UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Technology Compendium for Energy Efficiency and Renewable Energy Opportunities in Foundry Sector

Indore Foundry and Auto Cluster

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

September 2020

Disclaimer

This document is prepared to provide overall guidance for conserving energy and costs. It is an output of a research exercise undertaken by Confederation of Indian Industry (CII) supported by the United Nations Industrial Development Organization (UNIDO) and Bureau of Energy Efficiency (BEE) for the benefit of the ***Foundry Industry located at Indore, Madhya Pradesh, India***. The contents and views expressed in this document are those of the contributors and do not necessarily reflect the views of CII, BEE or UNIDO, its Secretariat, its Offices in India and elsewhere, or any of its Member States.

Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India

(A GEF funded project being jointly implemented by UNIDO & BEE)

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Compendium of

Energy Efficiency and Renewable Energy Technologies for Indore Foundry and Auto Cluster

September 2020

Developed under the assignment

Scaling up and expanding of project activities in MSME Clusters

Prepared by

Confederation of Indian Industry

125 Years - Since 1895

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Acknowledgement

Acknowledgement

This assignment was undertaken by Confederation of Indian Industry (CII) as a project management consultant under the Global Environment Facility (GEF) funded project 'Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India.' The Technology Compendiums are meant to serve as an informative guide to the clusters that the project is currently working in and also to the other potential clusters across the country.

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CII Team

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List of Abbreviations

AC	Alternating Current
APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
BEP	Best Efficiency Point
BLDC	Brushless Direct Current
CAGR	Compound Annual Growth Rate
CII	Confederation of Indian Industry
CIP	Cleaning in Place
DC	Direct Current
DG	Diesel Generator
DPIIT	Department for Promotion of Industry and Internal Trade
EHP	Electric Heat Pump
FO	Furnace Oil
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Green House Gas
HID	High-intensity discharge
HSD	High Speed Diesel
HTST	High Temperature Short Time
IFC	Intelligent Flow Controller
IIF	The Institute of Indian Foundrymen
IIUS	Industrial Infrastructure Up-gradation Scheme
IoT	Internet of Things
IRR	Internal Rate of Return
LED	Light Emitting Diode
LP	Low Pressure
LSP	Local Service Provider
MPPT	Maximum Power Point Tracker
MPLUN	Madhya Pradesh Laghu Udyog Nigam
MSME	Micro Small and Medium Enterprises

NG	Natural Gas
NPV	Net Present Value
OEM	Original Equipment Manufacturer
PF	Power Factor
PV	Photovoltaic
RE	Renewable Energy
SEC	Specific Energy Consumption
TOE	Tons of Oil Equivalent
UNIDO	United Nations Industrial Development Organisation
UOM	Unit of Measurement
VFD	Variable Frequency Drive
WHR	Waste Heat Recovery

Unit of Measurements

CFM	Cubic feet per minute
gm	Grams
HP	Horse Power
kg	Kilogram
kg/cm^2	kilo gram per area
kJ	Kilo Joule
Kl	Kilo Litre
kl/hr	Kilo Litre per Hour
Km	Kilometre
kVar	Reactive Power
kW	Kilo Watt
kWh	Kilo Watt Hour
kWp	Kilowatt Peak
^oC	Degree Celsius
ppm	parts per million
psi	Pounds per Square Inch
INR	Indian Rupees
TCO_2	Tons of Carbon dioxide
TDS	Total Dissolved Solids
THD	Total Harmonic Distortion
TOE	Tons of Oil Equivalent
TPD	Tons Per Day
TPH	Tons per Hour

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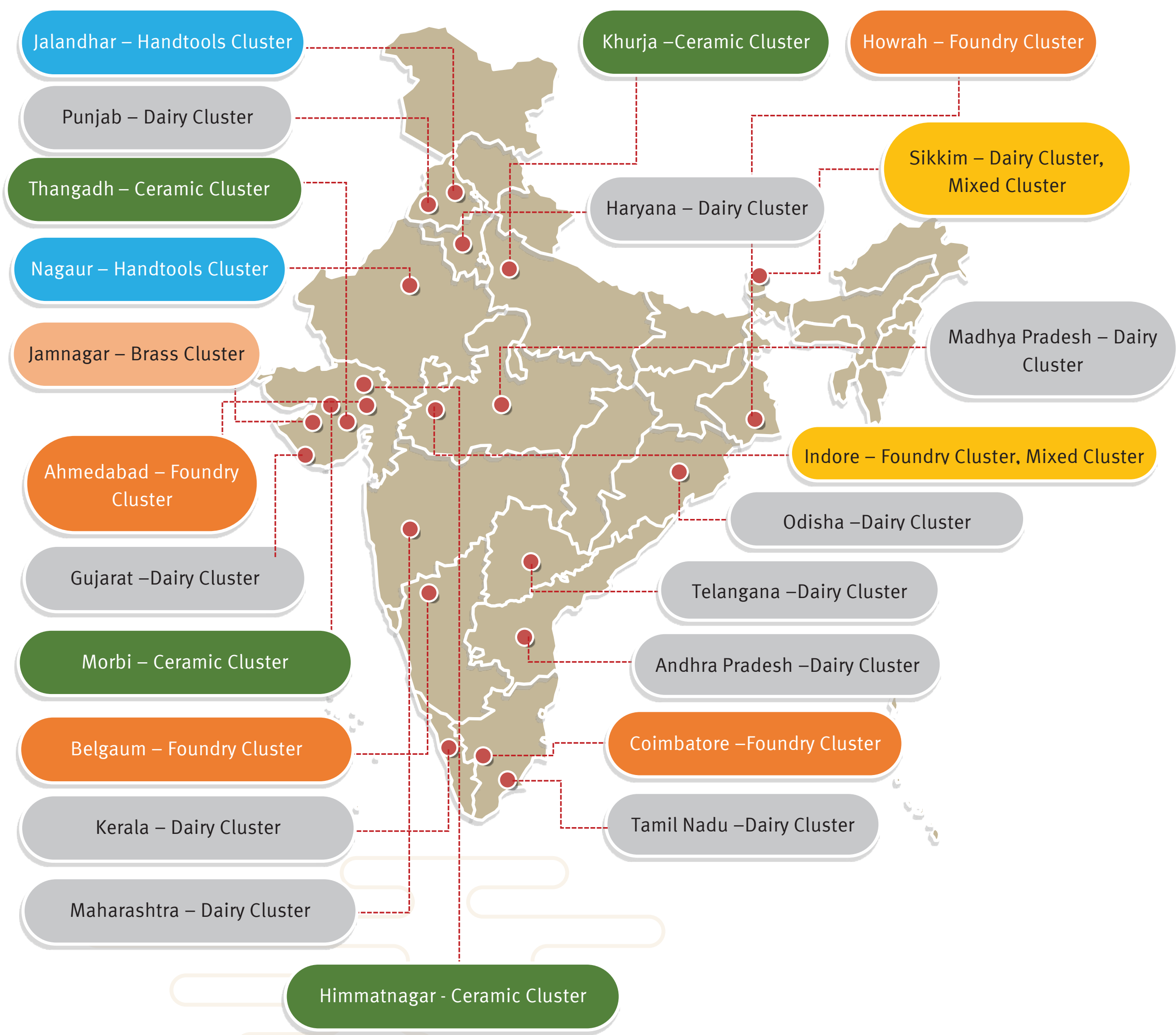
About Project & Technology Compendium

About The Technology Compendium

The United Nations Industrial Development Organization (UNIDO), in collaboration with the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India, is executing a Global Environment Facility (GEF) funded national project titled 'Promoting energy efficiency and renewable energy in selected MSME clusters in India'. The project was operational in 12 MSME clusters across India in five sectors, respectively: Brass (Jamnagar); Ceramics (Khurja, Thangadh and Morbi); Dairy (Gujarat, Sikkim and Kerala); Foundry (Belgaum, Coimbatore and Indore); Hand Tools (Jalandhar and Nagaur). The Project has now scaled-up and expanded its activities to 11 new clusters, namely in Dairy (Tamil Nadu, Odisha, Madhya Pradesh, Andhra Pradesh & Telangana, Haryana, Maharashtra & Punjab), Foundry (Ahmedabad & Howrah), Ceramic (Himmatnagar) Mixed Cluster (Indore & Sikkim) in order to reach out to MSME's at national level.

This project so far has supported 303 MSME units in implementing 603 Energy conservation Measures and thus resulted in reduction of about 10,850 TOE energy consumption and avoided 62,868 metric tons of CO_2 emissions as on date.



The key components of the project include:

- Increasing capacity of suppliers of EE/RE product suppliers / service providers / finance providers
- Increasing the level of end user demand and implementation of EE and RE technologies and practices by MSMEs.
- Scaling up of the project to more clusters across India.
- Strengthening policy, institutional and decision-making frameworks.
- Significant progress has been made in the project and it is now proposed to scale up and expand. The activities envisaged under the scaling up phase of the project include:
  - Establishment of field level Project Management Cell (PMC)
  - Organizing cluster level awareness program and identification of potential MSME enterprises
  - Development of cluster specific EE and RE based technology compendiums
  - Providing implementation support and other related activities to the identified enterprises

About The Technology Compendium

Foundry and Auto component sectors are among the fast-growing industrial sectors in India and having a bearing on the socio-economic development of the country. The majority of the units from these sectors in India fall under the category of Small & Medium Scale industry. These industrial units are important employment providers for many people.

Indore is home to many small and medium scale industries of different sectors. All the above mentioned sectors have a great presence in Indore, operating in clusters thanks to its favourable conditions. Due to their high export quotient, these Industrial sectors are considered among the best in the country. In spite of all this, there are developmental challenges for global competitiveness on the following fronts: Capital expenditure, energy cost, availability of raw material, green technology adoption and quality improvement. Over the years, there has been significant technology improvement in process and utilities and units have been able to improve energy efficiency in their operations. However, various opportunities exist for foundry and other cluster companies to improve their energy efficiency and to become more competitive, while also having environment-friendly operations. To accomplish this goal, energy efficiency is critical.

The technology compendium is prepared with the objective of accelerating the adoption of energy efficient technologies and practices in the mixed industry cluster, it focuses on equipment upgrades, new technologies and practices for improving energy efficiency. The technologies case studies have been included in the compendium provides all the necessary information to enable industry to implement them in their operations. The case studies are supported by technology background, baseline scenario, merits, challenges, technical feasibility, financial feasibility and technology provider details. This compendium is expected to assist the foundry industry to improve their energy efficiency and competitiveness.

- The objective of this compendium is to act as a catalyst to facilitate industries in the cluster towards continuously improving energy performance, thereby achieving world class levels (with thrust on energy & environmental management).
- The compendium includes general energy efficiency options as well specific case studies on applicable technology upgradation project which can result in significant energy efficiency improvements.
- The suggested best practices may be considered for implementation only after detailed evaluation and fine-tuning requirements of existing units.
- In the wide spectrum of technologies and equipment applicable for above mentioned sectors for energy efficiency, it is difficult to include all the energy conservation aspects in this manual. However, an attempt has been made to include the more common implementable technologies across all the units.
- The user of the compendium has to fine-tune the energy efficiency measures suggested in the compendium to their specific plant requirements, to achieve maximum benefits
- The technologies collated in the compendium may not necessarily be the ultimate solution as the energy efficiency through technology upgradation is continuous process and will eventually move towards better efficiency with advancement in technology.

- The Indore mixed industrial cluster should therefore view this manual positively and utilise this opportunity to implement the best operating practices and energy saving ideas during design and operations to facilitate achieving world class energy efficiency standards.

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Executive Summary

Executive Summary

United Nations Industrial Development Organization (UNIDO), in collaboration with the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India, is executing a Global Environment Facility (GEF) funded national project called 'Promoting energy efficiency and renewable energy in selected MSME clusters in India'.

The project execution is planned in multiple phases. The aim of the Phase-I of the project was to develop and promote a market environment for introducing energy efficiency and enhanced use of renewable energy technologies in process applications in the selected (12) energy-intensive MSME clusters in India, with feasibility for expansion to more clusters. Phase-II of the project is to scale up and expand the project activities to a greater number of enterprises in existing clusters, as well as 11 new clusters, for better implementation of energy efficiency technologies and practices.

