energy manager

energy efficiency initiatives in industries

energy saving projects
waste heat recovery
root cause analysis
urban planning to accompany energy transition
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ADEME
the energy efficiency imperative in the industrial sector

The industry sector is a crucial component of the Indian economy in terms of its contribution to economic growth, trade, and as a provider of employment. The sector is a mix of large-scale state-of-the-art plants as well as traditional micro, small and medium enterprises (MSMEs). India's growth story and the government's ambitious 'Make in India' campaign is dependent upon the prosperity of this sector. The challenge, however, is to grow in a manner that is resource-efficient and addresses sustainability considerations from all perspectives - social, economic, and environmental. Given that the industrial sector is a major energy consumer, consuming about 44% of the commercial energy consumption of India; substantial efforts are required both at the government and private level to improve the energy performance of this sector. This is even more important considering India's ambitious 'Intended Nationally Determined Contribution' (INDC) emissions reduction targets.

In this context, the government under the National Mission on Enhanced Energy Efficiency (NMEEE), has taken several steps to promote energy efficiency in the sector. Ambitious programs like the PAT (Perform, Achieve and Trade) mechanism aimed to reduce specific energy consumption in large energy consumers (referred to as Designated Consumers) under eight energy intensive industrial sectors (aluminum, cement, chlor-alkali, fertilizer, iron & steel, pulp & paper, textile and thermal power plants) was launched in the first cycle. The notification for the second phase of the PAT cycle has also now been issued and will have a wider coverage to cover additional sectors like the railways, refineries and DISCOMS. The DCs in the 2nd phase have to comply with the new targets by the year 2018-19.

The MSME sector has also received considerable attention in the recent past. Apart from the government, several multilateral and bilateral agencies have initiated cluster-level energy efficiency improvement programs in the MSME sector. The BEE-SME program, launched under the 11th plan focused on identifying energy conservation options in 29 energy intensive MSME clusters. More than 1000 comprehensive energy audits and 350 detailed project reports on EE technologies were prepared under the program. Under the 12th plan, BEE is supporting demonstration of some of these technologies in selected clusters. The much talked about World Bank-GEF project focused on the 'Saturation approach' wherein most of the units in the clusters are targeted for energy audits and subsequent implementations. Despite all this, most of the MSMEs continue to face barriers to growth which are primarily linked to lack of access to technology/technical expertise and finance. The problem is compounded by the fact that most of the MSMEs are traditional, micro in size, geographically dispersed and deploy inefficient technologies and operating practices.

As per TERI's (The Energy and Resources Institute) estimates, there are over 200 energy intensive...continued in page 30
efficient industries for an equitable energy future

The 21st century has perhaps witnessed some of the best efforts in relation to energy management and energy security. Reduction in energy demand and consumption at the end-user’s premises can free up electricity generation, transmission and distribution capacity at a fraction of the costs required to provide new capacity. India is not new to the current challenge of energy constraints and in the face of this present situation; the country needs to use its energy as productively as possible. 40% of the nation’s energy consumption is accounted for by its industrial sector. All the initiatives taken in various segments to promote energy efficiency have resulted in substantial cost savings and promoting energy efficiency for the country.

Along with environmentally benign business growth, India also aims towards sustainable and inclusive development that ensures a resource efficient future. Unlike most developed economies, the formidable challenge of achieving economic development while fulfilling significant commitments toward climate action still remains. Rising energy prices coupled with the changing Indian regulatory landscape and uncertainties in availability of fuel leaves no choice for industrial organizations but adopt a continuous improvement approach and strive to implement energy efficient practices across their value chain.

Everyone strives for reasonable income and a decent quality of life; hence there is a large latent demand for energy services. India is heavily dependent on imported energy sources like coal and oil. From about 450 million tons of oil equivalent (toe) in 2000 the primary energy demand in India has grown to about 770 million toe in 2012. This is expected to increase to about 1250 to 1500 million toe in 2030. The driving forces behind this increase are increasing income and economic growth which lead to greater demand for energy services such as lighting, cooking, space cooling, mobility industrial production, office automation, etc. This growth also reflects the low level of energy supply in India, the average energy supply being 0.6 toe per capita in 2011.

To cater to the energy demand while ensuring minimum CO2 emissions, the Government of India has undertaken a two pronged approach so that the global emissions do not cause an irreversible damage to the earth system. Considering the generation aspect of the situation, greater use of renewable energy sources is encouraged mainly through solar and wind and at the same time the implementation of supercritical technologies for coal based power plants is suggested. On the other hand, efforts are also being made to efficiently use the energy in the demand side through various innovative policy measures under the overall ambit of Energy Conservation Act 2001.

However, market failures lead to unexploited opportunities in the energy savings sector. The public policy aims to address these failures through demand side management and performance contracting.

In this special issue of energy manager, we aim to give our readers a glimpse into the different energy saving initiatives and techniques that have been successfully implemented by industries in different sectors throughout the country. Our case studies include works from reputed facilities namely The Academy for Conservation of Energy, Orient Cement, Jindal Steel and ICICI bank.

We hope you find this issue enlightening and informative and would love to receive your comments and suggestions.

K. Madhusoodanan
Editor

(Please contribute your articles and case studies to reach the editor at madhukoovaprath@gmail.com or energymanagerhq@gmail.com)
energy saving projects at Orient cement

RVR Murthy
The Orient Cement plant at Devapur has been continuously upgrading and modernizing the plant with special emphasis on Energy Conservation, Pollution Control and Productivity through various management tools. To meet the power demand Orient installed a coal based 50 MW (25×2) Captive Power Plant. This has given the company substantial benefits in terms of increased plant operating efficiency and reduced energy consumption. Orient Cement, with consistently good capacity utilization is a growing organization. The management is well committed to the environment and since inception modern equipment like Electro Static Precipitators, Bag house and Dust Collectors are installed and used with the main equipment. This case study presents the energy efficiency initiatives undertaken by the plant during the year 2014-2015.
1. Power Saving in Raw Mill-II Vent Fan

Raw Mill-II Vent Fan was being operated at full speed (990 rpm) in GRR mode and the damper actuator position was 60% open. The circuit of Raw Mill-II was completely studied and air balance was carried out. The system was suited to operate the fan at 780 rpm, keeping the productivity unaltered. To meet the requirement SPRS was installed. This resulted in reduction of 277 kWh of electricity consumption (power consumption reduced from 692 kW to 415 kW).

Installation of SPRS in the Raw Mill resulted in the reduction of energy consumed by the II Vent Fan by more than 270 kWh

2. Power Saving in Coal Mill and Packer Fans

a) Coal Mill-II CA Fan:

Coal Mill-II CA Fan was being operated at 1480 rpm with damper actuator control of 70%. Pressure drop across the damper was 130 mm Hg. The power drawn by the motor was 113 kW. The power loss in damper was avoided by installing a VFD and the operating speed of the fan was brought to 1250 rpm and that reduced the power drawn by the motor to 98 kW. This resulted in energy saving of 15 kWh.

Installation of VFD to the Coal Mill-II Fan avoided damper losses and resulted in an energy saving of 15 kWh. An equal saving in energy consumption was also recorded upon installing the VFD in the Packer-VI Bag Filter Fan.

b) Packer-VI Bag Filter Fan:

The fan of the Bag Filter connected to Packer-VI was being operated at 1470 rpm with damper actuator control of 60%. Pressure drop across the damper was 96 mm Hg. The power drawn by the fan motor was 55 kW. The damper loss was avoided by installing the VFD by which the operating speed of the fan was reduced to 1235 rpm and the corresponding power drawn by the motor was 40 kW. This resulted in saving of 15 kWh.

Installation of screw compressors in place of old reciprocating ones resulted in an energy saving of 126 kWh without affecting the process requirements

3. Replacement of old reciprocating compressors with new screw compressors

There were five old generation reciprocating compressors in operation under utilities to cater to compressed air demands of Line-1 Kiln and raw mill circuits. The power consumption contributed by all the compressors was 246 kW.

These were then replaced with two units of kaeser-30 and kaeser-90 screw compressors. With this the power consumed by the whole circuit came down to 120 kW without affecting the process requirements. The resultant energy saving was 126 kWh.

The energy audit revealed heavy pressure drop in compressed air lines due to many bends and improper sizing. Correction of the routing and optimization of compressor size resulted in almost 50% reduction of power consumption.

4. Re-routing of compressed air pipeline

In-house audit was carried out in Packing Plant and the complete system was studied. The study revealed that there was a heavy pressure drop in the compressed air line due to several bends and also improper sizing. The compressed air for the whole packing plant was catered by 11 units of reciprocating compressors, which consumed a power of 336 kW.

The routing and the sizing of the compressed air line was then scientifically corrected and then the required compressed air could be supplied by just 5 units of the compressors, thus the power consumption came down to 235 kW. The energy saving achieved was 101 kWh.

A power savings of 257 kwh was recorded following installation of Dense Phase System for pumping Cement.
5. Installation of Dense Phase System for pumping Cement

The additional FK Pump operated to fill cement silo No. 5 from the cement mill was consuming a power of 442 kW. Later Dense Phase System was installed to pump cement to cement silo No. 5 from cement silo No. 3 instead of using the FK Pump. The Dense Phase System consumed only 185 kW. This resulted in energy saving of 257 kWh.

Modifying the fan speed from 984 rpm to 740 rpm by providing suitable pulley size resulted in better functioning of the bag filter and reduction of emission level. Moreover, there was a power saving of 12 kW.

6. Power Saving in Lime Stone Crusher Bag Filter Fan by reducing fan speed

The Bag Filter connected to the vent line of Limestone Crusher was being operated inefficiently due to higher speed of the fan (984 rpm) without any control. The emission through chimney was uncontrollable due to frequent jamming tendency of bag filter.

The fan speed was then reduced from 984 rpm to 740 rpm by providing suitable size of the pulley in the drive. With this modification, the bag filter started functioning well and the emission level came down to normal value. Moreover, there was a power saving of 12 kW, being reduced from 45 kW to 33 kW.
two energy conservation projects of BILT, Ballarpur

The two case studies showcased here highlight the commitment towards energy conservation and are excellent examples of team building in BILT. By imparting TQM and ISO 50001 methodology inputs to shop floor operators, implementation of low cost small improvement ideas yielded significant savings. With a very low investment of Rs 5L they achieved monetary savings of Rs 84L per annum.

Case Study 1

Taking in line B L preheater prior to Effect 1

Sunil B Sapre

The Background

The new recovery and new pulp mill for production of pulp at 900 TPD was commissioned in the year 2013. The evaporation plant with water evaporation capacity of 360 TPH is a part of the new recovery. The role of evaporation plant in the pulp mill is to concentrate the weak black liquor of 15% TS (generated during pulping/cooking process) to strong black liquor of 70% TS. This strong black liquor is fired into the recovery boiler as the primary fuel to recover the chemicals and to generate green steam. The evaporator plant consists of six Effects, three.
Finishers and two Black Liquor (BL) pre heaters. The role of BL preheater is to raise the temperature of the black liquor entering the particular Effect to its boiling point for effective evaporation. The BL preheater prior to Effect 1 was not taken in line during commissioning of the evaporator plant due to various problems like:

- Effect 1 delta T rise problem
- Vibration / Starvation in BL heater when taken to in line

The evaporation plant of 360 TPH capacity is a part of the New Recovery. The evaporator plant consists of six Effects, three Finishers and two Black Liquor (BL) pre heaters. To reduce the delta-T rise and to improve the efficiency, Black Liquor pre heater prior to Effect 1 has to be taken in line.

The Task
To improve the delta T and efficiency, the BL pre heater prior to Effect 1 is to be taken in line.

The Methodology Adopted
Taking the BL Pre heater in to line requires some modifications to overcome the problems. The modifications and the new installations are:

- BL pre heater inlet valve Size - 250 mm
- BL pre heater outlet valve Size - 250 mm
- BL pre heater bypass valve Size - 200 mm
- BL pre heater inlet steam control valve Size - 150 mm
- BL pre heater outlet temp. indication in DCS
- Flow meter in BL pre heater inlet steam line

Taking the B L Pre heater in to line required changes like modification of the heaters inlet and outlet valve size. New installations included a temperature indicator in DCS and a flow meter in the steam line. The project process involved data collection and analysis as well as measurement and verification of operational and financial gains.

