate in a market-driven economic environment. This will help the industry generate funds for capital investment and allow the industry to take investment decisions based on purely techno-economic considerations.

References