Efficient use of energy in any facility is invariably the most important strategic area for manageability of cost or potential cost savings. Awareness of the personnel, especially operators in the facility becomes a significant factor for the proper implementation of energy conservation initiatives. With this context, this Technology Compendium has been prepared, which comprises of various technologies and best practices to save energy.

The information in this compendium is intended to help the managers in the Indore Mixed Cluster to reduce energy consumption in a cost-effective manner while maintaining the quality of products manufactured. Further, analysis on the economics of all measures – as well as on their applicability to different production practices – is needed to assess their cost effectiveness at individual industrial units. Additionally, this compendium shall also serve the purpose of tapping the opportunities to significantly reduce energy consumption. Further, this shall also serve as a guide for estimating the feasibility of energy saving project at the first place and ensure accelerated implementation.

Chapter 1 of the compendium provides an overview of Indore industrial profile and brief about Foundry & Auto component clusters.

Chapter 2 focus on a brief overview of process, technology status in the cluster and energy saving opportunities.

Chapter 3 Details all the general energy saving opportunities and best practices which are common and applicable to all the above mentioned sectors of this cluster.

Chapter 4 & 5 provides detailed case studies for some of the high impact and implementable energy efficient technologies in all the focussed sectors under separate sections of the chapter. In this chapter, **19** case studies have been included in areas such as:

- Furnaces, molten metal handling systems including ladle, Automation in heat treatment, Hydroxy fuel substitution, sand moulding systems for foundry & auto components.
- Compressor load optimization, automatic power factor correction, renewable energy, day light harvesting and other utility energy enhancement systems for all the above-mentioned sectors in common.

- These technologies are described in detail, such as baseline scenario, proposed scenario, merits, demerits, etc., and wherever possible, a case reference from a similar industry that has implemented the technology has been included. In most of the case studies, typical energy saving data, GHG emission reduction, investments, payback period, Local service/ technology provider details etc., have been highlighted.

Industries under Indore mixed cluster should view this manual positively and utilise this opportunity to implement the best operating practices and energy saving interventions during design and operation stages, and thus work towards achieving world class energy efficiency standards.

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Indore Industrial Profile

1. Indore Industrial Profile

Madhya Pradesh is known as the Heart of India thanks to its central geographic advantage. Till 31 October 2000, geographically, it was the biggest state in India. After the formation of Chhattisgarh on 1 November 2000, it became the 2nd largest state of the country. Over the years, tribal population has dominated the state. Industrialization took place in the state before independence but the growth rate was very slow. Industrialization in the state boomed after independence utilizing all available resources for sustained overall growth.

Indore is the industrial capital of Madhya Pradesh. With a long and chequered history, Indore has been a major Indian city right from the pre-Independence days. Indore has had the advantage of being centrally located in the country, such that most places in the central, western and northern India are within reasonable reach. The richness of resources in the central Indian plains has made Indore a fertile ground for industrialization. It has had a heady blend of old and new, with the bustling factories on one hand in Dewas, Pithampur and Sanwer Road, and palace complexes on the other.

Indore is called the 'Mini Mumbai' of India. A town that has seen rapid growth in the last 10 years, it is an important business and industrial centre. Pithampur the third largest Industrial belt in Asia and Dewas houses major factories of large companies. It has also shown a keen interest in the area of communication and information technology. In the last decade, Pithampur, Indore and Dewas have performed as the most dynamic industrial zones of Madhya Pradesh. Pithampur, a well-developed industrial area 20 km from Indore, has 107 large & medium scale, and 1,480 small scale industries. Companies of national and international repute are functioning here.

A large number of small-scale engineering ancillaries are also working in this prestigious industrial area. Globalisation and liberalisation policies of the government and the industrial policy of the state government have opened new potential of industrialization in each and every block (taluka). MP Audhyogik Kendra Vikas Nigam Ltd, Indore, has taken up various prestigious projects for infrastructure development in and around Indore of which Electronic Complex, Readymade Garments Complex, Software Complex, etc., are some of the major ones. The city is also known as one of the largest producers of pharmaceuticals in Asia.

Pharmaceutical industries started in Indore about 100 years back with the birth of 'Wadnere Industries'. After Independence, the first Industrial Estate at Polo ground came up in 1954, which was a major milestone in the overall industrialization. During the 60's, another Industrial Estate at Laxmibai Nagar, and in 70's, the Sanwer Road Industrial Area were developed.

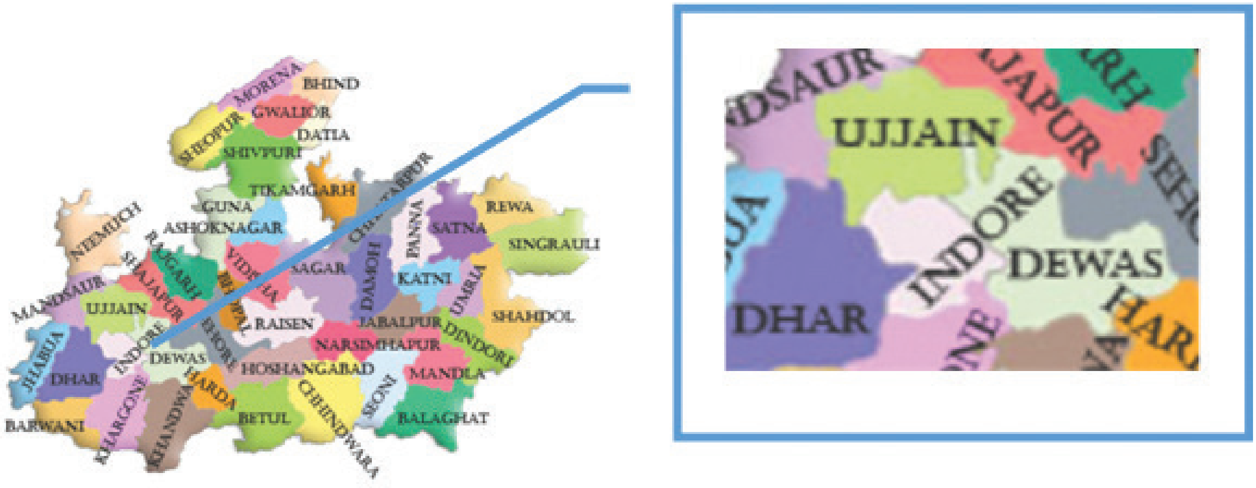

Figure 1: MSME clusters in & around Indore

Many different industrial clusters have been formed in and around the districts of Indore & Ujjain, with the goal of regional economic development and to strengthen competitiveness by increasing productivity, stimulating new partnerships, even among competitors, and presenting opportunities for entrepreneurial activity. The clusters and their locations can be seen in the list below:

1.	Foundry Cluster	– Indore, Dewas
2.	Food Processing Cluster	– Indore & Ujjain
3.	Pharma Cluster	– Indore & Pithampur
4.	Readymade Garment Cluster	– Indore
5.	Auto Component Cluster	– Pithampur, Ujjain

1.1. Indore Foundry Cluster

Indore is one of the biggest industrial cluster belts of Madhya Pradesh. Nearly 70 foundry units are operating here. The foundry industry in Indore came up to cater to the textile machinery manufacturing units which were required by the cotton mills in the area. Subsequently, the foundry units started catering to the demands of the automobile industry (mainly commercial vehicles and construction equipment) which came-up in the Pithampur SEZ (Special Economic Zone). Indore cluster is also famous for the manufacture of ornamental castings, a substantial quantity of which is now being exported to overseas markets.

Figure 2: Metal Pouring

The key products manufactured by these units include Cast Iron (CI) castings, Spheroidal Graphite (SG) Iron castings, Investment casting and Sand castings. Most of these units have got local customer base which includes companies like Kirloskar Brothers, Jash Engineering, Avtech Ltd., Tata International, and BHEL Bhopal.

There are about 45 foundry units in Indore cluster. Apart from the foundry units in Indore city, the foundry industry is spread across four industrial areas - Pithampur (30 km from Indore city), Dewas (35 km from Indore city), Ujjain and Sanwar (very near the city). There are about six foundry units in Pithampur SEZ. Porwal Auto Components Ltd is one of the largest foundry unit in Pithampur and has a production of nearly 900 tons per month of cast iron and SG iron automobile castings. Other foundry units in Pithampur area are – MWP Mahalay (800 tons/month, chilled iron), Ranika Industries (500 tons/month, steel castings for railways), Sian (300 tons/month, steel castings for railways) and Technocast and Ananth Steel. There are 6-7 foundry units in Devas including Bagree Alloys and Kirloskar. Ujjain has about 3-4 foundry units while about 30 foundry units are there around Indore city.

As per industry estimates, the annual production of casting in the cluster is around 42,000 tons. Most of the small foundry units in Indore, Ujjain and Dewas use cupola furnaces, while the larger automotive and steel foundry units use induction furnaces. Although the number of foundries using cupolas is higher (about 30 nos.), due to their smaller size, they account for just 20% of the clusters production. Majority (80%) of the castings in the cluster are produced using electric induction route by 20% of the large foundry units in the cluster. The annual turnover of foundries in Indore is approximately INR 250 crore. The industry provides direct employment to nearly 2,000 people.

Cluster Association:

The Institute of Indian Foundry men (IIF): Association was set up in 1950 to promote education, research, training and development to Indian foundry men and to serve as a nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale. With its Headquarters in Kolkata, IIF presently services the entire country through its 26 Chapters under four Regional Offices located at Kolkata, Delhi, and Mumbai & Chennai.

1.2. Indore Auto Components Cluster

Madhya Pradesh has an automotive cluster located at Pithampur, which is an industrial growth centre near Indore. The Pithampur automotive cluster is among the industrial clusters in India that have been identified by the Central Government for implementation of the Industrial Infrastructure Up-gradation Scheme (IIUS). The scheme aims at improving the competitiveness of functional clusters across the country. Pithampur has several inherent strengths that provide it with the potential to emerge as a vibrant cluster in India's automotive industry. The Pithampur automotive cluster has automotive original equipment manufacturers (OEMs) such as Force Motors, Eicher Motors, Hindustan Motors and Mahindra two-wheelers, a major tyre producing unit of Bridgestone and about 60 auto-component and ancillary units.

Figure 3: Auto Component Manufacturing

Cluster Association:

Pithampur Auto Component: The Government of India, through the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry, New Delhi, has sanctioned the scheme of Auto Cluster for Pithampur Industrial Area, under Industrial Infrastructure Upgradation Scheme (IIUS).

As directed by the Government of India, the main Auto Units of Pithampur have been joined together for implementation of the scheme, for this purpose, under Companies Act 1956, and an S.P.V. named Pithampur Auto Cluster Ltd. has been formed. Following are the objectives of this association:

❖ To design and manufacture high quality precision dies, moulds, jigs, fixtures & gauges for automobiles as primary focus area.

- To develop the human resources (technical & managerial) in the field of tool/die making and allied areas.
- To provide consultancy services in the field of tool/ die making and allied areas.
- To manage and dispose the hazardous waste generated from the industries.
- To produce world class entrepreneurs through cutting edge and relevant management technical education by highly competent research oriented and skilled faculty and state-of-the-art training centres.

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Indore Foundry & Auto Components Cluster

2. Indore Foundry & Auto Components Cluster

Historically, casting is a vital part of human progress, as different civilizations have used it to create utensils, weapons, jewellery, and then later agricultural and industrial equipment. Casting runs as a crucial theme throughout the Copper Age, Bronze Age, Iron Age and the Industrial Era, right up to modern times. As civilizations have developed, casting processes have also become more refined and efficient. Early foundries would have manually operated bellows, which then gave way to steam-powered pistons. Foundries now rely on electric motors and fans, and computer-designed castings.

Technological advances in industrial insulation have also contributed to the increased efficiency of modern foundry processes. Old cupola furnaces are making way for either divided blast cupola (DBC) or energy efficient induction furnaces.