The Project Planning
The following procedure was adopted during inception, engineering, implementation and monitoring of gains of the project:

- Cross functional team formation
- Data collection
- Weekly meetings
- Identification of various reasons and plotting on fish bone diagram
- Data analysis
- Identification of activities and preparation of micro activity chart
- Execution of work
- Measurement and verification of operational/financial gains.

Project Implementation
As planned, during the annual shut down of the evaporator plant in December 2015, BL heater inlet
and outlet, BL heater, and steam connection were made, instrumentation loops were tested and the plant was started on. Benefits could be noticed within 8 hours of the start up.

The benefits could be noticed within 8 hours of start up. The temperature of Black liquor entering pre heater improved from 98°C to 105°C. The value of Delta-T rise decreased to 3 deg.

Impacts and benefits realized

i. During Implementation and Trial Period

Temperature of Black liquor entering the pre heater improved from 98°C to 105°C. Delta T rise minimized to 3 deg.

ii. Investments and Savings

Improvement in steam economy - Reduction in L P steam consumption

Steam applied in B L pre heater : 0.7 to 0.8 TPH
Reduction in steam consumption : 1.5 TPH
Net steam saving : 0.7 to 0.8 TPH
Annual Monetary Gain : Rs. 44.0 L
Investment : Rs. 2.0 L

iii. Impact of the project on the overall performance of the plant

- B L entry to Effect 1 is at its boiling temperature of 105°C
- Effect 1 Delta T rise is minimized yielding improvement in run ability of Effect 1 and evaporator plant
- B L processing rate improved
- It will help to achieve 816 MTOE during PAT

To stop a 315 kW MC pump to avoid double pumping

S K Jain

The Fiber Line team working on the project challenged the need of running two pumps for the Diffuser operation which was not adding any value either to the volume of pulp or towards consumption of bleaching chemical. Finally the least cost option of stopping the discharge pump was taken and implemented successfully.

The Background

The New Fiber line having continuous cooking with ECF bleaching facility to produce bleached pulp of 900 TPD was commissioned in 2013. Oxygen Delignification is an environmental friendly process for further reduction of lignin after cooking to reduce consumption of bleaching chemicals as well as to reduce load on ETP. There are three stages of pulp washing before ODL viz.

- Washing in cooking diffuser
- Double decker
- TRPB Press

There are two stages of washing after ODL viz.

- Washing in ODL diffuser
- Dewatering Press

- Washing in DPA press was better compared to ODL diffuser, as the discharge pulp consistency from DPA press is 30-32% compared to 9-10% from ODL diffuser.
- There was no remarkable reduction in COD level when ODL diffuser was in line besides giving operational problems; so ODL diffuser has been bypassed for the last 1.5 years

Even after bypassing the ODL diffuser, both the feed and discharge MC pumps of the ODL diffuser were running, causing wastage of power through double pumping.
The Task
The Fiber Line team that worked on this project challenged running of the two pumps. Various options to reduce the net power consumption like replacing with smaller pumps, installation of VFDs on both pumps and even elimination of one pump were discussed. Finally the least cost option of eliminating the discharge pump was decided for a trial.

The operation of the ODL diffuser discharge MC pump of rating 315 kW was stopped successfully. The flushing line to the MC pump vacuum was modified and two manual valves of 24" dia. and 10" dia each were installed.

The Methodology Adopted
- The diffuser feed pump delivery is connected to discharge line.
- Additional ON/OFF valve is provided to operate from DCS.
- Two manual valves, one each of 24" and 10" in diameter, are provided for isolation.
- The diffuser feed pump vacuum flushing line is modified.
- The ODL diffuser discharge MC pump of 315 kW motor is then stopped successfully

The Project Plan
The project was planned similar to Case Study 1

The Project Implementation
As per the plan the modifications were done in 12 hours during the shutdown of pulp mills on 12th January, 2016.

With an investment of just Rs 3 L, the power savings achieved from this project was calculated to be around 4100 kWh/day. This project can contribute to achieving PAT targets around 365 MTOE.

Investments and Saving
- Reduction in power consumption: 4100 kWh/Day (6.5 kWh/ADT pulp)
- Investment made: Rs. 3 L
- Savings achieved: Rs. 40 L/year

Impact of the project on the overall performance of the plant
- Operation is made simple
- Motor-Pump is used as spare
- It helps to achieve 365 MTOE in PAT.

Mr. S.K. Jain is the GM(Engg) at BILT, Ballarpur

The Background
Delignification is an environmental friendly process for further reduction of lignin after cooking to reduce consumption of bleaching chemicals as well as to reduce load on ETP. There are three stages of pulp washing before ODL viz. Dewatering Press, Washing in ODL diffuser and TRPB Press.

Washing in ODL diffuser is significant for achieving PAT targets. With an investment of just Rs 3 L, the project can contribute to PAT targets around 365 MTOE.

There are two stages of washing after ODL viz. Washing before ODL and Washing in DPA press. Washing in DPA press was better compared to TRPB Press. The benefits could be noticed within 8 hours of the start up. The temperature of Black liquor entering the pre heater improved from 98°C to 105°C. Delta-T rise minimized.

Effect 1 Delta-T rise is minimized yielding improvement in run ability of Effect 1 and Black liquor entry to Effect 1 is at its boiling temperature.

The New Fiber line having continuous cooking with ECF bleaching facility to produce bleached pulp of 900 TPD was commissioned in 2013. Oxygen pumping.

At BILT, Ballarpur Mr. Sunil. B. Sapre is the GM(Engg)
installation of back pressure recovery turbine at Jindal Steel

Srimanta Kumar Das

JSPL is an industrial power house with dominant presence in steel, power, mining and infrastructure. The company produces economic and efficient steel and power through backward and forward integrations. This case study presents a project that reduced the overall power consumption of the blast furnace blower by the installation of BPRT system; earlier the blower consumed around 70% of the total power of the furnace. The result was a total power saving of 3 MW at a pressure of 2.5 kg/cm².

The Problem

The Blast Furnace (BF) is a counter current reactor that requires a certain amount of hot air at a certain pressure and temperature. To get this hot air at desired pressure and temperature, we pass cold air through the stoves where it gets heated up. The cold air is introduced into the stoves by use of blowers which delivers cold air at desired flow and pressure. The total power consumed by the blower is about 60-70% of the total power consumed by the blast furnace.

Objective

- To decrease the power consumption of the blower by innovation.

Approach

- Distribute the load on the blower by using some device which can contribute in providing the rotational energy.
The main approach adopted was to distribute the load on the blower by using a device which provides rotational energy. The BPRT system consists of a motor, a gear box, an axial flow compressor, a speed change clutch and a gas energy recovery turbine.

Work done
- Installation of Back Pressure Recovery Turbine (BPRT) system in the Blast Furnace.
- Total duration of the project was 121 days.
- BPRT system includes (i) Motor, (ii) Gear box, (iii) Axial flow compressor, (iv) Speed change clutch, and, (v) Gas energy recovery turbine.
**Working Principle**

When gas leaves from the furnace top, it has high potential energy due to high pressure and high thermal energy due to high temperature. After passing through the GCP, the BF gas pressure is reduced by Pressure Reducing Valve (Septum valve). The energy recovered from BF gas can be utilised to rotate the blower. The motor is to run the blower independently and selected for the maximum power. The gearbox increases the RPM.

Initially the blower is driven only by the motor there is no power saving. As the cleaned BF gas enters the turbine, it expands thus transforming the BF gas pressure to mechanical energy. The speed increases and the clutch interlocks at 3000 RPM. At this stage the load on the motor decreases leading to energy saving. The blower flow can be adjusted using the adjustable stator blades.

**Technical Specifications**

**Turbine**

- Make: Shaangu; RPM: 3000; Inlet BF gas flow: 150000/h; Inlet BF gas temperature: 170-250°C
- Inlet BF gas pressure: 0.27 Mpa; Outlet BF gas pressure: 0.1 Mpa; Shaft power: 3920-4820 kW (max)

**Motor**

- Voltage: 11 kV; Current: 613 A; RPM: 1495; Power: 10500 kW; Efficiency: 96.8%

**Blower**

- Make: Shaangu; RPM: 6414; Air inlet pressure: 0.0957 Mpa; Discharge pressure: 0.4 Mpa

**Clutch**

- Increasing ratio: 2.135; Rated Power: 5000 kW

**Gearbox**

- Speed ratio: 4.29; Rated Power: 10500 kW

Installation of the BPRT system required less space, less investment and a total power reduction of around 40%.

Advantages and Energy Saving Achieved

- Electrical Power reduction up to 40%.

- Less space utilization as compared to separate Electric Blower and TRT
- Less capital investment as compared to separate Electric Blower and TRT
- Total power saving up to 3 MW at a pressure of 2.5 kg/cm²
- The blower is provided with adjustable stator blades, so as to regulate the volume of air flow.
- The turbine is also provided with adjustable stator blades that help in controlling the BF top pressure.

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Mr. Srimanta Kumar Das is the Energy Manager at JSPL.
CLP India is the wholly owned subsidiary of CLP Holdings Ltd, which is listed on the Hong Stock Exchange and is one of the leading investor-owned power businesses in Asia. This investment is spread across a diversified and environment-friendly generation portfolio that covers renewable energy, and supercritical coal and gas fired power plants, amounting to over to 3,000 MW. This article presents, working of a Mini-Oil Ignition System at Jhajjar Power plant in Haryana in detail. This process limits startup oil combustion to a great extent and thus proves very effective in reduction of carbon emission as well.
CLP entered the Indian power sector in the year 2002 with the acquisition of a 655 MW gas-fired power plant, located in Bharuch, Gujarat. This is one of the first independent power projects in India. With significant advances in the critical areas of its operations over the past few years, this power plant has achieved NOSA 5-Star accreditation for complying with the highest level of internationally accepted safety standards and is ISO 14001 certified, complying with the highest standards in environment conservation. The plant was also awarded the status of a "NOSCAR" company - one of the most credible recognitions of excellence in occupational risk management. Paguthan CCPP also recently won RoSPA Order of Distinction for its superior performance in Occupational Health and Safety. This award is a result of Paguthan CCPP winning RoSPA Gold Award for stellar 15 consecutive times.

In addition to this, CLP India owns and operates a 1,320 MW (2 X 660MW) supercritical coal-fired power plant in Jhajjar, Haryana, which is one of India’s first and largest supercritical coal-fired power plants. This power plant was awarded the CNBC TV18’s Infrastructure Excellence Award in the Main Category of Energy & Power in 2012, Dun & Bradstreet’s ‘2013 Infrastructure Project of the year’ award under Projects category, Project Finance International’s (PFI) Indian Deal of the Year award for its ECB financing, EPC World Award 2014 for ‘outstanding contribution in power generation’, among others.

Wind has been an integral part of CLP’s business philosophy and is expected to continue making a vital contribution not only to CLP’s growth plans for India but also to its commitment to reducing its CO₂ emission. CLP India is also one of the largest wind power developers in India with committed wind projects of over 1,000 MW, spread across six states. CLP India is also one of the largest wind power developers in India with committed wind projects of over 1,000 MW, spread across six states. Wind has been an integral part of CLP’s business philosophy and is expected to continue making a vital contribution not only to CLP’s growth plans for India but also to its commitment to reducing its CO₂ emission. CLP believes that growing the renewables will help reduce its business’ carbon footprint and increase the share of carbon free generation in its portfolio.

The assorted Oil Combustion Unit is designed and manufactured for Boilers of 2x660 MW units for Jhajjar Thermal Power Plant. The Oil Combustion Unit is made up of Oil Gun, Air register (Combustion Stabilizer), Air cylinder unit for ignition gun etc. Primary air temperature of the mill is increased by SCAPH.