The foundry industry is a differentiated and diverse industry. It consists of a wide range of installations, from small to very large; each with a combination of technologies and unit operations selected to suit the input and types of product produced by the specific installation. The organisation within the sector is based on the type of metal input, with the main distinction being made between ferrous and non-ferrous foundries. Since castings in general are semi-finished products, foundries are located close to their customers. For e.g., Belgaum and Kolhapur are located very close to Pune, which is one of the important automobile hubs in the country. Similarly, foundry units in and around Coimbatore are catering to the pump industry in the cluster, which is one of the largest in the country. The foundry sector has also played a critical role in the socio-economic development of the country as it provides employment opportunities to 2 million people in the country; 0.5 million directly and 1.5 million indirectly.

Consistent power supply and availability of quality electrical equipment are necessary for the growth of the Indian economy from a global perspective. As of December 2018, India had a power generating capacity of ~349.28 GW. The Government of India has targeted an addition of ~88.5 GW under the 12th Five-Year Plan (2012-2017), and another ~100 GW under the 13th Five-Year Plan (2017-2022). The foundry industry is expected to benefit from such power generation installations. The share is expected to increase considerably by the end of 2023, owing to a shift in demand from iron to lighter castings materials for manufacturing fuel-efficient automobiles and electric vehicles (EVs). Expansion of infrastructure by the government is expected to generate demand for a wide variety of machinery and equipment such as cranes, fans, motors, appliances, pumps, conveyor equipment, etc., which in turn will create fresh demand for metal castings.

The opportunities coming from the defence, railways and the automobile sectors would boost demand further. The foundry sector in the country is expected to witness an annual growth of 13-14% as compared to the present 5-7%. Since most of the castings manufacturing units fall under small and medium enterprises (SMEs), they cannot use advanced technological equipment or automation due to high costs, thus limiting their marketing strength. It is challenging for them to sustain their position in the global marketplace. The inability to meet the domestic demand for castings and to supply quality products to the global market acts as a huge barrier for the industry to grow further.

2.1. Process Description

Typical sections in a foundry unit and the process involved are as follows:

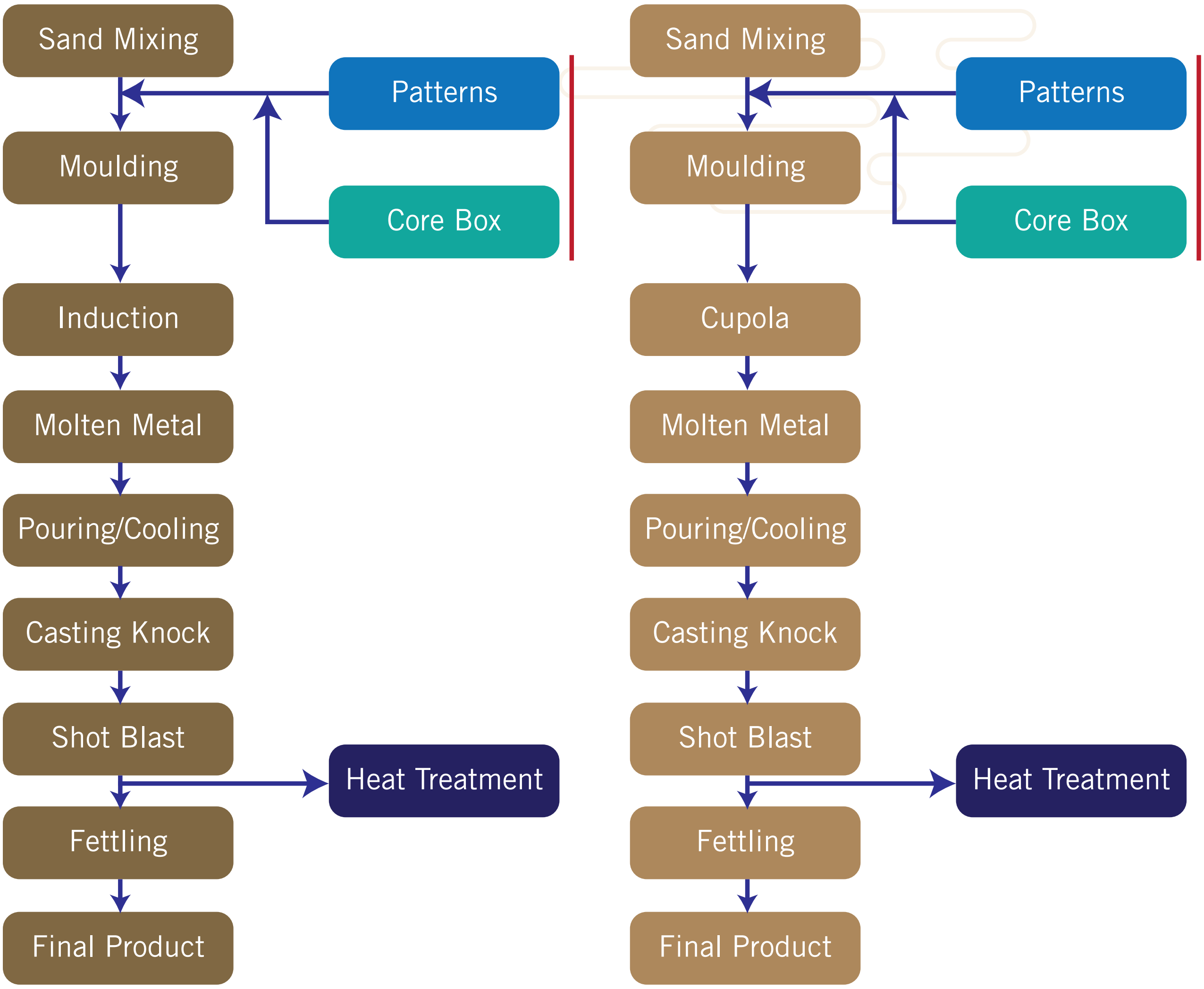

Figure 4: Processes in a Foundry

Sand Plant:

Sand moulds are commonly used for iron foundries. To produce depression in the sand into which the metal is poured. A pattern of the object to be cast has formed. Hard woods, metals or resins are used by pattern makers. In the sand plant, silica sand is mixed with coal dust and organic binders like bentonite powder or dextrin. All these components are mixed well with the help of mixer. The moulding sand from previous pouring is also recycled; water and organic binders are added to the sand before it is reused.

Figure 5: Sand Plant

Fettling Shop:

The main activities of this section include shot blasting, fettling and grinding. In these processes castings are cleared and dressed to remove any extra metal, rough surfaces, sand and other material left from moulding processes. In shot blasting processes, castings are kept in the shot blasting machine and small steel shots or balls present strike over the castings from all sides, so that castings are cleaned and all adherent sand is removed. In the process of shot blasting, large amount of silica and coal dust is generated in the nearby area. During grinding and fettling rough and unwanted surfaces of castings are removed.

Figure 6: Fettling Shop

Moulding Section:

Different activities are carried out here, including mould making, casting, pouring, knock out, decoring, and preparation of ladles or buckets. While making the mould, two half portions of mould boxes are used, and one is called pattern box. In both the boxes, a mixture of prepared sand is poured with the help of shovel or by using automated moulding machine, which is operated by moulder. Then sand is properly rammed into its cores and placed properly. Both the portion of boxes are kept accurately one above the other, and fixed with a fastener. Then the box is passed ahead for pouring the molten metal. At the time of pouring, molten metal temperature ranges between 1,450°C to 1,500°C. It is carried in the ladle. Ladle is operated by two workers, with the help of a pulley system, weighing approximately 500 kg. The worker pours the metal into the mould box. After 4-5 hours of cooling process, mould boxes are carried forward for knock out. In knock-out process, mould boxes are kept on the vibrator, which is operated by worker, and the boxes are vibrated so that the mould boxes break down and inside castings can be removed. This process is called decoring, and the castings are further cleaned.

Figure 7: Moulding Section

Furnace Section:

In this section, charging, melting, slagging, and refining processes are carried out. For charging pig iron, C.I. scrap, steel, limestone, coke, etc. are used. The quantity of material depends upon the capacity of furnace. Nowadays in the majority of foundries, electric arc furnaces are used for proper melting routes in terms of molten metal, cost and fuel saving.

Melting of metal temperature is controlled manually by a worker. The required temperature is achieved within 30 minutes from electric arc furnace. After getting proper temperature in the furnace, slag is removed by the workers and at the time of pouring, the entire furnace is lifted slowly, controlled by workers, and then poured into the ladle. Ladle is then carried towards respective mould boxes for pouring the molten metal. Maintenance of furnace includes cleaning the furnace, removing the attached metal of furnace, checking inner layer and electric cables, coils and sealing.

Figure 8: Furnace Section

Core Shop:

Cores are made and inserted into the mould in order to determine the internal configuration of a hollow casting. The core must be strong enough to withstand the casting process but at the same time must not be too strong as to resist removal from the casting during the knocking out stage. Core mixture comprises sand and binders, to give necessary strength such as linseed oil, dextrin, which are dried in oven and produce a core. Cores are made from core sand to which an organic (resin) binding agents are added. The processing of these traditional cores involves oven curing or stoving. For curing, various synthetic resins are used. Curing is achieved by chemical reaction and heating the core at temperature 260°C to 300°C for about

3-5 minutes. Then core box is removed from the core furnace or automated core machine, and baked cores are removed and kept for cooling. Inner cavity of cores and outer margins with surplus material are removed and cores are finished.

Figure 9: Core Section

Energy Consumption in Foundry

The energy cost accounts for around 15% of the total cost of production, second only to the raw material cost (around 60%). Various fuels such as coke, firewood, HSD, LDO, furnace oil, etc., and electricity are used to meet the energy requirement of the units.

- ❖ In a foundry that uses induction furnace for melting, electricity accounts for about 85-95% of the total energy consumption of the unit. In such foundry units, induction furnace is the major electricity consuming equipment; it consumes about 70-85% of total electrical energy consumption. If the foundry units are heat treating the castings, diesel consumption comes out to around 15-25% of the total energy consumption of the unit.
- ❖ In the cupola-based foundry units, coke is the primary fuel for melting operation and this typically accounts for 85-90% of the total energy consumption of the unit.
- ❖ Generally, melting accounts for about 70-80% of energy consumption in a foundry unit. The other important energy consuming areas include sand preparation, moulding, core preparation and other utilities. Major energy consuming areas in a foundry are charted below.

Table 1: Details of Major Energy Consuming Areas

Equipment	Process	Type of energy
Cupola	Melting	Thermal (Coke)
Induction furnace	Melting	Electricity
Motors	Moulding & sand blasting machines, compressor, pumps etc.	Electricity
DG Set	Power generation	HSD
Others	Lighting	Electricity

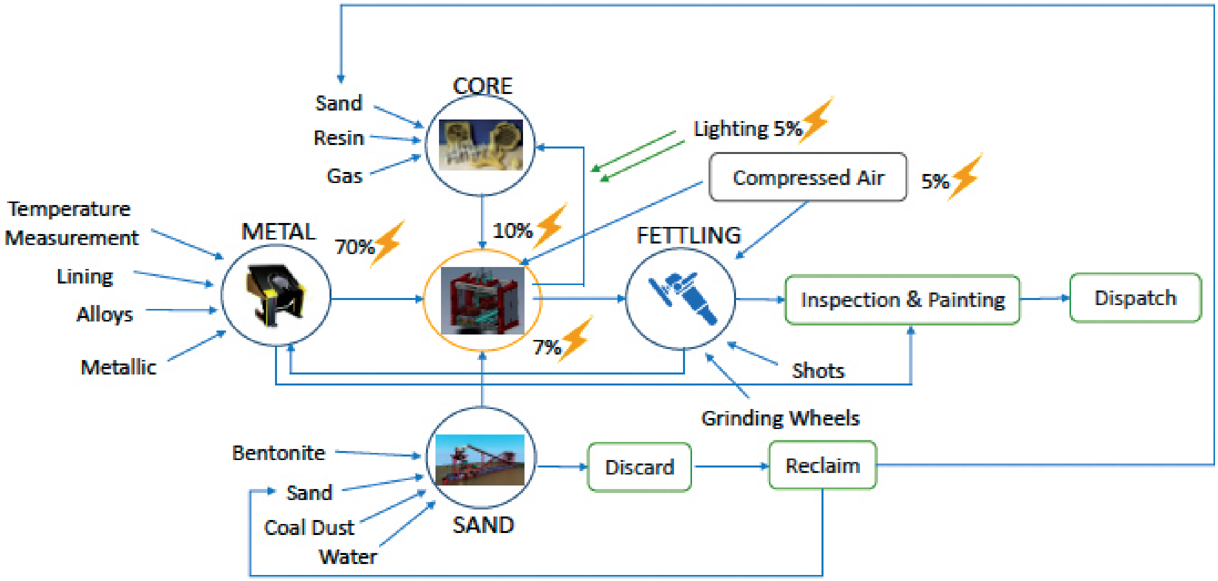

Figure 10: Energy Consumption in Foundry

2.2. Technology Status

As per industry estimates, the annual production of casting in the cluster is around 42,000 tons. Most of the small foundry units in Indore, Ujjain and Devas use cupola furnaces, while the larger automotive and steel foundry units use induction furnaces. Although the number of foundries using cupolas is higher (about 30 nos.), due to their smaller size, they account for just 20% of the clusters production. Majority (80%) of the castings in the cluster are produced using electric induction route by 20% of the large foundry units in the cluster.

Electricity, coke and firewood are the major fuels used in the foundry units. The annual quantity of the fuels consumed by the foundry industry, their energy equivalent and percentage share are given in the table. The total amount of energy consumed in the cluster is about **5,516 TOE/ Year.**

The medium and small enterprises predominantly use electric induction furnace. The micro scale units are however using cupolas. In most cases the transition from cupola to electric furnace occurred in recent years due to environmental pressures coupled with the inherent limitation of cupolas to produce multiple grades. Mostly, SG iron and mild steel castings are produced using induction furnaces. The specific energy consumption of these furnaces varies from 560 kWh to about 750 kWh per tonne. Smaller foundry units manufacturing grey iron castings use conventional cupolas, which are energy inefficient. The specific energy consumption of cupola furnaces varies from 2.0 to 5.4 GJ/tone (0.048-0.129 TOE/t). Very few foundry units have converted to energy efficient 'Divided Blast Cupola' (DBC). One foundry in the cluster has converted to cokeless (gas-fired) cupola provided by Westman, Kolkata. The gas consumption in the coke less cupola is about 75 cu m / tone. However, the molten metal temperature from the coke-less cupola is low (about 1300°C) and hence the metal needs to be transferred to electric induction furnace for superheating. Energy cost accounts for about 15%, which are then cooled and knocked out. The castings are then exposed to shot blast for improving the surface finish, and thereafter sent for grinding, painting and finally for packing and dispatch. The other energy consuming equipment in the foundry are sand Mullers, moulding machines, shot blasting machines and sand dryers and because of the predominant use of energy in melting process the focus of saving energy in a foundry is around melting equipment.

2.3. Energy Efficiency Opportunities

Installation of energy efficient induction furnace: An induction furnace is an electrical furnace in which the heat is applied by induction heating of metal. They are used to melt iron, steel, copper, aluminium and precious metals. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. Since no arc or combustion is used, the temperature of the material is no higher than required to melt it; this can prevent loss of valuable alloying elements. Replace the inefficient induction furnaces, SCR furnaces, and diesel fired furnaces with energy efficient furnaces will have following advantages:

- Lower power consumption.
- Better quality of the product.
- Easy to handle and operate.
- Reduced initial investment costs.
- Good production efficiency.

Automation in metal pouring system (CRANE): Metal pouring in foundries is one of the most important processes involved in the melting process. The temperature to which the metal has to be heated and the time taken by the melt to be poured into the mould has a significant impact on the quality of the castings. The faster the melt gets poured into the mould, the lower would be the temperature to which the melt has to be heated. Manual metal pouring may leads to higher tapping temperatures and results in high heating losses too. It is therefore efficient to automate the metal pouring system through the crane, so that the molten metal gets immediately poured into the mould without causing any time gap.

Installation of LID mechanism for Induction Furnace: Crucible Furnace is a device that is used for high temperature heating. It may be referred to as the heart of a foundry operation. The main process of melting the metal to be cast occurs in the melting furnace. Most of the foundries operate without a lid mechanism. There is a large amount of heat loss occurring through these openings in the form of radiation and convection. Providing as lid cover for the furnace was the possible solution, which would reduce the unwanted radiation and convection losses.

Installation of energy efficient sand mixer and mixer motor: Sand mixers are devices which are used to improve the binding properties of the sand prior to it being used for moulding purposes. The binding agents will be generally chemicals of different properties that are mixed with the sand at different temperatures. The mixing happens on the account of a rotary action for which an electric motor is provided. Old sand mixing systems are in efficient due to the inherent technology itself leading to higher cycle times and unwanted heating of sand. It is efficient to install new energy efficient sand mixers which will be embedded with energy efficient motors.

Insulating the ladle cover: A ladle is a vessel used in transporting and pouring molten metals in a foundry. They can be used handle molten metals ranging from 20 kg to 330 tons. The most common shape for a ladle is a vertical cone, but other shapes are possible. Having a tapered cone as the shell adds strength and rigidity to the shell. Ladles can be either open-topped or covered. Covered ladles have a (sometimes removable) dome-shaped lid to contain radiant heat; they lose heat slower than open-topped ladles. Small ladles do not commonly have covers, although a ceramic blanket may be used instead. When hot molten metal is transferred using these ladles, there will be a time period when the metal losses its temperature. Loss in temperature also adds to a loss in energy. It is efficient to provide glass wool coating or thermal insulation in the ladles to prevent the heat loss. In most cases the insulation will be fabricated in house.

Energy Conservation Measures in Cupola Furnace: Cupola, which is the most commonly used melting furnace in the Indian foundries, is also the most energy intensive equipment. It accounts for up to 60% of a foundry's total energy consumption and is the prime candidate to focus attention on, for improving energy use efficiency in a foundry. Some of the technology upgradation / energy conservation opportunities w.r.t cupola furnace are listed below. These measures will help in optimising specific energy consumption and increasing operational efficiency.

- Installing coke-less cupola
- Replacing cupola furnace with energy efficient induction furnace
- Providing insulation (for e.g. paint) on cupola surface
- Installing high performance castable refractories for cupola
- Installing combustion air preheating system
- Recovering waste heat from furnace flue gases and using it for preheating combustion air
- Installing energy efficient combustion air blower
- Maintaining optimum excess air by installing VFD in blower
- 10% drop in excess air amounts to 1% saving in fuel consumption in furnace
- Maintaining the size / weight of raw material
- Weight of a single piece of metal should be limited to 1% of the hourly melting rate
- Oxygen enrichment in cupola furnace and installing flue gas analyser for measuring furnace oxygen level
- 4% oxygen enrichment in a conventional cupola improves the production rate by 25%
- Ensuring that the vents in the cupola bottom doors are open
- Installing energy efficient burner
- Using alternative fuels in cupola
- Reducing the length of spout (louvers)

Reduction in rejection by process improvement study: Loss of raw material in the form of both sand as well as the additives used in moulding is a serious problem faced in foundries. If the casting process is not properly optimised, it leads to situation where the amount of product getting rejected will be high. This happens particularly in situations where the product quality is not as per the standard required. For the foundries where the rejection percentage is high, it is efficient to conduct a process response study, which would help in reducing the unwanted use of both raw material as well as fuel consumption.

Installation of divided blast cupola: A cupola is a melting device extensively used in foundries to melt the cast iron that has to be processed. The shell of the cupola is made of steel which is incorporated with a refractory lining. It is generally cylindrical in shape and is available in dimensions ranging from 0.5 to 4m. The metal to be processed is introduced into a bed of heated coke which is maintained in the cupola. The molten metal is then collected at the bottom. This technology has nowadays been replaced with an improved form of cupola called the divided blast cupola (DBC) that overcomes many of the disadvantages of the former technology.

Advantages of divided blast cupola:

- Higher metal tapping temperature
- Lower coke consumption
- Better carbon pick up
- Reduction in amount of rejects
- Savings in both material and energy
- Lower pressure drop in air flow

Figure 11: Divided Blast Cupola

Optimization of process by pre heating air / raw material: Low inlet air temperatures of furnace could result in wastage of fuel. The flue gases with an average temperatures of 650°C – 750°C are often rejected through the stack and this can be re-utilized to heat the input air of the furnace with the help of a recuperator. By recovering waste heat, a recuperator often reduces fuel requirements by 5% to 10% and pays in less than 2 years. The lowest temperature to which flue gases can be cooled depends on the type of fuel used: 250°F for Natural Gas, 300°F for coal and low sulphur content fuel oils, and 350°F for high sulphur fuel oils. These limits are set to prevent condensation and possible corrosion of the stack. With the help of this, either air used for combustion or the raw material can be preheated.

Induction Billet heating system: Replacing of oil fired furnace with induction billet heater is more energy efficient. Main benefits of the technology are reduced energy cost, uniform heat distribution and high surface quality for the finished product. Other benefits include reduced scale loss and better control over production rate. Besides, there is better working environment from the workers' health and safety perspective.

Installation of ceramic coating and external insulation for heat treatment furnaces: Normally in a heat treatment furnace the external temperature is an indication of the effect of refractory. The heat loss to the refractory occurs in furnace and external temperature is partly an indication of the heat loss. There is a good potential to install ceramic coating inside the furnace and external insulation to meet the required surface temperature of 30°C above ambient temperature. This ceramic coating is available in form of paint and hence easy to apply too.

Installation of servo motor For Hydraulic Power Pack: Servo motors installed in most of the CNC machines will run at under loaded or in idle loading condition for more than 50% of time. Hence there is a good scope for saving the energy by installation of servo motors on the same which can regulate the speed as per the loading requirement. Servo motors can withstand 300% overloading and can maintain required pressure at reduced RPM. Also Servo motors has quick ramp up time of 0.2 Sec to provide required torque.

Energy Efficiency in Mould, Sand Handling, Core Making and Finishing Process: Moulding, sand handling, core making, related heat treatment and product finishing processes typically account for 22–25% of the total energy consumed in a foundry. Adopting the following energy conservation measures will optimize energy consumption in mould and core making process and heat treatment.

- Installing energy efficient sand handling plant
- Installing biomass gasifier for sand and core drying application
- Using transvector nozzle for mould cleaning
- Ensuring sand in free from metal pieces
- Optimizing the operation of shot blast machine by installing timer for cycle time
- Converting pneumatic system to electrical system for sand conveying in knockout

Replacement of Thyristor-based welding machines with Inverter-based machines: In thyristor based welding machines, significant part of the power consumption goes into heating the transformer and the surrounding air. These systems are having slow response time, high ripple content and have low power factor. In inverter section, supply power is switched on and off by solid-state switches at frequencies as high as 30 kHz. This pulsed, high voltage, high frequency AC is then fed to the main power transformer, where it is transformed into low voltage suitable for welding. These machines will produce more stable DC welding arc at faster response time. Nearly 10 - 15% power savings is possible.

Furnaces:

- Optimising the height of furnace opening (if adjustable mechanism provided) as per requirement.
- The quality of insulation and refractory lining within the furnace are necessary improvement options to reduce heat losses occurring from side walls.
- If high exit flue gas temperatures persist, a feasibility study would be required for suggesting the appropriate heat recovery system.
- Optimising combustion parameters within furnace as per the product and process requirement to optimise the temperature and subsequently the gas consumption, if feasible.
- A provision for combustion control can be achieved using temperature controllers or PIDs.

Other Energy Efficiency Opportunities:

- Online monitoring of melt temperature.
- Control on cooling water flow rate and temperature.
- Ladle preheating & improved refractory linings.
- Solid state converters for medium and high frequency furnaces.
- Reduction in cycle time through better weighing and charging of raw material.