**Mini Oil Ignition System at Jhajjar Power Ltd**

Mini oil ignition system is used for pulverized coal fired boiler for boiler start up, stabilization and shutdown. It mainly involves conventional oil gun and plasma igniter. Its capacity is lower than the conventional one, having the oil gun in the coal pipe structure. The assorted Oil Combustion Unit is designed and manufactured for Boilers of 2x660 MW units for Jhajjar Thermal Power Plant. The Oil Combustion Unit is made up of the Oil Gun, Air register (Combustion Stabilizer), Air cylinder unit for ignition gun etc.

The ignition system consists of two major components:

1) Mini gasified oil ignition system: - This system consists mainly of fuel oil system, compressed air system, burners, combustion air, wall temperature monitoring and flame inspection system.

2) Primary air heating system (SCAPH): -

This system consists of air heater, air damper, support and hanger system.

**Working Principle**

With the action of the high-pressure compressed air, oil that leaves the atomization nozzle suddenly expands, crashes with air and atomizes to be a hollow fog cone. Primary air temperature of the mill is increased by SCAPH. As the core temperature of mini oil gun lies between 1500-1800 deg C, pulverized coal is burned directly. Hence with the help of mini oil, coal can be fired at the initial stage.
As core temperature of mini oil gun lies between 1500-1800 deg C, pulverized coal is burned directly. At early stage of cold boiler ignition, due to low furnace temperature, combustion efficiency is low but as the temperature increases, combustion efficiency improves further. Maximum steam temperature rise of 1.53 deg C/min and pressure of 0.06Mpa/min is achieved in coal firing with the Mini Oil Gun, matching the standard boiler firing rule.

Firing rate is regulated based on difference between the inner and outer wall temperatures of the storage vessel while monitoring the boiler water wall temperature. A maximum steam temperature rise of 1.53 deg C/min and a pressure of 0.06Mpa/min is achieved in coal firing with the mini oil gun, matching the standard boiler firing rule.

At the early stage of cold boiler ignition, due to low furnace temperature, combustion efficiency is low but as the temperature increases, combustion efficiency improves further.
Conclusion

Substantial fuel oil saving during boiler start up has been achieved thanks to use of the mini oil gun in coal firing at the start. It helps to conserve oil and in turn reduces the carbon footprint. Because of the very small oil consumption and the high pulverized coal burning rate, electrostatic precipitator can be taken into service at an early stage of the boiler start up, thus reducing the emission. Coal firing with mini oil ignition system is fairly safe, efficient and cost effective; it is best suited for Indian coal.

Mr Santosh Mestry works as the Senior Plant Energy Manager at Jhajjar Power Ltd
The case study presented here highlights an effort taken at the Shree Digvijay Cement Company towards efficient plant operation. The slip ring induction motor with liquid resistance speed controller, used in an exhaust fan system, was replaced by a VFD driven cage induction motor to avoid unnecessary waste heat. It drastically reduced the plant operating cost.
The Old System

The vertical coal grinding mill was having an exhaust fan driven by 6.6 kV, 250 kW slip ring induction motor. There was no damper in the gas circuit to control the flow. The fan speed was controlled by Liquid Rotor resistance Regulator (LRR) connected in the rotor circuit of the motor. Due to the heating effect of the rotor current in LRR, the water was getting heated up. The hot water was cooled by circulating through a heat exchanger by using a small pump of 2.2 kW capacity. The schematic of the arrangement is shown in Figure 1.

Figure 1: The Fan motor and cooling arrangement

The fan motor used LLR for speed control. Due to heating effect of rotor current LRR was getting heated up. It also suffered other disadvantages like less precise fan speed control, high maintenance cost and even motor failure.

The following exercise was done to establish the power loss in the rotor circuit, i.e. in LRR:

The water circulating pump was stopped for around 12 minutes with the fan in running condition, in order to measure the rise in temperature of the liquid in LRR tank. The temperature rise observed was 15°C.

Mass of liquid in LRR = 328 litres × 1.025 kg/litre = 336.2 kg
Temperature rise of the liquid = 15°C
Time taken to raise the temperature of the liquid by 15°C = 12 minutes = 720 seconds
Specific heat of the solution = 4.2 kJ/kg°C
The average heat power loss = 336.2 × 4.2 × 15/720 = 29.42 kW.

The following were the disadvantages other than the heat power loss in the old system:

1. Speed control of fan was not precise, so process disturbance used to be there.
2. The system (including LRR, heat exchanger and water circulating pump) demanded high maintenance cost.
3. Motor was running on almost full load, and it used to fail once in a year.

To overcome these disadvantages it was decided to install LT motor and VFD for the application. The cost of the LT motor with VFD is much less compared to that of MV motor and MV VFD.

Replacing the slip ring motor by VFD driven cage motor not only solved the problem of heat loss, but reduced the maintenance cost and increased the motor life too.

The New System

By installing the LT motor with VFD, the heat power loss was abated and the loading of the fan also got reduced by 30 kW.

Mr. Arvind Prakash Gupta is the DGM(E&I) at Shree Digvijay Cement Company Limited.
Mahindra & Mahindra Ltd. in their auto plant at Kandivli has implemented waste heat recovery. Their paint shop in this plant was selected to carry out this energy conservation project that fetched significant opportunity of saving piped natural gas. The case study presents essential details.

**Introduction**

Mahindra & Mahindra Ltd. is a $16.9 billion conglomerate with presence in Auto, Agri, Retail, Hospitality, Defense, IT etc. The plant at Kandivli occupies 64 acres and is the only Mahindra Auto plant fully integrated with captive foundry. The plant always believes in sustainable business solution, with main focus on fossil fuel conservation. The Plant uses the grid electricity from DISCOM as well as LPG/PNG as fuel for heating applications.

After mapping energy balance in the ovens used in the paint shop, we felt that there is significant opportunity of saving PNG (Piped Natural gas) through waste heat recovery.

**Methodology**

The following methodology is adopted for energy conservation projects.
Data collection

We mapped all PNG consuming equipment in the plant:

<table>
<thead>
<tr>
<th>Location</th>
<th>Equipment</th>
<th>Age in Years</th>
<th>PNG consumption in SCM/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Shop</td>
<td>Thermopacs</td>
<td>20+</td>
<td>1800</td>
</tr>
<tr>
<td></td>
<td>Body Top</td>
<td>04</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Coat Oven</td>
<td>01</td>
<td>1000</td>
</tr>
<tr>
<td>Heat Treatment</td>
<td>CGC-1 (Recuperator already provided)</td>
<td>30</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>CGC-2 (Recuperator already provided)</td>
<td>18</td>
<td>1000</td>
</tr>
<tr>
<td>Foundry</td>
<td>Vertical Oven</td>
<td>15</td>
<td>200</td>
</tr>
</tbody>
</table>

We decided to concentrate on paint shop for which further data collection and analysis is done. The following instruments were used to collect data:
1. Flow meters
2. Flue gas analyser
3. Non contact thermometer

Analysis

Thermopac

Cause & Effect Diagram

<table>
<thead>
<tr>
<th>Equipment</th>
<th>PNG Consumption SCM/Day</th>
<th>Air to Fuel Ratio</th>
<th>Flue Gas Temperature in °C</th>
<th>Surface Temperature in °C</th>
<th>Combustion Air Temperature in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermopacs</td>
<td>1800</td>
<td>Within normal</td>
<td>190</td>
<td>45</td>
<td>Ambient</td>
</tr>
<tr>
<td>Body Top Coat Oven</td>
<td>1000</td>
<td>Limit</td>
<td>190</td>
<td>45</td>
<td>Ambient</td>
</tr>
<tr>
<td>PT-CED Oven</td>
<td>1000</td>
<td></td>
<td>190</td>
<td>40</td>
<td>Ambient</td>
</tr>
</tbody>
</table>
Waste Heat Recovery system was finalized based on Heat Pipe Exchanger Technology. The heat pipe reduces contact between hot exhaust air and fresh suction air. The suction air blower manifold for supplying combustion air has limitation as its diaphragm cannot withstand above 100°C. Hence design is done in such a way that suction combustion air shall not exceed 100°C.

### Choice of technology

The team studied various Waste Heat Recovery Systems (WHRS) based on efficiency and finally selected the WHRS based on Heat Pipe Exchanger Technology, due to the following merits:

1. It is a static device. Maintenance of the device is minimal as it has no moving parts, no friction and wear-tear.
2. Does not need power input
3. Capable of operating at 325°C with 60%-80% heat recovery capability.

### Implementation

#### Operational Principle

<table>
<thead>
<tr>
<th>No</th>
<th>Option</th>
<th>Savings MKcal</th>
<th>Investment Rs. Lacs</th>
<th>Payback in Years</th>
<th>Installation Feasibility</th>
<th>Reliability</th>
<th>Timeline</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Replacement of all 3 Termopacs with New Ones</td>
<td>Approx. 350</td>
<td>200.00</td>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
<td>1 Year</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Magnetic Ionisers to ensure complete combustion</td>
<td>50</td>
<td>4.00</td>
<td>2</td>
<td>Yes on PNG pipeline close to burner</td>
<td>No</td>
<td>4 Months</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Waste Heat Recovery from Flue Gases</td>
<td>188</td>
<td>8.00 to 9.00</td>
<td>1.5</td>
<td>Yes</td>
<td>Yes</td>
<td>4 Months</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Direct firing in ovens instead of using Thermopacs</td>
<td>Approx 400</td>
<td>150</td>
<td>10</td>
<td>Safety Concerns</td>
<td>Yes</td>
<td>1.5 Years</td>
<td></td>
</tr>
</tbody>
</table>

The 3rd option was more lucrative under the current circumstances.
PNG savings accounted for 22700 SCM/annum, amounting to around Rs 7.25 lakhs per annum, on an initial investment of Rs 9 lakhs

Challenges faced

1. OEM was against any such modification for direct firing on the oven as the oven was very old.

2. There were chances of mixing hot exhaust air with fresh suction air (combustion air) in case of puncture of any tube - therefore the new technology, the heat pipe which eliminates any chance of contact of both circuits, was adopted.

3. The suction air blower manifold for supplying combustion air has limitation as its diaphragm cannot withstand temperature above 100°C. Therefore design is done in such a way that suction combustion air shall not exceed 100°C.

4. Implementation was very difficult as the machine runs for 24×7. So the activities which required shutdown were carried out during annual shutdown (tapping and placing damper etc). Rest of the work is done during normal working condition.

Cost-benefit analysis

1. Investment : Rs. 9.00 Lacs
2. Payback : 15 Months
3. Savings : Rs. 7.25 Lacs/annum (PNG Saved 22700 SCM/annum)
4. CO₂ Emission Reduction : 44 Tons/ annum

Mr. Sandip D. Priolkar is DGM and the Head of Energy Management at Mahindra and Mahindra Ltd., Kandivli
This case study of ICICI Bank, Guwahati, states how the unsatisfactory performance of a HVDC system was corrected through energy audit followed by energy conservation measures. The investment of Rs 1.59 Lac was paid back in about 8 months.

**Introduction**

In order to identify wastages as well as to explore energy saving opportunities, ICICI Bank decided to carry out detailed energy audit at their facility in Guwahati. Creating a mechanism for compiling energy data and setting up desired benchmarks for each office category was the first step though it entailed various challenges. ICICI Bank's Infrastructure Management & Services Group (IMSG) serves about 14 Million sq.ft. area of branches and offices pan India. During FY13, the total energy consumption of
the bank was 210 million units & annual energy expenses were to the tune of rs 2000 million which was about 1.8% of the bank's total expense. As a step towards energy conservation, we set a target of 20% reduction by FY18 in base annual energy consumption of FY13. This cannot be achieved through marginal improvements, but it is possible with some path breaking initiatives.

The installed capacity of HVAC system was 100 TR of ductable units. In FY 2013, the energy consumption of the premises found increasing together with the detection of hot and cold pockets. In order to cool the hot pockets, the set point of the HVAC system had to be lowered leading to overall consumption increase.

The Problem

ICICI Bank commenced its operations at Zonal Office, Fancy Bazaar, Guwahati in 2006. The bank occupies 16240 sq.ft. area for its operation with 160 employees operating from these premises. The installed capacity of HVAC system is 100 TR of ductable units. The air conditioned area is 12800 sq.ft. The HVAC system was commissioned in 2006. In FY 2013, the energy consumption of the premises was found increasing. Also at a few locations in the offices, distinct hot and cold pockets were detected. In order to cool the hot pockets, the set point of the HVAC system had to be lowered and thus the overall consumption of the office increased substantially. (EPI of 192 in FY2014)

Energy Audit Findings

- HVAC system consumes 65% of the total energy.
- Longer running hours of the compressor
- Improper temperature feedback to control the compressor unit
- Lower set points on HVAC (20 to 23°C)
- Higher specific power consumption (kW/TR) of machines
- Heat ingress from glass facade increasing the load on HVAC system
- Non uniform air delivery resulting into cold and hot pockets

A systematic approach was finalized by bank's facility team with energy audit team to arrive at suitable solutions, which included provision for uniform distribution of cooling, correct feedback from sensors to HVAC system operation and reduction of heat load from glass facade.

Approach

A systematic approach was necessary to drive energy efficiency in the system.

Phase 1: Reduce consumption without investment

Phase 2: Invest in energy efficient equipment to further reduce energy consumption

We also decided to create a portfolio of renewal energy, which could help us in business continuity planning where power situation is unreliable, and towards cost effectiveness through private parties.

Project Execution

We deployed a four pronged strategy to drive this project:

A) Ensured stakeholder’s involvement
   a) Created awareness amongst employees through regular communication and appreciation
   b) Put targets (which were simple to understand) for energy conservation for each and every premise.
   c) Implemented performance guarantee / benchmarks for service partners
   d) Involved security & house-keeping personnel in energy conservation

B) Improved process controls
   a) Maintained temperature at 24°C and adhered to scheduling of equipment
   b) Eliminated wastages in energy through balancing and power factor correction
   c) Implemented energy monitoring & recording ( manual / auto )
   d) Benchmark were set for each office/branch category
   e) Monthly energy review across all zones
   f) Ensured ‘Integrated preventive maintenance’ of equipment to get uptime and energy efficiency

- House-keeping & security personnel were instructed to ensure that entry door is closed at all times.
- Heat ingress thereby reducing the heat load.
- Proper feedback to HVAC units.
- Shading provided on glass facade to reduce heat load.
- Temperature sensors were relocated to provide proper feedback to HVAC units.
- Air balancing was done by modifying the duct layout.
- Re-orientation of duct was done as per the heat load calculation done to check whether the installed capacity is adequate to serve the area.
- Re-orientation of IDU was done depending upon the latest workstation layout. IDU were brought closer to the service area.
- CFM requirements were calculated and the modified duct layout was prepared.
- The same was found in order.
- The installed capacity of HVAC system is 100 TR of ductable units. The air conditioned area is 12800 sq.ft. The HVAC system was commissioned in 2006. In FY 2013, the energy consumption of the premises was found increasing. Also at a few locations in the offices, distinct hot and cold pockets were detected. In order to cool the hot pockets, the set point of the HVAC system had to be lowered and thus the overall consumption of the office increased substantially. (EPI of 192 in FY2014)
C) Procured energy efficient products / services focused on office design
   a) Procured energy efficient lighting, HVAC and other electrical equipment
   b) Energy audit of large facilities were carried out
   c) Retrofits/replacements of old equipment were done to enhance efficiency
   d) Modification to design templates of branches to ensure overall highest system efficiency and 3 STAR rating criteria for new branches
   e) Reduction in connected loads to reduce overall CAPEX of the project
D) Enhanced renewable energy portfolio
   a) 1kWp onsite solar power plant was commissioned at 410 Grameen Branches
   b) Solar water heating system was installed in Canteen/Hostel at 2 large offices
   c) 65 kWp Root top solar PV system was deployed at Chandivali Towers; and a total of 30 kWp was installed at other 5 branches
   d) Third party renewable power purchase agreement was executed for 3 large solar power plants of a total capacity of 9 MWp

It was observed that the workstation layout has undergone changes since inception to suit the business requirements as and when required. However, the duct layout remained unchanged resulting in non-uniform distribution of chilled air across the premises.

In line with the adopted approach, the following actions were implemented in a time period of 2 months.

**Actions taken**
- Heat load calculation done to check whether the installed capacity is adequate to serve the area. The same was found in order.
- CFM requirements were calculated and the modified duct layout was prepared.
- Re-orientation of IDU was done depending upon the latest workstation layout. IDU were brought closer to the service area.
- Re-orientation of duct was done as per the heat load of the particular air-conditioned zone.
- Air balancing was done by modifying the duct branches.
- Temperature sensors were relocated to provide proper feedback to HVAC units.
- Shading provided on glass facade to reduce heat ingress thereby reducing the heat load.
- Set point temperature was made 24°C as mandatory.
- House-keeping & security personnel were instructed to ensure that entry door is closed at all times and door closures were installed.
At the end of FY16, we have saved 39.60 Million Units (400 Mn) against the baseline of FY13 (equivalent to savings of 32475 Tons of CO2). This accounts to 18% savings in the last 3 years. The large offices as a portfolio have ‘Energy Performance Index’ of 115 signifying a 4 star category as per BEE benchmarking in India. The branches and small offices as a portfolio have ‘Energy Performance Index’ of 163 which denotes a 2 star Rating.

**Post implementation results**
- Hot and cold pockets in the office area were completely eliminated thereby enhancing the occupants’ comfort.
- Correct feedback from temperature sensor to HVAC system resulted in reduction in compressor loading as well as in running hours.
- Annual energy saving of 20,000 units were achieved by this project.

**Benefits in energy consumption**

![Unit consumption pattern of Duct AC after re-orientation](image)

<table>
<thead>
<tr>
<th>Consumption (Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>Apr 13-14</td>
</tr>
<tr>
<td>May 13-14</td>
</tr>
<tr>
<td>Jun 13-14</td>
</tr>
<tr>
<td>Jul 13-14</td>
</tr>
<tr>
<td>Aug 13-14</td>
</tr>
<tr>
<td>Sep 13-14</td>
</tr>
<tr>
<td>Oct 13-14</td>
</tr>
<tr>
<td>Nov 13-14</td>
</tr>
<tr>
<td>Dec 13-14</td>
</tr>
<tr>
<td>Jan 14-15</td>
</tr>
<tr>
<td>Feb 14-15</td>
</tr>
<tr>
<td>Mar 14-15</td>
</tr>
</tbody>
</table>

**Financial benefits**

<table>
<thead>
<tr>
<th>Investment (Rs in Lac)</th>
<th>Total Savings (Lac Units)</th>
<th>Net Savings (Rs in Lac)</th>
<th>Payback period (Month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.59</td>
<td>0.20</td>
<td>2.34</td>
<td>8.14</td>
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</tbody>
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**Awards & Accolades**

a) 1st Prize in 2015 in Office Building Category at the prestigious National Energy Conservation Awards organized by Bureau of Energy Efficiency, Ministry of Power, Government of India. ICICI was the only Bank to have received this award.

b) Seven of our Towers won Energy efficiency Award in ‘National Awards for Excellence in Energy Management-2015’ by CII. ICICI Bank received the maximum number of awards at the event.

c) 1st & 3rd Prizes in 2015 in Office Building Category at the prestigious 10th State Level Awards for Excellence in Energy Conservation & Management organized by Maharashtra Energy Development Agency.


e) Golden Peacock Award 2016 - Innovative Product/Service for solar project in Gramin branches.

f) IGBC (Indian Green Building Council) has recently launched its Ratings for Building Interiors. ICICI Bank- Madhapur Branch was the first site in the country to be rated ‘PLATINUM’.

*Mr. Anuj Agarwal is the Head - Infrastructure Management & Services Group at ICICI Bank Limited.*

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MSME clusters in India covering sub-sectors such as glass & ceramics, chemicals, metallurgy, textile, food processing, forging etc. where energy costs account for a sizeable portion of energy costs. These sub-sectors/clusters offer immense potential for energy/cost savings through technology up-gradation and operational improvement. Government and donor agencies need to formulate and implement targeted programs aimed at providing technology, finance and technical handholding support to the MSMEs in these clusters. In order to take the movement of energy efficiency forward, the need therefore, is to get more and more professionals interested in working in the energy-efficiency field and to promote the uptake of new technologies through enabling policies, and easy-to-access financing mechanisms.

...continued from page 04
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CIN: L34101TN1948PLC000105
facilities management at IBS
Sankar Janardhanan and Prashant Pillai

By taking care of small things IBS made substantial savings in energy. Saving in electricity charges by improving HVAC efficiency is presented in this case study.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Location</th>
<th>Area in sq.ft</th>
<th>Seating Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Campus Phase 1</td>
<td>89,000</td>
<td>588</td>
</tr>
<tr>
<td>2</td>
<td>Campus Phase 2</td>
<td>52,000</td>
<td>684</td>
</tr>
</tbody>
</table>
The Utilities:
- 11 KV HT line as incoming supply from Technopark.
- Total Contract Demand - 1100 kVA
- Average Maximum Demand - 750 kVA
- Average Consumption - 2,20,000 kWh/Month
- Present cost per unit - Rs. 5.60 (Rs. 15 Lakhs / month, on an average)
- HT/LT Oil cooled OLTC Transformer - 1250 kVA (Make: Intrans, Age: 5 years)
- DG sets - 750 kVA + 500 kVA + 250kVA with synchronization.
- UPS Capacity - 490 kVA
- Total AC tonnage - 680 TR
- Sewage Treatment Plant 250 KLD - Integrated Aerobic & Anaerobic system

Glass panelling of the building had increased the heat load. Application of sun control films in the glass panes reduced the same thereby saving energy from HVAC operation.

Building envelope design for energy conservation
- Our facility is built with glass panelling architecture for availability of natural light inside the office space which increased the heat load.
- Application of sun control films in the glass panes reduced the heat load of the building, thereby saving energy from HVAC operation.

Best practices for energy conservation
- Improved Facility uptime
- Daily and Monthly Energy monitoring system
- Energy conservation survey and campaign among employees
- Incentive for maintaining PF between 0.98 and 1
facilities management at IBS
January - March  2016

a quarterly magazine of the society of energy engineers and managers / India

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Facilities Management at IBS

- Periodic review of the task groups on the energy performance.
- Training for the engineering team in energy conservation
- Utilization of STP water for irrigation purpose.
- Sensor taps and urinal sensors for judicious use of water.
- Descaling of Chillers - dirty HVAC can increase energy consumption by 30 -37 %
- Transformer maintenance and oil filtration
- Periodical Advanced Electrical Inspection and Electrical Safety Audits
- Variable Speed Drives for Air Handling Units (AHUs), to reduce the speed of fans, thereby reducing energy consumption, based on the varying occupancy levels in the building.

Quarterly thermal imaging audits and monthly electrical safety audits are conducted on a regular basis to minimize system breakdowns. We have improved the facility uptime from 99.5 % to 100% in FY 2014-15 with zero breakdowns in our electrical system.

We have achieved 36% energy savings per seat in FY 2014-15. In FY 2013-14 it was 233.65kWh per seat which was reduced to 137.14kWh in FY 2014-15.

**Achievements**

- We have achieved 36% energy savings per seat in FY 2014-15. New facility at our campus came into operation from Q2 - 2014 with increase of 40% load and seating capacity of 684 totaling to 1272 seats in our Campus.
- We have used centralized Chillers (165TR x 3 - Helical Rotary liquid chillers) for optimal use of energy.
- Facility uptime was 100% for FY 2014-15 with zero breakdowns.