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General Energy Saving Opportunities

3. General Energy Saving Opportunities – Applicable to all Sectors

Apart from specific process related energy efficiency opportunities, there are many common opportunities in utilities and electrical sections applicable across the Indore cluster, including Foundry, Auto Components, Pharma, Readymade Garments & Food Processing units.

Motors and Motor Systems

Motor management plan: A motor management plan is an essential part of a plant's energy management strategy. Having a motor management plan in place can help companies realize long-term motor system energy savings and will ensure that motor failures are handled in a quick and cost effective manner. Steps involved in motor management plan include:

- Creation of a motor survey and tracking program.
- Development of guidelines for proactive repair/replace decisions.
- Preparation for motor failure by creating a spares inventory.
- Development of a purchasing specification.
- Development of a repair specification.
- Development and implementation of a predictive and preventive maintenance program.

Strategic motor selection: Several factors are important when selecting a motor, including motor speed, horsepower, enclosure type, temperature rating, efficiency level, and quality of power supply. When selecting and purchasing a motor, it is also critical to consider the lifecycle costs of that motor rather than just its initial purchase and installation costs. Up to 95% of a motor's costs can be attributed to the energy it consumes over its lifetime, while only around 5% of a motor's costs are typically attributed to its purchase, installation, and maintenance.

The choice of installing a premium efficiency motor strongly depends on motor operating conditions and the life cycle costs associated with the investment. In general, premium efficiency motors are most economically attractive when replacing motors with annual operation exceeding 2,000 hours/year.

In some cases, it may be cost-effective to rewind an existing energy efficient motor, instead of purchasing a new motor. As a rule of thumb, when rewinding costs exceed 60% of the costs of a new motor, purchasing the new motor may be a better choice. When best rewinding practices are implemented, efficiency losses are typically less than 0.5% to 1%. However, poor quality rewinds may result in larger efficiency losses.

Maintenance: The purposes of motor maintenance are to prolong motor life and to foresee a motor failure. Motor maintenance measures can be categorized as either preventative or predictive. Preventative measures, the purpose of which is to prevent unexpected downtime of motors, include electrical consideration, voltage imbalance minimization, load consideration, and motor ventilation, alignment, and lubrication. The purpose of predictive motor maintenance is to observe ongoing motor temperature, vibration, and other operating data to identify when it becomes necessary to overhaul or replace a motor before failure occurs.

Adjustable speed drives (ASDs): Adjustable-speed drives better match speed to load requirements for motor operations, and therefore ensure that motor energy use is optimized to a given application. Adjustable-speed drive systems are offered by many suppliers and are available worldwide.

Power factor correction: Inductive loads like transformers, electric motors, and HID lighting may cause a low power factor. A low power factor may result in increased power consumption, and hence increased electricity costs. The power factor can be corrected by minimizing idling of electric motors (a motor that is turned off consumes no energy), replacing motors with premium-efficient motors, and installing capacitors in the AC circuit to reduce the magnitude of reactive power in the system.

Minimizing voltage unbalances: A voltage unbalance degrades the performance and shortens the life of three-phase motors. A voltage unbalance causes a current unbalance, which will result in torque pulsations, increased vibration and mechanical stress, increased losses, and motor overheating, which can reduce the life of a motor's winding insulation. Voltage unbalances may be caused by faulty operation of power factor correction equipment, a 36 unbalanced transformer bank, or an open circuit. A rule of thumb is that the voltage unbalance at the motor terminals should not exceed 1%. Even a 1% unbalance will reduce motor efficiency at part load operation, while a 2.5% unbalance will reduce motor efficiency at full load operation. By regularly monitoring the voltages at the motor terminal and through regular thermographic inspections of motors, voltage unbalances may be identified. It is also recommended to verify that single-phase loads are uniformly distributed and to install ground fault indicators as required. Also installation of a suitable voltage controller will help.

Replacement of belt drives: Pumps having V-belt drives, can be replaced with direct couplings to save energy. Based on assessments in several industries, the savings associated with V-belt replacement are estimated at 4% with a simple payback period up to 2 years.

Compressed Air Systems

Compressed air generally represents one of the most inefficient uses of energy in industry due to poor system efficiency. Typically, the efficiency of a compressed air system – from compressed air generation to end use—is only around 10%. Because of this inefficiency, if compressed air is used, it should be of minimum quantity for the shortest possible time; it should also be constantly monitored and weighed against potential alternatives. Many opportunities to reduce energy consumption in compressed air systems are not prohibitively expensive; payback periods for some options can be extremely short. Energy savings from compressed air system improvements can range from 20% to 50% of total system electricity consumption. Common energy efficiency measures for industrial compressed air systems are discussed below.

System improvements: Adding additional compressors should be considered only after a complete system evaluation. In many cases, compressed air system efficiency can be managed and reconfigured to operate more efficiently without purchasing additional compressors. System improvements utilize many of the energy efficiency measures for compressors discussed below.

Ongoing filter inspection and maintenance: Blocked filters increase the pressure drop across the filter, which wastes system energy. By inspecting and periodically cleaning filters, filter pressure drops may be minimized. Fixing improperly operating filters will also prevent contaminants from entering into equipment, which can cause premature wear. Generally, when pressure drops exceed 2 psi to 3 psi, particulate and lubricant removal elements should be replaced. Regular filter cleaning and replacement has been projected to reduce compressed air system energy consumption by around 2%.

Inspection of drain traps: To ensure that drain traps are not stuck in either the open or closed position or are clean. Some users leave automatic condensate traps partially open at all times to allow for constant draining. This practice wastes substantial energy and should never be undertaken. Instead, simple pressure driven valves should be employed. Malfunctioning traps should be cleaned and repaired instead of left open. Some auto drains, such as float switch or electronic drains, do not waste air. Inspecting and maintaining drains typically has a payback of less than two years.

Compressor belt inspection: Where belt-driven compressors are used, belts should be checked regularly for wear and adjusted. A good rule of thumb is to adjust them after every 400 hours of operation.

Proper Assessment of Application: Applications requiring compressed air should be checked for excessive pressure, duration, or volume. Applications not requiring maximum system pressure should be regulated, either by production line sectioning or by pressure regulators on the equipment itself. Using more pressure than required wastes energy and can also result in shorter equipment life and higher maintenance costs.

Monitoring: In addition to proper maintenance, a continuous monitoring system can save significant energy and operating costs in compressed air systems. Effective monitoring systems typically include the following:

- ❖ Pressure gauges on each receiver or main branch line and differential gauges across dryers, filters, etc.
- ❖ Temperature gauges across the compressor and its cooling system to detect fouling and blockages.
- ❖ Flow meters to measure the quantity of air used.
- ❖ Dew point temperature gauges to monitor the effectiveness of air dryers.
- ❖ Kilowatt-hour meters and hours run meters on the compressor drive.
- ❖ Checking of compressed air distribution systems after equipment has been reconfigured to be sure that no air is flowing to unused equipment or to obsolete parts of the compressed air distribution system.
- ❖ Checking for flow restrictions of any type in a system, such as an obstruction or roughness, which can unnecessarily raise system operating pressures. As a rule of thumb, every 2 psi

pressure rise resulting from resistance to flow can increase compressor energy use by 1%. The highest pressure drops are usually found at the points of use, including undersized or leaking hoses, tubes, disconnects, filters, regulators, valves, nozzles and lubricators (demand side), as well as air/lubricant separators, after-coolers, moisture separators, dryers and filters.

Leak reduction: Air leaks can be a significant source of wasted energy. A typical industrial facility that has not been well maintained will likely have a leak rate ranging from 20% to 30% of total compressed air production capacity. Overall, a 20% reduction of annual energy consumption in compressed air systems is projected for fixing leaks.

The magnitude of the energy loss associated with a leak varies with the size of the hole in the pipes or equipment. A compressor operating 2,500 hours per year at 87 psi with a leak diameter of 0.02 inches (½ mm) is estimated to lose 250 kWh per year; 0.04 inches (1 mm) to lose 1,100 kWh per year; 0.08 inches (2 mm) to lose 4,500 kWh per year; and 0.16 in. (4 mm) to lose 11,250 kWh per year. Several industrial case studies suggest that the payback period for leak reduction efforts is generally shorter than two months.

In addition to increased energy consumption, leaks can make air-powered equipment less efficient, shorten equipment life, and lead to additional maintenance costs and increased unscheduled downtime. Leaks also cause an increase in compressor energy and maintenance costs.

The most common areas for leaks are couplings, hoses, tubes, fittings, pressure regulators, open condensate traps and shut-off valves, pipe joints, disconnects, and thread sealants. The best way to detect leaks is to use an ultrasonic acoustic detector, which can recognize the high frequency hissing sounds associated with air leaks. Leak detection and repair programs should be ongoing efforts.

Modification of system in lieu of increased pressure: For individual applications that require a higher pressure, instead of raising the operating pressure of the whole system, special equipment modifications should be considered, such as employing a booster, increasing a cylinder bore, changing gear ratios, exploring the option of installing LP compressor for low pressure applications or changing operation to off peak hours.

Replacement of compressed air by alternative sources: Many operations can be accomplished more economically and efficiently using energy sources other than compressed air various options exist to replace compressed air use, including usage of blowers for cleaning, electric tools instead of pneumatic tools etc.

Improved load management: Because of the large amount of energy consumed by compressors, whether in full operation or not, partial load operation should be avoided. For example, unloaded rotary screw compressors still consume 15% to 35% of full-load power while delivering no useful work. Air receivers can be employed near high demand areas to provide a supply buffer to meet short-term demand spikes that can exceed normal compressor capacity. In this way, the number of required online compressors may be reduced. Multi-stage compressors theoretically operate more efficiently than single-stage compressors. Multi-stage compressors save energy by cooling the air between stages, reducing the volume and work required to compress the air. Replacing single-stage compressors with two-stage compressors typically provides a payback period of two years or less using multiple smaller compressors instead of one large compressor can save energy as well. Large compressors consume more electricity when they are unloaded than do multiple smaller compressors with similar overall capacity.

Pressure drop minimization: An excessive pressure drop will result in poor system performance and excessive energy consumption. Flow restrictions of any type in a system, such as an obstruction or roughness, results in higher operating pressures than is truly needed. Resistance to flow increases the drive energy on positive displacement compressors by 1% of connected power for each 2 psi of differential. The highest pressure drops are usually found at the points of use, including undersized or leaking hoses, tubes, disconnects, filters, regulators, valves, nozzles, and lubricators (demand side), as well as air/lubricant separators on lubricated rotary compressors and after-coolers, moisture separators, dryers, and filters (supply side). Minimizing pressure drop requires a systems approach in design and maintenance. Air treatment components should be selected with the lowest possible pressure drop at specified maximum operating conditions and best performance. Manufacturers' recommendations for maintenance should be followed, particularly in air filtering and drying equipment, which can have damaging moisture effects like pipe corrosion. Finally, the distance the air travels through the distribution system should be minimized. Aluminium piping replacing conventional mild steel piping will be an attractive option for pressure drop minimization.

Inlet air temperature reduction: If airflow is kept constant, reducing the inlet air temperature reduces the energy used by the compressor. In many plants, it is possible to reduce the inlet air temperature to the compressor by taking suction from outside the building. As a rule of thumb, each temperature reduction of 5°F (3°C) will save 1% compressor energy. In addition to energy savings, compressor capacity is increased when cold air from outside is used. Industrial case studies have found an average payback period for importing outside air of less than 1.7 years, but costs can vary significantly depending on facility layout.

Multi-master controls: These are the latest technology in compressed air system control. Multi-master controls are capable of handling four or more compressors and provide both individual compressor control and system regulation by means of a network of individual controllers. The controllers share information, allowing the system to respond more quickly and accurately to demand changes. One controller acts as the lead, regulating the whole operation. This strategy allows each compressor to function at a level that produces the most efficient overall operation. The result is a highly controlled system pressure that can be reduced close to the minimum level required & such advanced compressor controls are expected to deliver energy savings of about 3.5% where applied.