**Electricity Consumption record 2013-2014**

<table>
<thead>
<tr>
<th>Month</th>
<th>Fixed units (kW)</th>
<th>Fixed charges (Rs)</th>
<th>Energy consumed (kWh)</th>
<th>Energy charges (Rs)</th>
<th>Electricity duty</th>
<th>KSEB Surcharges (Rs)</th>
<th>Incentive for maintaining power factor (Rs)</th>
<th>Grand total (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-13</td>
<td>562.5</td>
<td>157521</td>
<td>145608</td>
<td>610242</td>
<td>14560</td>
<td>3640</td>
<td>14798</td>
<td>871785</td>
</tr>
<tr>
<td>May-13</td>
<td>562.5</td>
<td>168750</td>
<td>138936</td>
<td>707010</td>
<td>13893</td>
<td>3473</td>
<td>16614</td>
<td>965857</td>
</tr>
<tr>
<td>Jun-13</td>
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<td>168750</td>
<td>125388</td>
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<td>808296</td>
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<tr>
<td>Jul-13</td>
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<td>168750</td>
<td>138828</td>
<td>710760</td>
<td>13882</td>
<td>3470.7</td>
<td>15636.72</td>
<td>881227</td>
</tr>
<tr>
<td>Aug-13</td>
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<td>168750</td>
<td>136428</td>
<td>698655</td>
<td>13642.8</td>
<td>3410.7</td>
<td>15719.74</td>
<td>868739</td>
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<tr>
<td>Sep-13</td>
<td>562.5</td>
<td>168750</td>
<td>134400</td>
<td>687045</td>
<td>13440</td>
<td>3360</td>
<td>16832.6</td>
<td>855762</td>
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<tr>
<td>Oct-13</td>
<td>562.5</td>
<td>168750</td>
<td>137784</td>
<td>703800</td>
<td>13778</td>
<td>3444.6</td>
<td>17243.1</td>
<td>872530</td>
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<tr>
<td>Nov-13</td>
<td>562.5</td>
<td>168750</td>
<td>134256</td>
<td>686500</td>
<td>13425</td>
<td>3356</td>
<td>11840</td>
<td>860092</td>
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<tr>
<td>Dec-13</td>
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<td>134604</td>
<td>688515</td>
<td>13460.4</td>
<td>3365</td>
<td>9983</td>
<td>864107</td>
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<tr>
<td>Jan-14</td>
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<td>Feb-14</td>
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<td>15238.8</td>
<td>3809.7</td>
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</table>

Average Consumption (kWh) 1,37,385

Seating capacity 588

kWh per seat 233.65

Electricity Consumption record 2013-2014
Electricity Consumption record 2013-2014

<table>
<thead>
<tr>
<th>Month</th>
<th>Fixed units (kW)</th>
<th>Fixed charges (Rs)</th>
<th>Energy consumed (kWh)</th>
<th>Energy charges (Rs)</th>
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<th>KSEB Surcharges (Rs)</th>
<th>Incentive for maintaining power factor (Rs)</th>
<th>Grand total (Rs)</th>
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<td>19741</td>
<td>4935</td>
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<td>19686</td>
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<td>1598176</td>
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</table>

Average Consumption (kWh) 1,74,447 Total (Rs) 1,52,70,469

Seating capacity 1272 kWh per seat 137.14

Mr. Prashanth Pillai is Head - Facilities Planning & Development at IBS Software Service Pvt Ltd.

Mr. Sankar Janardhanan is Senior Executive - Facilities at IBS Software Service Pvt Ltd.
The possibility of energy saving is generally overlooked in automated systems because the parameters concerned are pre-programmed by OEM. This case study conducted by ACE focuses on processes in an HV/EHV cable manufacturing plant. The method adopted in this study is termed as Byproduct Separator System (BPS).
H/V/EHV cable manufacturing processes involve a high level of automation. The processes are usually run as per OEM recommendations without much deviation. This case study aims at highlighting the possibilities of energy saving in automated systems which are normally not checked and audited as the parameters are pre-programmed by OEM.

The BPS requires the entire process line to be pressurized with nitrogen for proper curing of the cable sheathing. As the line is filled with pressurized nitrogen, it saturates with the hot fumes/particles of the sheathing material.

Manufacturing Process
The process requires the entire process line to be pressurized with nitrogen for proper curing of the cable sheathing. As the line is filled with pressurized nitrogen, it saturates with the hot fumes/particles of the sheathing material. The nitrogen requires to be cleaned in-situ for the process to continue. In order to do so, the nitrogen is cooled to condense the product vapors and then reheated to desired temperature and then introduced back into the process line. The condensed material is purged through a timer based valve. This system is known as the By-Product Separator (BPS) System.

The BPS system utilized a heat exchanger column to cool nitrogen using chilled water and an electric heater to heat the clean N2 up to the process requirement before reintroducing it into the process line:
Innovative Heat Recovery scheme

The energy consumption of the nitrogen heater can be reduced substantially by preheating the cooled nitrogen before it is fed into the heater. Implementation of this scheme would result in substantial saving. A conceptual diagram of the proposed system is shown in Figure 2.

Potential Cost Savings

The Process Line Zone temperatures were controlled through thyristor based set points shown in Table 1. The savings achievable by implementation of the proposed system are not only in the nitrogen heater but also in chiller as the heat rejected earlier in chilled water is now being partly reduced due to pre-cooling of the hot stream by the exhaust stream from the chiller heat exchanger.

Based on the operational data collected and the analysis carried out a summary of achievable savings along with estimated investment and payback is shown in Table 2.
Innovative Heat Recovery scheme

The energy consumption of the nitrogen heater can be reduced substantially by preheating the cooled nitrogen before it is fed into the heater.

Figure 1 - BPS nitrogen reheater (right) & cooling column (left)

Figure 2 - Proposed nitrogen bps system modification

Table 1: Temperature Set Points

<table>
<thead>
<tr>
<th>Tube</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp'C</td>
<td>425</td>
<td>375</td>
<td>355</td>
<td>346</td>
<td>345</td>
<td>335</td>
<td>331</td>
<td>330</td>
<td>320</td>
<td>320</td>
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Table 2: Estimate of Energy Saving and Payback period

<table>
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<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
<th>Comment</th>
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</thead>
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<tr>
<td>Average Power in Nitrogen Heater</td>
<td>21</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td>Heating Element Temp</td>
<td>600</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Heater Inlet N2 Temp</td>
<td>38</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Heater Outlet N2 Temp</td>
<td>328</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Specific heat of N2</td>
<td>0.249</td>
<td>kcal/kg °C</td>
<td></td>
</tr>
<tr>
<td>Mass flow of N2 through heater</td>
<td>250</td>
<td>kg/h</td>
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</table>

Existing nitrogen cooler (heat exchanger)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>Specific heat of water</td>
<td>1</td>
<td>kcal/kg °C</td>
<td></td>
</tr>
<tr>
<td>H/E CHW Flow</td>
<td>3</td>
<td>m³/h</td>
<td></td>
</tr>
<tr>
<td>CHW temp in</td>
<td>14.5</td>
<td>°C</td>
<td></td>
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<tr>
<td>CHW temp out</td>
<td>32</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>H/E N2 temp in</td>
<td>348</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>H/E N2 temp out</td>
<td>38</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>N2 Heat rejection into CHW</td>
<td>22</td>
<td>kW/h</td>
<td></td>
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<tr>
<td>Total heat rejected into CHW</td>
<td>61</td>
<td>kW/h</td>
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<tr>
<td>Difference</td>
<td>39</td>
<td>kW/h</td>
<td>To cool extruders etc.</td>
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</table>

Proposed Vertical Heat Exchanger (to drain out any condensate)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>Hot N2 temp</td>
<td>348</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Cool N2 temp</td>
<td>38</td>
<td>°C</td>
<td></td>
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<tr>
<td>Mass of N2 through H/E</td>
<td>250</td>
<td>kg/h</td>
<td></td>
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<tr>
<td>Expected N2 temp after pre heater</td>
<td>310</td>
<td>°C</td>
<td></td>
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<tr>
<td>Expected N2 temp gain from cold to hot exchange in N2pre-heater</td>
<td>19.7</td>
<td>kW</td>
<td></td>
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<tr>
<td>Reduction in heat load in CHW</td>
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<tr>
<td>SPC of chiller</td>
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<td>Saving in CHW load</td>
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<td>kW</td>
<td></td>
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<tr>
<td>Total saving in kW</td>
<td>24.2</td>
<td>kW</td>
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<tr>
<td>Average running</td>
<td>7200</td>
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<td>Annual Saving</td>
<td>1,41,815</td>
<td>kWh</td>
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<tr>
<td>Annual saving in CHW load</td>
<td>32,265</td>
<td>kWh</td>
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<tr>
<td>Total Annual Saving</td>
<td>1,74,080</td>
<td>kWh</td>
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<td>Annual Monetary Saving</td>
<td>11,94,189</td>
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<tr>
<td>Investment in modifications</td>
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<td>Rs</td>
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</tr>
<tr>
<td>Payback period</td>
<td>10</td>
<td>months</td>
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Conclusion

The savings achievable by implementation of the proposed system are not only in the nitrogen heater but also in chiller as the heat rejected earlier in chilled water (CHW) is now being partly reduced due to pre-cooling of the hot stream by the exhaust stream from the chiller heat exchanger.
The following case study conducted by ACE highlights the importance of root cause analysis in energy audits. This idea was applied to the evaluation process at a chemical manufacturing plant that was suffering from maintenance and environment related problems caused by a byproduct. The improvement in the manufacturing process suggested through RCA fetched the company Rs. 66.5 lakhs as annual saving.
Root-cause analysis can be helpful when analyzing the energy consumption data to identify energy saving potential. This case study establishes that an enormous energy saving was made possible by employing root cause analysis RCA in a chemical plant that manufactured Thionyl Chloride (TC) - SOCl₂.

The plant was fencing with problems that byproducts of a reaction -SO₂⁺ and HCl - were causing frequently. For the company dealing with the SO₂ and treating dilute HCl before letting it out as an effluent, demanded staggering energy costs, maintenance overtimes and a bloated work-force.

The plant was fencing with problems that byproducts of a reaction -SO₂⁺ and HCl - were causing frequently, like SO₂ compressor failures and environmental concerns that came with disposal of dilute HCl. The SO₂ and HCl were formed as a result of water scrubbing of uncondensed SOCl₂ and the un-reacted SO₂ vented from chilled water condenser after the reactor. For the company dealing with the SO₂ and treating dilute HCl before letting it out as an effluent, demanded staggering energy costs, maintenance overtimes and a bloated work-force.

The Manufacturing Process:

TC was being manufactured in a reactor using certain chemicals. The resultant products from the reactor were SOCl₂ and SO₂ which were condensed in a series of condensers using first cooling water and then chilled water heat condenser. The vent of chilled water condenser still had uncondensed TC and un-reacted SO₂. Both these chemicals being hazardous could not be vented off in the atmosphere as per Pollution board’s guide lines.

For dealing with uncondensed TC and SO₂, the company had set up additional infrastructure to scrub the vent gases (SOCl₂ and SO₂) with water. SOCl₂ on reacting with water decomposes into SO₂ and HCl.

SOCl₂(g) + H₂O(l) → 2HCl(l) + SO₂(g)

The dilute HCl was causing disposal problems due to environmental concerns, due to which the company had set up an ETP plant to neutralize the dilute HCl, which meant increased energy costs on account of pumping, neutralization, filtration and effluent disposal.

The balance vent gases, after the water scrubber was a wet mixture of SO₂ and H₂O which forms sulfurous acid. The dry SO₂ has a market potential as a product which can be compressed in cylinders and sold. Thus the wet SO₂ needs to be treated to form pure dry SO₂ which can then be bottled. The wet mixture was so scrubbed with concentrated H₂SO₄ (as it absorbs the moisture quickly), resulting in dilution of concentrated H₂SO₄, which was sold to the market at a discounted price. The balance stream now has dry SO₂ with traces of sulfuric acid fumes (as dilution is exothermic). The dry SO₂ was fed to multiple compressors in parallel after passing the stream through a charcoal and sand filter (to minimize sulfuric vapour). The SO₂ stream with minor traces of sulfuric acid was also causing havoc on the compressors by constantly contaminating the lubricating oil, corroding the piston rings and increasing the carrying-over of lubricating oil in the discharge product line. The SO₂ stream after compression has oil contamination. To remove the oil, the SO₂ was liquefied using brine so that lub. oil could be separated by density difference. The decanted high pressure liquid SO₂, was again evaporated by steam, then passed through some final filters and sent for bottling.

The flow diagram in Figure 1 illustrates this process.

Employing Root-Cause Analysis

The energy costs involved in the manufacturing of TC were enormously high, and the manufacturing process was extremely complex and hazardous. RCA tools like Herring-Bone structure and ABC analysis were employed in determining how and why an operation was carried out and which activity/asset/process was contributing the maximum to energy loss and downtime.

The Herring-Bone structure revealed a flaw in the process, that the uncondensed product was decomposed, rather ensuring that it gets completely condensed by using appropriate technology.

The Herring-Bone structure revealed a flaw in the manufacturing process - the uncondensed product was decomposed, instead of getting it completely condensed by using appropriate technology. In order to tackle the root-cause problem a process improvement was suggested which involved designing a heat exchanger.

Process Improvement:

In order to tackle the root-cause problem, which was a flawed manufacturing process, a process improvement was suggested which involved designing a heat exchanger that uses Dx type chiller coils of appropriate MOC after the chilled water to
recover all the balance of all TC traces from the vent stream keeping Dx temp at -20°C. This could be possible since complete condensing of TC requires it to be cooled to -10°C. Once all TC is condensed the balance will be just SO2 that can be directly compressed by passing the water scrubber, acid scrubber, charcoal filtration etc. and deploying oil free compressors to send the vented dry SO2 directly after compression to bottling plant. This would result in maximum TC recovery in the condensed form, eliminating many unwanted costs.

The dry SO2 to compression could pass through prefilter and coalescing filters before going through charcoal filtration and sent to bottling where it was rendered as safe for filling in cylinders. This improved manufacturing process was not only simpler, but also was cost effective. Figure 2 illustrates this improved manufacturing process.

Cost Savings Achieved:

A. Additional recovery of TC/day = 500 Kg x Rs.20 = Rs.10000

B. Reduction of Effluent/day = 20 m³ x Rs.5.50 = Rs.110/day

C. Reduction in lime consumption/day in ETP = 2100 Kg x Rs.2.5 = Rs.5250/day

D. Manpower cost for lime handling/day = 3 people x Rs.130/person = Rs.390/day

E. Consumption of bag for slug filling/day = 42 bags x Rs.3/bag = Rs.126/day

F. Cost of Disposal of Lime sludge/day = 2 MT x Rs.60/MT = 120/day

G. Elimination of spray pump water & acid = Rs.1200/day

H. Cost of lube oil in SO2 compressor due to acid degradation = Rs.1500/day

I. Cost of chilling load & water evaporator after SO2 compression = Rs.1500/day

With elimination of a number of equipment such as pumps and other systems, the maintenance cost is reduced, yet it is not considered here.

J. Cost to run earlier manufacturing process
   = A + B + C + D + E + F + G + H + I
   = Rs.20196/day

Figure 1: The Manufacturing Process prior to improvement

Figure 2: The Improved manufacturing process
Spare chiller system was available and commissioned to be integrated in to the proposed process improvement in the manufacturing.

K. The cost of running Dxchiller for TC condensing = Rs.1200/day

Total Savings by adopting improved process = J-K = Rs.18996/day on a regular basis

Annual Savings = Rs. 66,48,600/year
(350 days a year working)

Investment = Rs.6,00,000

Payback Period = 1 day

A simple RCA on why the TC was not completely condensing led to this major energy conservation. The investment was a meager Rs. 2,00,000 for modifying and commissioning the spare heat exchanger from vent stream solved all the subsequent process & plants of water scrubbing, dilute HCl handling & treatment. The elimination of concentrated acid scrubbing and frequent lubricating oil changes is carried over by switching to oil free compressors. As there was no oil carry over the need for first liquefying hot compressed stream and then decanting & again heating was eliminated as the SO2 after compression can be directly bottled after filtration.

Subsequently excess SO2 was shut down.

**Conclusion:**

The case study is a real-life-on-site example of the power of root-cause analysis in the field of energy conservation and optimization. As a result of the improvement in the manufacturing process the client company saved Rs. 66.5lakhs annually.

This is a typical example of how ignoring the root cause and only attacking the output of a process can be a costly proposition.

A simple RCA on why the TC was not completely condensing led to this major energy conservation. The investment was a meager Rs. 2,00,000 for modifying and commissioning the spare heat exchanger from vent stream solved all the subsequent process & plants of water scrubbing, dilute HCl handling & treatment. The elimination of concentrated acid scrubbing and frequent lubricating oil changes is carried over by switching to oil free compressors. As there was no oil carry over the need for first liquefying hot compressed stream and then decanting & again heating was eliminated as the SO2 after compression can be directly bottled after filtration.

Subsequently excess SO2 was shut down.

Ms. Shail Derashri is presently working as a Senior Energy & Root Cause Analyst with Academy for Conservation of Energy, Baroda.
Background

On auditing the performance of Raw Mill ESP Fan it was found that the fan is operating at 355 rpm against the rated 468 rpm and generating a pressure rise of 80mm WG at a flow rate of 172.66 m/s. The HT Slip Ring Induction motor rated for output power of 710 kW and at a speed of 740 rpm was driving the fan at 355 rpm which is the normal speed required for the process. The fan speed was being controlled by a delta-connected external Grid Rotor Resistance (GRR) where a significant amount of power was lost. The fan motor had a rated efficiency of 79% at the operating pressure and flow, but the motor was operating at 43% efficiency only. The power loss in GRR was measured and found to be 193 kW. Also the CGR and GRR required 5×2.2 kW blowers for cooling.

This is the case of a 710kW HT Slip Ring Induction motor used in Raw Mill ESP Fan that had its speed controlled by rotor resistance. Due to heavy rotor losses the motor was performing at half the rated efficiency. The energy audit recommendation to replace it with an energy efficient HT motor of 450kW, 450 RPM with HT VFD yielded annual energy saving of 1615.68 MWh worth Rs 97 lakhs.

**Motor specifications**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit Value</th>
</tr>
</thead>
<tbody>
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<td>Star</td>
</tr>
<tr>
<td>Pole</td>
<td>8</td>
</tr>
<tr>
<td>Rated Output kW</td>
<td>710</td>
</tr>
<tr>
<td>Voltage V</td>
<td>6600</td>
</tr>
<tr>
<td>Frequency Hz</td>
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</tr>
<tr>
<td>Full load current</td>
<td>A 82</td>
</tr>
<tr>
<td>Speed rpm</td>
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</tr>
<tr>
<td>Slip %</td>
<td>1.333%</td>
</tr>
<tr>
<td>Efficiency %</td>
<td>94%</td>
</tr>
<tr>
<td>Insulation Class</td>
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</tbody>
</table>
This is the case of a 710kW HT Slip Ring Induction motor used in Raw Mill ESP Fan that had its speed controlled by rotor resistance. Due to heavy rotor losses the motor was performing at half the rated efficiency. The energy audit recommendation to replace it with an energy efficient HT motor of 450kW, 450 RPM with HT VFD yielded annual energy saving of 1615.68 MWh worth Rs 97 lakhs.

### Background

On auditing the performance of Raw Mill ESP Fan it was found that the fan is operating at 355 rpm against the rated 468 rpm and generating a pressure rise of 80mm WG at a flow rate of 172.66 m³/s. The HT Slip Ring Induction motor rated for output power of 710 kW and at a speed of 740 rpm was driving the fan at 355 rpm which is the normal speed required for the process. The fan speed was being controlled by a delta-connected external Grid Rotor Resistance (GRR) where a significant amount of power was lost. The fan motor had a rated efficiency of 79% at the operating pressure and flow, but the motor was operating at 43% efficiency only. The power loss in GRR was measured and found to be 193 kW. Also the CGR and GRR required 5×2.2 kW blowers for cooling.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor connection</td>
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<td>Star</td>
</tr>
<tr>
<td>Pole</td>
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<td>8</td>
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<tr>
<td>Rated Output</td>
<td>kW</td>
<td>710</td>
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<td>Voltage</td>
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<tr>
<td>Frequency</td>
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<td>rpm</td>
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</tr>
<tr>
<td>Slip</td>
<td>%</td>
<td>1.333%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>94%</td>
</tr>
<tr>
<td>Insulation Class</td>
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<td>F</td>
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No load test Measurements

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage, U</td>
<td>V</td>
<td>6600</td>
</tr>
<tr>
<td>Current, Inl</td>
<td>A</td>
<td>38</td>
</tr>
<tr>
<td>No load power input, Pi-nl</td>
<td>W</td>
<td>22.85</td>
</tr>
<tr>
<td>Stator phase resistance after NL test, Rph-nl</td>
<td>°C</td>
<td>0.2650</td>
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<tr>
<td>Ambient Temperature, Ta</td>
<td>°C</td>
<td>20</td>
</tr>
<tr>
<td>Frequency, f</td>
<td>Hz</td>
<td>50</td>
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Measurements at actual load

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Voltage, UL</td>
<td>V</td>
<td>6520</td>
</tr>
<tr>
<td>Load current, IL</td>
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<td>57.00</td>
</tr>
<tr>
<td>Power input, PL</td>
<td>kW</td>
<td>398</td>
</tr>
<tr>
<td>Winding Temperature, Tw</td>
<td>°C</td>
<td>115</td>
</tr>
<tr>
<td>Winding resistance at operating temp., Rph</td>
<td>kW</td>
<td>0.3509</td>
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<tr>
<td>Operating speed, NL</td>
<td>rpm</td>
<td>355</td>
</tr>
<tr>
<td>Frequency, f</td>
<td>Hz</td>
<td>49.50</td>
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</table>

Calculation of Operating Parameters:

Motor Input power = 398kW,
Motor Speed = 355 rpm,
Slip = 52.19%
Air Gap Power = 373kW,
Total Cu Loss in Rotor = 373kW × 52.19% = 195kW
Motor efficiency at operating load = 43%

Operating parameters of the Motor

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Stray losses Full load</td>
<td>%</td>
<td>1.00</td>
</tr>
<tr>
<td>% friction &amp; windage losses at full load</td>
<td>%</td>
<td>1.00</td>
</tr>
<tr>
<td>Stator Copper loss - no load</td>
<td>kW</td>
<td>1.15</td>
</tr>
<tr>
<td>Constant loss</td>
<td>kW</td>
<td>21.70</td>
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<tr>
<td>Friction &amp; windage loss</td>
<td>kW</td>
<td>7.11</td>
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<tr>
<td>Core loss at rated voltage</td>
<td>kW</td>
<td>14.59</td>
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<tr>
<td>Stator Copper loss at actual load</td>
<td>kW</td>
<td>3.42</td>
</tr>
<tr>
<td>Slip at actual load</td>
<td>%</td>
<td>52.19%</td>
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<td>Core losses at actual measured voltage</td>
<td>kW</td>
<td>14.24</td>
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<td>Stray losses actual load</td>
<td>kW</td>
<td>7.10</td>
</tr>
<tr>
<td>Rotor input at actual load</td>
<td>kW</td>
<td>373</td>
</tr>
<tr>
<td>Rotor copper loss at actual load</td>
<td>kW</td>
<td>195</td>
</tr>
<tr>
<td>Total losses</td>
<td>kW</td>
<td>227</td>
</tr>
<tr>
<td>Motor Shaft power</td>
<td>kW</td>
<td>171</td>
</tr>
<tr>
<td>Motor Efficiency at actual load</td>
<td>%</td>
<td>43.05%</td>
</tr>
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Fan Efficiency Calculation

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Temperature t2</td>
<td>°C</td>
<td>105</td>
</tr>
<tr>
<td>Temperature T2</td>
<td>K</td>
<td>378</td>
</tr>
<tr>
<td>Pressure P1</td>
<td>mmWC</td>
<td>10,333</td>
</tr>
<tr>
<td>Draft Pressure p2</td>
<td>mmWC</td>
<td>-106</td>
</tr>
<tr>
<td>Pressure P2</td>
<td>mmWC</td>
<td>9,644</td>
</tr>
<tr>
<td>Air Density at NTP (1)</td>
<td>Kg/m3</td>
<td>1.35</td>
</tr>
<tr>
<td>Air Density at operating temp. &amp; Pressure (2)</td>
<td>Kg/m3</td>
<td>0.910</td>
</tr>
<tr>
<td>Duct Size (Square)</td>
<td>m</td>
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</tr>
<tr>
<td>Duct Area</td>
<td>m2</td>
<td>10.2272</td>
</tr>
<tr>
<td>Velocity Pressure</td>
<td>mmWC</td>
<td>17.62</td>
</tr>
<tr>
<td>Velocity</td>
<td>m/s</td>
<td>16.88</td>
</tr>
<tr>
<td>Flow</td>
<td>m3/s</td>
<td>172.66</td>
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<tr>
<td>Draft at fan inlet</td>
<td>mmWC</td>
<td>-90</td>
</tr>
<tr>
<td>Draft at fan outlet</td>
<td>mmWC</td>
<td>-10</td>
</tr>
<tr>
<td>Air kW</td>
<td>kW</td>
<td>135</td>
</tr>
<tr>
<td>Fan Shaft Power</td>
<td>kW</td>
<td>171</td>
</tr>
<tr>
<td>Fan Efficiency</td>
<td>%</td>
<td>79.03%</td>
</tr>
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</table>

Recommendation

Replace existing 710kW motor by 450kW, 450rpm HT motor with VFD.