Heat recovery: As much as 90% of the electrical energy used by an industrial air compressor is converted into heat. In many cases, a heat recovery unit can recover 50% to 90% of this available thermal energy and apply it to space heating, process heating, water heating, makeup air heating, boiler make-up water preheating, and heat pump applications. It has been estimated that approximately 50,000 Btu/hour of recoverable heat is available for each 100 cfm of compressor capacity. Payback periods are typically less than one year. Heat recovery for space heating is not as common with water-cooled compressors because an extra stage of heat exchange is required and the temperature of the available heat is somewhat low. However, with large water-cooled compressors, recovery efficiencies of 50% to 60% are typical.

Pumps

The pumping of coolants such as glycol or chilled water is common in pharmaceutical manufacturing facilities and is also a source of significant energy consumption. Studies have shown that over 20% of the energy consumed by pumping systems could be saved through changes to pumping equipment and/or control systems.

It is important to note that initial costs are only a fraction of the life cycle costs of a pump system. Energy costs, and sometimes operations and maintenance costs, are much more important in the lifetime costs of a pump system. In general, for a pump system with a lifetime of 20 years, the initial capital costs of the pump and motor make up a mere 2.5% of the total costs. In contrast, energy costs make up about 95% of the lifetime costs of the pump. Maintenance costs comprise the remaining 2.5%. Hence, the initial choice of a pump system should be highly dependent on energy cost considerations rather than on initial costs.

Maintenance: Inadequate maintenance can lower pump system efficiency, cause pumps to wear out more quickly, and increase costs. Better maintenance will reduce these problems and also save energy. Proper pump system maintenance includes the following:

- Replacement of worn impellers, especially in caustic or semi-solid applications.
- Bearing inspection and repair.
- Bearing lubrication replacement, on an annual or semi-annual basis.
- Inspection and replacement of packing seals. Allowable leakage from packing seals is usually between 2-60 drops per minute.
- Inspection and replacement of mechanical seals. Allowable leakage is typically 1-4 drops per minute.
- Wear ring and impeller replacement. Pump efficiency degrades 1-6 points for impellers less than the maximum diameter and with increased wear ring clearances.
- Pump/motor alignment check.

Pump demand reduction: Holding tanks can be used to equalize the flow over the production cycle, enhancing energy efficiency and potentially reducing the need to add pump capacity. In addition, bypass loops and other unnecessary flows should be eliminated. Each of these steps can save 5-10% of pump system electricity consumption. Total head requirements can also be reduced by lowering process static pressure, by minimizing the elevation rise from suction tanks to discharge tanks, by reducing static elevation changes via siphons, and by lowering spray nozzle velocities.

High-efficiency pumps: A pump's efficiency may degrade by 10-25% in its lifetime. Newer pumps are typically 2-5% more efficient, while high-efficiency motors have also been shown to increase the efficiency of a pumping system by 2-5%. A number of high-efficiency pumps are available for specific pressure head and flow rate capacity requirements. Choosing the right pump often saves both operating costs and capital costs. For a given duty, selecting a pump that runs at the highest speed suitable for the application will generally result in a more efficient selection as well as the lowest initial cost. Exceptions to this include slurry handling pumps, high specified-speed pumps, or pumps that require a very low minimum net positive suction head at the pump inlet.

Impeller trimming: If a large differential pressure exists at the operating rate of flow (indicating excessive flow), the impeller diameter can be trimmed (also called 'sheave shaving') so that the pump does not develop as much head. In the food processing, paper, and petrochemical industries, trimming impellers or lowering gear ratios is estimated to save as much as 75% of the electricity consumption of a given pump. In addition to energy savings, maintenance costs were reduced, system stability was improved, pump cavitation was reduced, and excessive vibration and noise were eliminated.

Lighting

The energy used for lighting in the industry is relatively small. Still, energy efficiency opportunities may be found that can reduce lighting energy use cost-effectively. Lighting is used either to provide overall ambient lighting throughout manufacturing, storage, and office spaces or to provide low-bay and task lighting to specific areas. High intensity discharge (HID) sources are used for the former, including metal halide, high pressure sodium, and mercury vapour lamps. Fluorescent, compact fluorescent, and incandescent lights are typically used for task lighting in offices. Lighting also generates a significant amount of heat. The downstream savings of lighting efficiency measures can therefore include cost savings in facility HVAC operation and energy use. The magnitude of downstream savings depends on climate and weather conditions.

Lighting controls: Lights can be shut off during non-working hours by automatic controls, such as occupancy sensors that turn off lights when a space becomes unoccupied. Occupancy sensors can save up to 10-20% of facility lighting energy use.

Electronic ballasts: A ballast is a mechanism that regulates the amount of electricity required to start a lighting fixture and maintain a steady output of light. Electronic ballasts save 12-30% power over their magnetic predecessors. New electronic ballasts have smooth and silent dimming capabilities, in addition to longer lives (up to 50% longer), faster run-up times, and cooler operation. New electronic ballasts also have automatic switch-off capabilities for faulty or end-of-life lamps. The typical energy savings associated with replacing magnetic ballasts by electronic ballasts are estimated to be roughly 25%; however, the total energy savings will depend on the number of magnetic ballasts still in use.

Replacing T-12 tubes with T-8 tubes: In many industrial facilities, it is common to find T12 lighting tubes in use. T-12 lighting tubes are 12/8 inches in diameter (the 'T' designation refers to a tube's diameter in terms of 1/8 inch increments). T-12 tubes consume significant amounts of electricity, and also have extremely poor efficacy, lamp life, lumen depreciation, and colour rendering index. Because of this, the maintenance and energy costs of T-12 tubes are high. Replacing T-12 lamps with T-8 lamps (smaller diameter) approximately doubles the efficacy of the former. Also, T-8 tubes generally last 60% longer than T-12 tubes, which leads to savings in maintenance costs. Typical energy savings from the replacement of a T-12 lamp by a T-8 lamp are around 30%.

Replacing mercury lights with metal halide or high-pressure sodium lights: Where colour rendition is critical, metal halide lamps can replace mercury or fluorescent lamps with energy savings of 50%.

High-intensity discharge (HID) voltage reduction: Reducing lighting system voltage can also save energy. As a rule of thumb 10% reduction in lighting voltage will result in an energy savings of 10%. There are commercial products on the market that attach to a central panel switch and constrict the flow of electricity to lighting fixtures, thereby reducing voltage and saving energy, with an imperceptible loss of light. Voltage controllers work with both HID and fluorescent lighting systems and are available from multiple vendors. It is important to note that these voltage stabilizers won't have any savings with LED systems.

Daylighting: Daylighting involves the efficient use of natural light in order to minimize the need for artificial lighting in buildings. Increasing levels of daylight within rooms can reduce electrical lighting loads by up to 70%. Unlike conventional skylights, an efficient daylighting system may provide evenly dispersed light without creating heat gains. The reduced heat gains will reduce the need for cooling compared to skylights. Daylighting differs from other energy efficiency measures because its features are integral to the architecture of a building; therefore, it is applied primarily to new buildings and incorporated at the design stage. However, existing buildings can often be cost effectively refitted with different daylighting systems like translucent sheets, light pipes etc. Various daylighting systems are available on the market, some of which can be supplied as kits to retrofit an existing building.

Daylighting can be combined with lighting controls to maximize its benefits. Because of its variability, daylighting is almost always combined with artificial lighting to provide the necessary illumination on cloudy days or after dark. Daylighting technologies include properly placed and shaded windows, atria, angular or traditional (flat) roof lights, clerestories, light shelves, and light ducts. Clerestories, light shelves, and light ducts accommodate various angles of the sun and redirect daylight using walls or reflectors. Not all parts of a facility may be suitable for the application of daylighting. Daylighting is most appropriate for those areas that are used in daytime hours by people. The savings will vary widely depending the facility and buildings. Daylighting systems typically have a payback period of around 4 years, although shorter paybacks have been achieved.

Blowers:

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.

- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Install energy efficient blowers.

Cooling Towers:

- Based on leaving water temperatures, the cooling tower fans must be controlled.
- From cooling tower and chiller performance data, optimise the water temperature as required.
- Use VFD for the cooling tower fans (when few in number) wherever required; On-off control should be provided if the fans are several in number.
- For preventing fouling from algal growth, cover hot water basins.
- Chemical use must be optimised.
- Velocity pressure fan rings must be used.
- Self-extinguishing PVC cellular-film fill must replace splash bars.
- Leaking cooling tower cold water basins must be re-lined.
- Water treatment of cooling tower side stream should be considered.
- Loads not in service should be shut off.
- Optimise and possibly automate blow down flow rate.
- When there is no water flow, interlocks can be installed to prevent fan operation.
- Fan blade angle must be optimised based on seasons and/or load.

Case Studies – Process

4. Case Studies — Process

Case Study 1: Fuel Switching from HSD to Natural Gas for Painting Oven, Boiler (Water Heater) & Pre-treatment Tank

Plant: M/s Ranvik Auto Components Pvt. Ltd, Pune

Implementation Details: The unit was operating HSD-fired oven. This oven has been constructed with the 13-inch refractory lining covered with metal sheet. The performance of HSD-fired oven was evaluated during the audit. Based on the audit report, the operational efficiency of the HSD-fired oven using boiler efficiency by direct method was 71%. The burning of HSD causes pollution with smoke formation in the working area and also burning efficiency for HSD is less.

In this regard the consultant has suggested / recommended to switch fuel from HSD to natural gas for Painting Oven, boiler and pre-treatment tank. The procurement and investment details of fuel switching and burner change and auxiliaries. Therefore the plant has replaced the fuel from HSD to natural gas for painting oven, boiler and pre-treatment tank. Presently plant team has completely stopped utilizing HSD in the oven and boiler. As the cost of natural gas is comparatively lower compared to HSD, the overall cost of fuel consumption has reduced.

Merits:

- No smoke formation, almost emission free.
- Higher system efficiencies with NG.

Limitations:

- Initial high capital investment for creating pipe line infrastructure.

S.No	Design Specification	Before Implementation	After Implementation
1	Capacity kcal/hr	2,25,000	2,25,000
2	Flow Rate Lit/hr; SCM/hr	17.2	665
3	Fuel	HSD	Natural Gas

S.No	Implementation Details	Before Implementation	After Implementation
1	Avg Material feeding rate, kg/day	375	249
2	Feed Temperature, °C	33.3	35.6
3	Flue gas temperature, °C	376	124
4	Excess Air level, %	6.63	11.7

S.No	Implementation Details	Before Implementation	After Implementation
5	Ambient temperature, °C	32.3	34
6	Fuel Consumed, litres/year ; SCM/year	59,308	45,427
7	Fuel Cost, INR/litre ; INR/SCM	56	42
8	Energy Cost, INR/year	3,306,106	2,394,660
9	Energy Savings, TOE/ year	163	
10	Annual reduction in CO_2 at 0.82 emission factor	1,555 MT	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
9.11 Lakh	18.31 Lakh	24 Months

Technology Supplier Details:

Patel Boiler Services

Plot No: 3610/2; Patel Commercial, Complex; Nr. Telephone Exchange;

Ficom Chowkdi; GIDC Estate; Pune – 393002;

Phone: 026 46223596

Local Technology Supplier / Service Provider:

Sun Pak Kiln (P) Ltd.

2, Udhyogpuri, Opp. R D Udhyog Nagar, Nemawar Road,

Indore, 452 003, Madhya Pradesh, India

Email: sunpak_kiln@yahoo.com

Phone: 0731 2403536

Case Study 2: Lid Mechanism for 750 kg Duraline Furnace

Plant: M/s K&K Foundry Pvt. Ltd, Kolhapur

Implementation Details: During the audit period, it was found that the opening of 750 kg induction furnace is circular with 460 mm diameter. The opening heat losses for one batch (heat) were calculated & it is recommended to use lid mechanism for the opening with hydraulic operation. During the detailed study post implementation. It was observed that plant has installed lid mechanism to reduce the heat loss due to the opening. It was observed that heat loss was reduced significantly. By successfully implementing this project, the plant has achieved energy savings of nearly 83,727 kWh.

Figure 12: Induction Furnace Lid Mechanism

Merits:

- Reduces significant heat losses.