Estimation of Savings

Power Saving potential = Total Rotor Cu Loss - Cu loss in rotor winding + Power wasted in Cooling Blowers = 195kW-(3×2002×0.016)/1000 + 11kW = 204kW
Energy Saved = 204kW × 24h/day × 330 days/annum = 16,15,680 kWh
Money Saved = 16,15,680 kWh × Rs.6/kWh = Rs.96.94 Lacs
Investment required = Rs 70 Lacs
Simple Payback period = 9 Months
Reduction in CO2 emission = 2×0.204MWx24×h×330days/annum = 3231 tCO2/annum
National Saving in terms of Power Plant Capital Cost = 2x0.204MWxRs.600Lacs/MW = Rs.244Lacs

Mr Prahlad Chandra Tiwari is an Accredited Energy Auditor and also an Assistant Engineer (IT/SCADA/Training) at Ajmer Discom.
energy star upgradation from 3 to 5

Akash Jain

M/s Pranat Engineers took up this project following a call from BEE to carry out performance enhancement of Yojana Bhawan, New Delhi, based on star rating in order to promote implementation of energy efficiency measures in the existing buildings. The following article gives an overview of the project done.
Preface

Yojana Bhawan (office of the Planning Commission) is one of the most prestigious buildings in the capital of India. BEE had invited Proposal from Energy Service Companies (ESCOs) empanelled with BEE for carrying out performance enhancement of Yojana Bhawan, based on star rating in order to promote implementation of energy efficiency measures in the existing buildings. The Government of India has a scheme to provide assistance for conducting Investment Grade Energy Audits (IGEA) for government buildings at central as well as state level. The Government of India has an approved scheme to provide assistance for conducting Investment Grade Energy Audits (IGEA) for government buildings at central as well as state level. Taking up Yojana Bhawan project was a feather on the cap of Pranat Engineers.

Pranat Engineers Pvt. Ltd. (PEPL) is serving the Indian society for more than two decades and contributing to energy conservation through energy efficiency enhancement route. 'Success comes with hard work and sense of responsibility' - getting selected to execute the IGEA at Yojana Bhawan is not just an achievement but also a great responsibility. Taking up Yojana Bhawan project was a feather on the cap of Pranat Engineers.

During the energy audit of Yojana Bhawan the ESCO identified that there existed a potential for energy saving by almost 30% if certain factors and states are modified

The Findings

Based on the current building standards the Yojana Bhavan was considered as 3 star rated building. It was observed that Energy Performance Index was high (130 kWh/sq.m/year). The areas in need of improvement were:
1. Power Factor
2. Replacement of existing AC units with 5 star rated products
3. Replacement of existing pumps with Energy Efficient pumps
4. Installation of Energy Savers in all AC Units.
5. Replacement of existing Lighting with Energy Efficient lamps.

Based on the current building standards the Yojana Bhavan was considered as 3 star rated building. It was observed that Energy Performance Index was high (130 kWh/sq.m/year) and an effort was made to reduce it to nearly 40% through implementation of 5 star rated products.

Project Implementation

- All the lights were replaced by Alien LED lights.
- All the fans were replaced by 5 star rated fans
- Energy savers for A.C. were installed.

The Results

- Savings was observed. More than 50% energy saving was obtained.
- EPI went down from 130 to 80 kWh/sq.m/year
- Building became 5 star rated.

This is the first government building that has been upgraded from 3 star rating to 5 star rating by the efforts of Pranat Engineers Pvt. Ltd.

Mr. Akash Jain is the Director at Pranat Engineers Pvt Ltd.
harnessing energy efficiency through social engineering: case of EMC Kerala

B V Subhash Babu and R Harikumar

The growth of an economy has a direct effect on its energy demand as well as consumption. Standing at fourth place in this regard after China, USA and Russia, India is no stranger to the scenario of the need to conserve available energy resources. This article highlights a few such initiatives proposed by the Energy Management Centre in Kerala. EMC is an autonomous organization under Department of Power, Government of Kerala and is the State Designated Agency (SDA) in Kerala to coordinate, regulate and enforce the provisions of the Energy Conservation Act, 2001.
The primary energy demand grows with the increase in income and economic growth of a country. The energy consumption in India is the fourth biggest after China, USA and Russia. The growing primary energy demand indicates the importance of conserving available energy resources. Energy conservation by avoiding wasteful use of energy can be termed as a new source of energy.

Energy Management Centre (EMC) has established itself as an autonomous organization under Department of Power, Government of Kerala in 1996. Since then EMC has been formulating and implementing energy efficiency and energy conservation programs and projects to promote efficient use of energy in all sectors of the economy in the State of Kerala. EMC is the State Designated Agency (SDA) in Kerala to coordinate, regulate and enforce the provisions of the Energy Conservation Act, 2001.

Kerala has a unique characteristic of having a large share of grid power consumed by its domestic sector, around 51%. Another 11% is being consumed by the commercial building sector; rest by industries, municipalities and a very minimal share by the agricultural consumers. Taking note of this, most of the EMC's initiatives were more of a social engineering effort by spreading awareness through outreach programs, motivating the consumers through recognizing energy efficiency excellence and enticing them to take up projects by implementing demonstration projects to help gain their confidence. Some of the recent promotional schemes of EMC are presented below.

EMC has initiated an awareness campaign "URJA KIRAN" through NGOs to create / enhance awareness on the importance of energy efficiency and energy conservation among general public. Participation of at least one people's representative and evolution of a social action component based on the discussions in the program to be taken up by the NGO in the next financial year with the support of EMC are highlights of this scheme.

Urja Kiran

Focusing the general public of Kerala, EMC has initiated an awareness campaign "URJA KIRAN" through NGOs to create / enhance awareness on the importance of energy efficiency and energy conservation among general public. Though there is a broad awareness about the need for energy conservation among the public, it has been found that the energy usage practices employed most often are not really scientific; for example, consumers’ rampant use of electric induction cookers, CFLs in very short time usage areas, unscientific cooking practices using the pressure cooker, etc. Programs under this
scheme in 2015-16 will be conducted covering all the 140 Legislative Assembly Constituencies in the State which will certainly provide a wide outreach to the campaign. Participation of at least one people’s representative and evolution of a social action component based on the discussions in the program to be taken up by the NGO in the next financial year with the support of EMC are highlights of this scheme. Proposals for 192 programs submitted by 150 NGOs have already been sanctioned with eligible financial assistance and organisation of the programs in progress in different parts of the State. Through a trainers’ training effort, around 128 resource persons are trained all across the State for providing resource support to the NGOs while conducting the programs.

The "ENERGY CLINIC" is a women oriented programme in which energy conservation and energy efficiency are ensured by enabling the proper selection and use of appliances, and advising them on proper ways to use energy.

Energy Clinic

To curtail increasing energy demand in the domestic sector, EMC has devised another scheme namely "ENERGY CLINIC". This program of awareness creation is being implemented through trained women Energy Conservation Animators (ECA).
Clinics are women oriented programme in which energy conservation and energy efficiency are ensured by enabling the proper use of appliances, advising them on proper ways to use energy and also make them aware how to select energy efficient appliances, by visiting individual households. EMC provides honorarium to the ECAs for this exercise against their report in a given format and also takes care of their hospitality while invited for periodic refresher training in different locations.

**Research and Education**

EMC has several schemes to support students and researchers. Such schemes are open not only to engineering faculty but also to other disciplines, including social science, law, arts, history, etc. The interdisciplinary research advisory council constituted for this purpose reviews/ evaluates the proposals, suggests amendments and also recommends for the financial assistance. EMC provides financial and technical support to students and researchers of Kerala to carry out energy related projects, studies and research. Educational institutions and other organizations can avail the support from EMC to conduct energy related workshops, seminars and conference by their organizations.

"SMART ENERGY PROGRAM" enrolls 50 schools from each of the 41 educational districts to participate in various activities to promote energy conservation. Coordinators and Joint Coordinators coordinate and monitor the activities under SEP. Each SEP member school will have at least 50 students enrolled in this program and a teacher coordinator.

**Smart Energy Program (SEP)**

For inculcating energy conservation habits among school students a program titled "SMART ENERGY PROGRAM (SEP)" is launched. 50 schools from each of the 41 educational districts are enrolled to SEP and they participate in various activities like project competition, essay competition etc to promote energy conservation. EMC has Coordinators for each of the 14 revenue districts and Joint Coordinators for each educational district to coordinate and monitor the activities under SEP. Each SEP member school will have at least 50 students enrolled in this program and this is being coordinated by a teacher coordinator in the respective schools. As part of the SEP, this year EMC is providing energy efficient devices (LED tube lights, street light, bulbs & star rated fans) worth Rs 25,000/- to each selected five numbers of government/ aided UP/LP schools in each revenue district; installation of which would demonstrate energy efficiency and motivate schools to become energy efficient utilizing local funds from the MPLAD scheme, etc.

**Institutional training programmes**

As part of enlarging its capacity building initiatives Energy Management Centre introduced its "Institutional training programmes". Ten numbers of in-house courses have been designed to be conducted through the training centre of the newly constructed Green building for different stakeholders including school/ college teachers, industrial engineers, architects, researchers, etc. The designing of the courses have taken in to account the importance of widening and deepening efforts of EMC in its capacity building initiatives in the State in a visible and impactful manner. The courses cover a wide range of topics in the field of Energy Management, Conservation, Energy Efficiency, Renewable Energy Technologies, etc.

EMC operates the scheme of "KERALA STATE ENERGY CONSERVATION AWARD" of the State Government to encourage conservation activity in the State. Six categories of this award scheme include large scale energy consumers, medium scale energy consumers, small scale energy consumers, etc.
energy consumers, buildings, institutions & organizations and individuals. Awards are conferred on 14th December, the national energy conservation day.

**Energy Conservation Award**

EMC operates the scheme of 'KERALA STATE ENERGY CONSERVATION AWARD' of the State Government to encourage conservation activity in the State. Six categories of this award scheme include large scale energy consumers, medium scale energy consumers, small scale energy consumers, buildings, institutions & organizations and individuals. Awards are conferred on 14th December, the national energy conservation day. EMC organizes a sensitization workshop for the prospective award applicants every year ahead of the announcement inviting applications. The previous year’s award winners present their success cases in that program and participate in the discussions. EMC also organizes a site visit for the award applicants to the facilities of the award winners to witness the projects they have implemented and also to understand the management practices adopted for bettering energy efficiency.

For promoting detailed energy audit in Public Sector Undertakings, EMC has devised a scheme namely "ENERGY AUDIT SUBSIDY SCHEME (EAS)". This scheme provides a subsidy for PSUs to conduct energy audit in their facility. Another scheme namely "WALK-THROUGH ENERGY AUDIT SCHEME" is aimed at preliminary energy audit/ Walk-though energy audit in Low Tension (LT) consumers. Through a peer review process, EMC has empanelled energy auditors and their list with all details is published in the website. Energy audits in Kerala are to be conducted through these energy auditors to comply with the government order.

**Small Hydro Power (SHP)**

EMC has taken initiatives for speedier development of SMALL HYDRO POWER (SHP) in Kerala, with people’s participation. Small and mini hydel plants can provide a solution for the energy problems in remote and hilly areas where extension of grid system is comparatively uneconomical. Therefore EMC is actively involved in efforts to develop, introduce and promote electricity generation and local area development through SHP.

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**Energy Audit Subsidy Schemes**

Govt. of Kerala has made energy audit mandatory for all HT/EHT consumers. EMC has several activities to assist State and Central Public Sector Undertaking in conducting Energy Audit in their firms. For promoting detailed energy audit in Public Sector Undertakings, EMC has devised a scheme namely "ENERGY AUDIT SUBSIDY SCHEME (EAS)". This scheme provides a subsidy for PSUs to conduct energy audit in their facility. Another scheme namely "WALK-THROUGH ENERGY AUDIT SCHEME" is aimed at preliminary energy audit/ Walk-though energy audit in Low Tension (LT) consumers.
urban planning at ADEME to accompany the energy transition in territories:

levers for action at the territorial level

ADEME
Five levers for action that are determinant for the Factor 4 planning process emerge from analysis of measures implemented in different territories. These levers point to steps for successful action, but also raise questions concerning organization and governance.

1. Putting knowledge at the heart of the process

To address the Factor 4 objective the planning process, from conception to evaluation, is based on an integrated multiple stakeholder approach.

From information to action

Factor 4 action involves elected officials, land use managers, operators, citizens and professionals, including energy producers. These actors bring their specific perspectives and thinking to the process, focusing variously on the economy, public image, quality of life, etc.

Some territories have developed ways to accompany the process, working in particular on energy renovation with home owners, both in single-family houses and multiple unit buildings. The support measures range from pooling financial instruments to technical coordination of renovation work.
Integrating knowledgeable stakeholders in the
decision-making process
As the issues and stakes have changed, new stakeholders have to be integrated in the process. Including public entities such as Chambers of Commerce and Industry enriches the discussion on the goals and outcomes of the planning process, but this practice is far from systematic.

Gathering and pooling data
Gathering data is key tool for objective assessment of public policy, but this is a difficult task. Comparison is often necessary to put territorial data into perspective. Sharing observatory units is one way to accomplish these tasks, confronting issues and sharing good practices.

The Grenoble territorial coherence scheme
The environmental assessment conducted under the Grenoble territorial coherence scheme (SCoT) was the occasion for work focusing specifically on energy and climate. The assessment highlighted the scope of these issues for the territory, and the impact of the coherence scheme. Integrating this approach from the start in the SCoT policy and decision process contributed to this success.

The performance chart for the Nord-Pas de Calais Region
The Nord-Pas de Calais Region and ADEME have developed a shared tool for pooling energy and climate data in territories, based on 10 indicators tracked in each territory that is engaged in a climate action plan. This tool shares information on challenges in the different territories, and contributes to the publication of thematic documents that can be disseminated to all the partners.

Monitoring and evaluating planning options
One of the immediate tasks for Factor 4 planning is defining energy and climate options that do not contradict each other, by using appropriate tools,

Build in My Back Yard: the BIMBY experiment in Tours
A study of the increasing density of single-family homes revealed a need for proactive measures to accompany residents, and for technical resources to support this accompaniment.

A local housing plan: the PLH in Nancy
Tools to work with homeowners in multi-family buildings (freeholders) have been developed under the local housing plan in the city of Nancy. These tools are part of a package to help owners set up financing, negotiate with contractors and follow execution of the work to be carried out.

notably tools on GhG emissions developed by the Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement (CErEMA) and ADEME.
2. Accompanying changes in lifestyle

Making cities "desirable"

One condition for achieving Factor 4 goals is to make cities the main place where people live and work, integrating jobs, retail shops, services and leisure activities. The aim is to propose an alternative urban model, taking today’s aspirations into account, and examining social aspects such as acceptable density and ageing population that force us to rethink local communities.

Accompanying changes in practices

How can cities be made attractive, combining density and fluidity of movement? How should low consumption marketing be shaped? Here the task is to identify the elements that trigger changes in behaviour, using participatory tools.

“The same city differently”, or making a post-carbon scenario acceptable

A sociological study conducted in the city of Tours showed ways to make a post-carbon urban scenario more acceptable. This scenario is based on credible, acceptable and attractive features, deployed on temporal and spatial scales that can be appropriated by individuals. The aspiration for a better quality of life is the main driver for change. A “desirable” city is one that reconciles the functional dimensions of the territory and public policy with the practical wishes and symbolic hopes of residents in terms of their lifestyle.

Conditions ensuring that public policy in Grenoble is acceptable

The Grenoble metro area government carries out regular surveys to gather residents’ views on the acceptability of measures enacted or anticipated, for instance to improve air quality or before lowering the speed limit on a major thoroughfare. These polls serve to amend measures and the ways in which information is communicated.
Survey of single-family homes in Nancy

The Grand Nancy public housing authority (SPL) conducted a survey in 20 residential areas of single-family homes, focusing on sociological aspects and energy issues. This work served as a major tool for raising residents’ awareness and helping them better understand the thermal characteristics of their homes, and be better informed about possible improvements and available aid.

3. Driving change in territorial organization and urban configurations

Factor 4 goals lead to rethinking urban configurations and their functions, in different areas: the links between urban planning and transport, a bioclimatic approach, access to energy, heat islands, the attractiveness of cities, community and proximity.

Developing a Factor 4 vision for a territory

To implement a Factor 4 urban organization the proper scale for territorial development must be defined, and appropriated by the whole chain of actors. Forward-looking exercises can be used to stimulate implementation of the Factor 4 approach in a territory, and help elected officials make choices.

A forward-looking exercise in the Tours metro area

A study was conducted to think about the future of Tours and its territorial coherence scheme in a post-carbon society, in order to perceive options to be chosen as of today in strategic planning documents.

Compact, attractive, accessible and economical cities

Factor 4 scenarios all agree on the need to implement urban systems that create compact centres and provide all necessary services. In denser cities there is less unavoidable automobile transport, public transport is more effective and energy grids are optimized. Controlling urban land uptake and soil sealing also serves this objective of building compact and active cities. The objective is also to make cities more desirable, to make city centres attractive, with high-quality urban amenities.

Land uptake in the Rennes local housing plan

The territory of the Rennes metropolitan area is structured according to the concept of urban archipelago. To reinforce urban poles and their connection, in order to preserve agricultural areas and natural spaces, the metro area has implemented a territorial coherence scheme (SCoT) and a local housing plan (PLH), tools that call for a minimum level of density and sufficient services.

Functional mixed use and energy objectives

To address energy issues through functional mixed use of urban spaces work must look at residents’ transport/travel chains, including thinking on services offered in train stations, and time coordination committees that focus on reconciling the demands of professional and personal life. These approaches can help reduce distances travelled, and make urban areas more attractive. Mixed use also aims to build cross-sectoral energy systems that serve both housing and economic activity. In this approach objectives are to work on equipment life to achieve optimum use over time, while allowing functions to evolve.

4. Cultivating an integrated approach

An integrated approach is based on a multidisciplinary analysis. In Factor 4 planning this approach is implemented within the planning...
documents themselves. This approach is also grounded in cross-sectoral treatment of thematic policies and coordination between different territorial scales.

Creating thematic bridges that stimulate local partnerships

Climate and energy issues touch upon many themes covered by the planning process. Accordingly organizational mechanisms are needed to link the actors of the energy sector with urban planners, to enable them to develop a common culture and share tools and practices. Environmental assessment, by nature iterative, can be a space for multidisciplinary work, if it is accorded a central place in defining planning orientation and objectives.

Linking strategic and operational tools

Planning options are implemented via operational tools. For example, strategic options concerning automobiles in the city are specified in territorial coherence schemes (SCoTs) and implemented via traffic circulation plans and neighbourhood improvement schemes.

Energy and climate in the Grenoble territorial coherence scheme

Energy and climate were designated as prime topics by elected officials from the very start of elaboration of the territorial coherence scheme (SCoT). To encourage appropriation of these themes, the multipartite SCoT syndicate, working with a technical consultant and the public urban planning agency, focused on increasing awareness, and also developed a modelling tool to highlight the effects of SCoT options on the environment. This approach underscored how important it is to have a group of elected officials who emphasise climate/energy thinking throughout the planning process.
The Bordeaux inter-municipal local urban planning document (PLUi)

The local energy agency and the local urban planning agency have pinpointed the potential for developing and optimizing urban heat networks, by bolstering construction options in areas served or potentially served by district heating. This approach, implemented prior to revision of the local urban planning document, links strategic and operational components. The success of this operation lies in its ongoing application under a joint work programme involving the two agencies over several years.

A cross-sectoral and cross-disciplinary approach also means working with different tools in a shared framework. Tools such as a local housing plan (Plh) call for a period of negotiation, to address distribution of housing units, for instance. The time required for this exchange must be included in the planning calendar and timetables so that they can be taken into account by other partners working on commuter travel or environmental issues.

The 4-in-1 integrated local urban planning approach in Brest

The Brest metropolitan area has set up an integrated approach combining the inter-municipal local urban planning document (PLUi) and the territorial climate and energy plan (PCET). Mounting these two approaches simultaneously has built up dialogue between municipal departments on the specific tasks and means for action in each policy area. This two-pronged approach has consolidated energy measures related to housing and transport. The observatory tools deployed under the climate plan have coordinated policy action for saving energy and preventing GHG emissions in these two sectors.

Encouraging dialogue between territorial entities at various scales

Factor 4 planning emphasises the complementary nature of policies conducted on a scope that is appropriate for addressing issues, for example energy and transport. This scope is often broader than a project scale alone. It may be a question of deploying complementary measures in terms of public transport services, an developing solidarity, in particular financial solidarity, between territories. The first stage in this process is sharing objectives and tools for understanding the territory as a whole.

A charter of commitments in the Nord-Pas de Calais Region

The FRAMEE network brings together the main actors involved in energy and urban planning in the Nord-Pas de Calais Region for the purpose of identifying and sharing their good practices. On the basis of these talks a "manifesto for sustainable urban projects" has been drawn up, presenting a shared vision of the issues at stake.

5. Mobilizing territorial resources to carry out Factor 4 projects

Rethinking planning means renewing practices new sources of funding and innovative forms of organization must be found.

Getting residents involved

One of the essential levers for Factor 4 projects is the implication of stakeholders, and more specifically residents, in the projects. Experience has shown that for programmes addressing housing issues a strong level of support to residents is required, e.g. audits or financial aid for improvement work. This means that territorial entities must deploy new financial and organizational resources.
Financing project engineering

Planning projects that aim to achieve Factor 4 goals require project engineering and management that can produce the tools needed to involve residents. One of the major tasks is to bolster project engineering in territories where these skills are lacking and in isolated areas, and to develop citizen awareness programmes.

In brief

Integration of Factor 4 goals in the planning process is an important task that territories are beginning to tackle. The steps already taken point to levers for success. The Factor 4 approach must be shared by partners, in an integral fashion, from initial observations to final decision. This cross sectoral and cross-disciplinary implementation, spanning actors, territories and themes, is one of the keys to success. Factor 4 planning questions the ways in which cities are made, via new urban configurations, appropriation by residents and its vision for the territory.

Financing of real estate development In question

Factor 4 planning has two main effects on housing construction, beginning with the impact on land available at a low cost. With the halt of soil sealing and covering, available land will be scarcer, and new spaces will have to be exploited, by denser construction, rehabilitation of brownfields, renewal of existing built-up areas by demolition and reconstruction, etc. The second effect is the higher cost of construction to achieve better energy performance in housing. Studies are underway to find ways in which the financial benefits of low-energy homes can be mobilized.
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