Limitations:

- Additional capital investment for creating lid handling system.

S.No	Implementation Details	Before Implementation	After Implementation
1	Temperature of the opening (°C)	1,500	465
2	Ambient temperature (°C)	33.6	35.2
3	Total heat loss per heat (kWh)	24.45	11.16
4	Saving potential per heat (kWh)	13.29	
5	Total heats per day	21	
6	Operational days in a year	300	
7	Annual saving potential (kWh/yr)	83,727	
8	Energy Savings, TOE/ year	7.2	
9	Annual reduction in CO_2 at 0.82 emission factor	68.65 MT	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
5.30 Lakh	3.50 Lakh	8 Months

Technology Supplier Details:

Mr S R Subramanian – National Sales Manager
Inductotherm (India) Pvt. Ltd.
Plot SM-6 Behind Colgate Palmolive,
Bol GIDC, Phase 2, Sanand, Gujarat 382170
Phone: 9328157679

Case Study 3: Replacement of existing FO-fired furnace with Induction Furnace

Plant: Sri Aurobindo Automotive Components, Faridabad

Implementation Details: FO-fired furnace was having high running cost and was inefficient as compared to electrical-fired Induction furnace. Efficiency of FO-fired furnaces was found to be 8.5%, which was very low. Measured FO-consumption per MT of raw material was 163, with annual running cost of INR 72 Lakh/Yr. It was suggested to install Electrical Furnace for better efficiency and for low running cost.

The unit has implemented this ECM and replaced FO-fired furnace with electric furnace. During the Monitoring & Verification, detailed measurements were taken and specific energy consumption of electric furnace was calculated and found to be 560 kWh/MT.

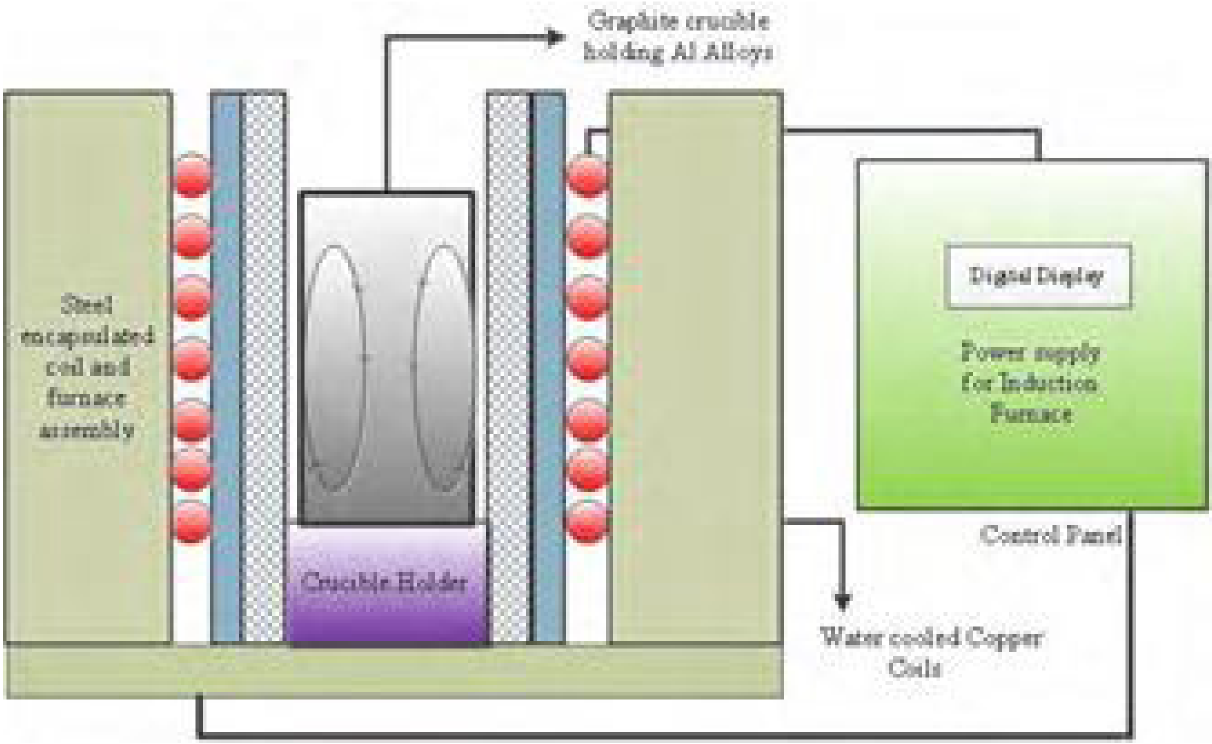

Figure 13: Induction Furnace Schematic

Merits:

- ❖ Operation is faster & more efficient.
- ❖ Cleaner & safer melting.

Limitations:

- ❖ Initial high capital cost.
- ❖ Special infrastructure for power quality improvement needs to be installed.

S.No	Implementation Details	Before Implementation	After Implementation
1	Power Cost (INR/kWh)	7.37	8.1
2	Cost of FO (INR/kg)	49	
4	Operating Hours (hrs/day)	22	22
5	Operating Days (days/year)	300	300
6	Annual production (Tons/year)	891	891
7	Weight of one piece (kg)		1.34
8	No. of piece in 5 minutes		16
9	Total heated mass in 5 minutes (MT)		0.0214
10	Energy consumption in 5 minutes (kW)		11.95
11	SEC (kg/MT, kWh/MT)	163	560
12	Fuel Consumption (kg/Year, kWh/year)	1,45,233	4,98,960
13	Annual Energy Cost saving (INR Lakh/Year)	72.0	40.4
14	Annual Energy savings (kwh/Year)	11,98,471.5	
15	Energy Savings, TOE/ year	103	
16	Annual reduction in CO_2 at 0.82 emission factor	982.7 MT	

Cost Benefits:

Annual Savings

31.60 Lakh

Investment

12.93 Lakh

Simple Payback Period

5 Months

Technology Supplier Details:

S.K.Tech & Services Pvt. Ltd. 137,Dsidc Sheds

Okhla Industrial Area , Phase-1 New Delhi-110020

Phone: 011 4161 9678

Case Study 4: Automation in heat treatment process

Plant: Omkar Foundries, Kolhapur

Implementation Details: The foundry has a heat treatment furnace installed which is HSD fired and used for normalizing, tempering and water quenching purpose. Each has different cycle time and temperature requirements. During audit, it was found that the fuel and air were un-controlled. This was leading to excess fuel consumption.

It was recommended to do automation in heat treatment process. VFD was proposed for blower motor to control the input air quantity and solenoid circuit was proposed for controlling fuel input. The unit has implemented the recommendation. The achieved annual energy saving with automation in heat treatment process is 1,700 litres of diesel.

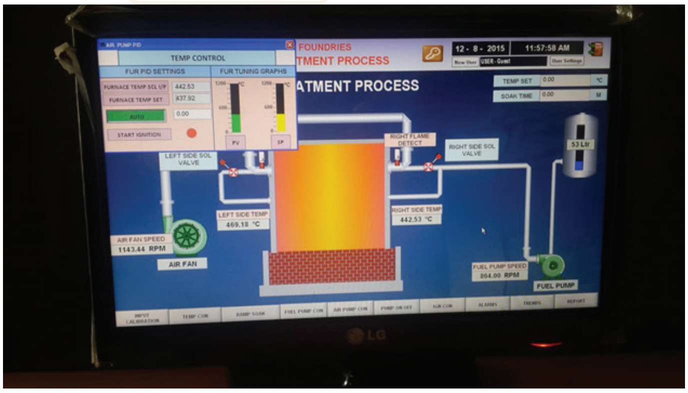

Figure 14: Automation in Heat Treatment Process

Merits:

- Avoids excess consumption of fuel.
- Precise control of process.

Limitations:

- There is no major limitation for this project except little harmonics produced due to VFD which can be easily gets mitigated through existing capacitor banks & cable reactance.

S.No	Implementation Details	Before Implementation	After Implementation
	Observed parameters		
1	Cost of FO(INR/ltr)	53	50
2	Diesel Consumption (Ltrs/yr)	8,400	6,700
3	Annual Production from furnace (Tones/ year)	176	176
4	Diesel savings (Litres/day)	17.00	
5	Annual Diesel savings (Litres/year)	1,700.00	
6	Energy Savings (TOE/ year)	1.68	
7	Annual reduction in CO_2 emissions	16 MT	
8	at 0.82 emission factor		

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
0.85 Lakh	2.05 Lakh	29 Months

Technology Supplier Details:

YU Technologies
B 8/5, Opposite MSEDC Power Substation,
MIDC, Miraj, 416 410, Maharashtra, India.
Phone: +91 916 832 4851
Email: info@yutech.in

Local Technology Supplier / Service Provider:

Autosys Indore
201- 202, saphire Square, Tower Chouraha,
Indore, Madhya Pradesh 452001
Phone: 7771898989
Email: info@autosysindore.com

Case Study 5: Reduction in furnace oil consumption by relining of melting furnace to reduce heat losses

Plant: Aum Prasad Casting (p) Ltd, Pune

Implementation Details: The unit is operating FO fired melting furnace of capacity 180 kg per batch. The average surface temperature was very high which was leading to higher heat loss & resulting in poor efficiency. The unit has implemented the measure of relining of the furnace to avoid the surface heat loss in terms of radiation & convection.

Merits:

- Reduced heat losses
- Better metallurgical control and optimum output

Limitations:

- Down time of furnace for relining.

Sr. No	Implementation Details	Before Implementation	After Implementation
1	Capacity of the Furnace, kg	180	180
2	Furnace Type	FO-Fired	FO-Fired
3	GCV of the fuel, kcal/lit or kcal/kWh	9870	9870
4	Annual Production, Tones/year	142	142
5	Operating Temperature (°C)	750	750
6	Skin Temperature	130	73.15
7	Fuel cost, INR/Lt	52	42.74
8	Reduction in Surface Losses (kcal/hr)	2,654.32 kcal/hr	
9	Energy Savings, TOE/year	1.97	
10	Annual reduction in CO_2 at 0.82 emission factor	18.78 MT	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
0.86 Lakh	0.35 Lakh	5 Months

Technology Supplier Details:

Industrial Minerals & Refractories,
J-222, MIDC, Bhosari, Pune-411026
Phone: 020 2713 0239

Local Cluster Supplier / Service Provider

Universal Refractories & Allied Construction Co
Plot No. 6 C, Sector A, Sanwer Road, Industrial Area, Indore – 452015,
Madhya Pradesh, India
Phone: +91 9827617286
Email: info@universalrefractories.co.in

Case Study 6: Replacement of SCR based Induction furnace with IGBT Induction Furnace

Plant: M/S Marvelous Metals Pvt Ltd. (Unit 2), Kolhapur

Implementation Details: The unit had installed three induction furnaces, one of them, the induction furnace II is of 500 kg capacity for melting. The calculated specific energy consumption was 656 kWh per Metric Tone of melting, which was higher in comparison to that of furnaces in similar category.

The SCR has a firing signal to turn it on. To turn it off the current flow in the power circuit must be reversed. The semiconductor physics of the SCR makes it ideal for use in low and medium frequencies from 50/60 Hz and less up to max 10 kHz. Above this frequency it is not possible it´s use in an economical and reliable way.

Figure 15: IGBT Module

Measurements	UOM	Value
Capacity of furnace	kg	500
No. of batches per day	Nos	27
Minutes per batch	-	52
Production of furnace	Tone/day	13.5
Operating hours per day	Hrs/day	23.4
Specific energy consumption	kWh/Tone	656
Annual production	MT/Year	3,994
Annual consumption	kWh/year	26,20,064

It was recommended to replace the existing induction furnace with a new IGBT-based Induction furnace. New IGBT furnace have better specific energy consumption than conventional one. The IGBT has a control signal to turn it on or off. The semiconductor physics of the IGBT makes it ideal for Medium & High Frequency Switching applications from 500 Hz to 100 kHz. They cannot be used in frequencies higher than 100 kHz.

Merits

- The biggest advantage of IGBT is the possibility of turn it on and off with control signal, low power losses due to low voltage drop while conducting.
- No need of snubber circuits.

Limitation

- ❖ The chips available today can handle small electrical current flows so the modules are basically a set of chips assembled in parallel to come up with high current devices.

Implementation Details	Unit	Before Implementation	After Implementation
Capacity of furnace (kg)	Kg	500	500
No. of batches per day	Nos	27	27
Minutes per batch		52	52
Production of Furnace	Tone/day	13.5	13.5
Operating hours per day		23.4	23.4
Specific Energy Consumption	kWh/Tone	656	602.1
Annual Production	MT/Year	3,994	3,994
Annual Consumption	kWh/year	26,20,064	24,04,787.4
Annual Savings	kWh	2,15,276.6	
Energy Savings	TOE/Year	18.5	
Annual reduction in CO_2 at 0.82 emission factor	MT	176	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
13.62 Lakh	27.75 Lakh	24 Months

Technology Supplier Details:

INDUCTOTHERM (INDIA) PVT. LTD.
Plot No. SM-6, Road No.11 Sanand-II, Industrial Estate,
BOL Village, Sanand Ahmedabad- 382170
Phone: +91 937 457 8586
Email: sales@inductothermindia.com

Case Study 7: Replacement of conventional cupola with divided blast cupola furnace

Plant: M K Iron Foundry, Kolhapur

Implementation Details: Plant was operating with conventional type cupola furnace. Plant has decided to reduce the coke consumption with minimum investment. Present coke consumption was 150 kg coke per ton of material. The plant has decided to replace the existing inefficient cupola furnace with new divided blast cupola.

Divided blast cupola (DBC) or twin blast cupola is a proven technology for improving the energy performance at a modest investment. As is evident from its name, a DBC supplies blast air to the cupola furnace at two levels through a double row of tuyeres. The advantages of a DBC, compared to a conventional cupola, are as follows.

- A higher metal tapping temperature and higher carbon pick-up are obtained for a given charge-coke consumption.
- Charge-coke consumption is reduced and the melting rate is increased, while maintaining the same metal tapping temperature.
- Optimum blower specifications (quantity and pressure).
- Optimum ratio of the air delivered to the top and bottom tuyeres.
- Minimum pressure drop and turbulence of the combustion air.
- Higher stack height.
- Mechanical charging system.
- Stringent material specifications.

Figure 16: Divided Blast Cupola Installation

The most energy-efficient cupola uses 13.6% charge coke (coke metal ratio of 1 to 7.5). The figure for the least energy efficient cupola was found to be as high as 26.5% (coke to metal ratio of 1 to 4).

S.No	Implementation Details	UOM	Before Implementation	After Implementation
1	Cost of Coke	INR/kg	30	30
2	Melting	Tones/yr	100	100
3	Coke for Melting per tone of metal	Tones	150	120
4	Coke consumption per year	Tones/yr	15	12
5	Coke savings	Tones/yr	3.0	
6	Energy savings	TOE/Yr	1.79	
7	Annual reduction in CO_2 at 0.82 emission factor	MT	17.16	

Cost Benefits:

Annual Savings

0.90 Lakh*

Investment

4.48 Lakh

Simple Payback Period

60 Months

** Note: The reason for lower savings achieved is mainly because of the market condition. The unit only runs inconsistently and for almost half a month.*

Technology Supplier Details:

Vandana Steel Corporation

E/204, near.mathoradas Extention Road, Kandivali West,

Mumbai-400067, Maharashtra, India

Phone: 9930978270

Case Study 8: Hydroxy Fuel Substitution in Industrial Furnaces

Plant: Ceramic tiles manufacturing industry

Implementation Details: Ceramic tiles industries are high energy consuming industries mainly thermal energy. More than 50% of total cost is energy cost in ceramic tiles industries here most energy consuming process is the firing process or kiln process. The primary energy use in ceramic manufacturing is for kiln. Natural gas, LNG and fuel oil are employed for most drying and firing operations. Nearly 30% of the energy consumed is used for drying. Over 60% of the energy consumed is used for firing. The percentage of the energy cost in the total ceramic production cost is between 5 and 20%.

The ceramic Industry manufactures Glazing material which is used for layering tiles. The dry chemicals are fed into industrial furnace for melting it at the temperature of 1,500°C Celsius. The fuel used is Furnace Oil. The daily consumption of furnace oil is 3,600 litres, which costs around 1.3 Lakh/day. The cost of furnace oil alone occupies 40% of total operating cost which is very high. High fuel price is a major challenge and has been one of the key reasons affecting the profitability of the ceramic industry. To control the fuel cost, Hydroxyl Gas Generator was proposed as it is capable of giving the required temperature to melt the chemicals.

HYDROXY GAS GENERATOR - Fuel without CARBON

Hydroxy gas is the a combination of hydrogen and oxygen gas produced from the electrolysis of water HHO system is composed of HHO Gas plant and hydroxy system combustion system (boiler, furnace etc.) The water fuelization system converts the water into hydroxy gas and makes thermal energy.

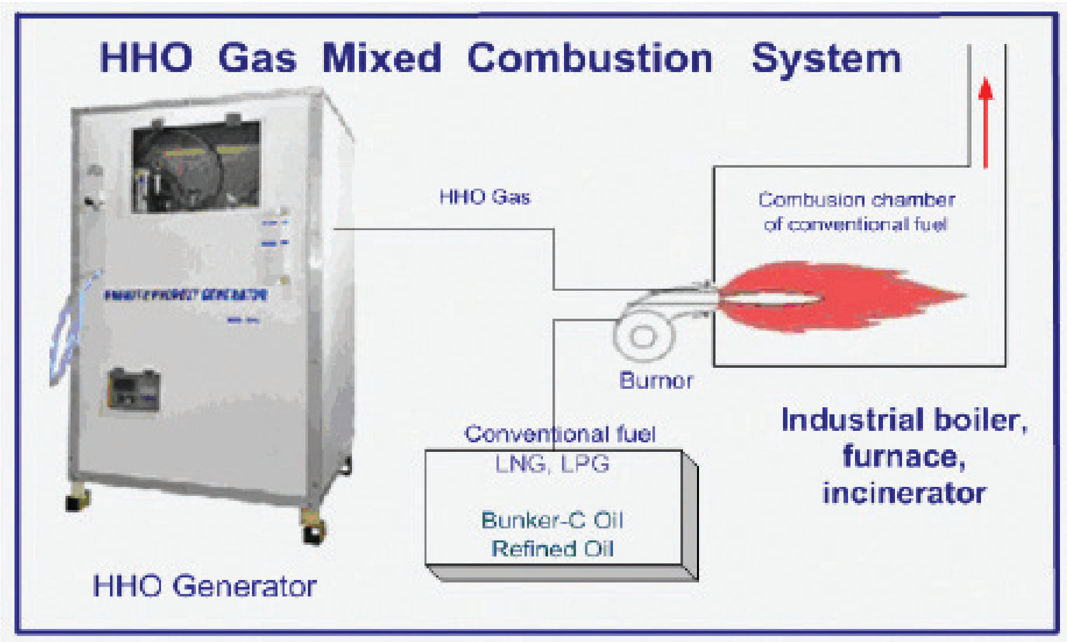

Figure 17: HHO Mixed Combustion System

From the Hydroxy gas, the heat generation device will convert into water energy which has calorific value of 10.7 KJ/Lit. The company which owns existing facility (industrial boiler, heating furnace, melting incinerator etc.) can have Hydroxy mixed combustion system (Min 5% of total energy) to mix and burn Hydroxy Gas with conventional fuel to achieve fuel savings. This plant supplies Hydroxy Gas 24 hours into the combustion chamber of existing facility. The Hydroxy Gas is mixed with conventional fuel and burned together.

Fuel Used	Furnace Oil
Annual Fuel Consumption	11,88,000 Litres
Fuel Cost	35 INR/Lit
Annual Fuel Cost	4 Crore
Proposed HHO Capacity	3,000 LPH
Fuel Savings through HHO	1,188,00 Litres
Energy savings	119 TOE
Annual reduction in CO_2 at 0.82 emission factor	1,141 MT

Merits

- Cleaner carbon free fuel
- Attractive payback of almost less than 2 – 2.5 years for wide range of applications
- Simple modular system

Limitation

- Fuel substitution percentage is limited to 10 –15% depending on the application

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
40 Lakh	55 Lakh	17 Months

Technology Supplier Details:

Kankyo group of companies

No. 11, Ayyavu Street, Ayyavu Colony, Amminjikarai, Chennai-29

Phone: 7550221943

Email: dev@kankyo.global

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General Case Studies

5. General Case Studies

Case Study 1: Replacement of existing raw water pump with energy efficient pump

Plant: Melting Centre Pvt Ltd, Kolhapur

Implementation Details: The unit has installed an induced draft cooling tower to cater to the cooling requirements of induction furnace coil and panel. The cooling water pump is circulating the raw water through the plate type heat exchanger for panel cooling. At the secondary of the PHE, DM water circuits have been provided. The performance parameters of this pump have been measured and efficiency has been estimated to be 31.7%.

Figure 18: Energy Efficient Pump

The power consumption of raw water pump was measured to be 3.4 kW. The water flow rate was measured to be 12.95 m^3 per hour which is less than the design flow rate (25.1 m per hour). The performance of an induction furnace is directly linked with the performance of the cooling water system associated with furnace coil and panel. Therefore, it is recommended to replace the existing raw water pump with an energy efficient pump.

Merits:

- Higher efficiencies
- Robust design & less maintenance

Limitations:

- Initial high capital cost

S.No	Implementation Details	Before Implementation	After Implementation
1	Cost of Electricity (INR/kWh)	7.83	7.83
2	Power Consumption kW	3.34	1.97
3	Annual Operating hours	7,200.00	7,200.00
4	Annual Savings (kW hr/yr)	9,864.00	
5	Annual Savings (TOE/Yr)	0.84	
6	Annual reduction in CO_2 at 0.82 emission factor	8 MT	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
0.77 Lakh	0.53 Lakh	8.30 Months

Technology Supplier Details:

Vakratund Enterprises,W-26, Opp Smak Building, MIDC Shiroli, Kolhapur

Phone: 9552202099

Local Technology Supplier Details:

Kirloskar Brothers Limited - Dewas Works, Station Road, Dewas 455 001,MP

Phone: 07272-227397

Applicable Sectors:

Foundry, Auto components, Pharma, Readymade Garments & Food processing

Case Study 2: Replacement of all old reciprocating air compressors with new energy efficient screw air compressor

Plant: Aum Prasad Casting (P) Ltd, Pune

Implementation Details: The unit was operating three reciprocating air compressors of rating 7.5 kW each and design capacity 35 CFM, 35 CFM & 27 CFM, to cater to the compressed air requirement of the pneumatic operations and utility. Those compressors had high SEC & low volumetric efficiency. Unit implemented installation of high efficiency screw air compressors of rating 40 HP and capacity 203 CFM. This single air compressor is catering to the compressed air demand of the unit at lower energy consumption due to the low SEC of the screw compressor.

Merits:

- 25 to 30% higher energy efficiency than piston compressors.
- Screw compressors have a lot less noise (<75 dB) and vibration than piston compressors (>100dB).
- Screw compressors occupy less space than piston compressors.
- In the screw compressors, in order to install the load / unload system, the compressor does not stop completely when the pressure of the reservoir reaches the desired pressure, and when the automatic pressure is lowered out of the idling state and the air produces.
- Therefore, a lower-capacity reservoir can be used. In the case of piston compressors with a system on / off, the high capacity of the reservoirs should be used in order to prevent the compressor switching off and on, which results in electricity costs and depreciation, which subsequently requires high cost.
- Direct coupled & hence lesser maintenance.

Limitations:

- More expensive.
- Failure to observe maintenance-use of inappropriate oil and non-standard parts of the device will be vulnerable.

S.No.	Implementation Details	Before Implementation	After Implementation
1	Electricity Cost (INR/kWh)	8.4	9.04
2	Number of Compressors Installed	03	01
3	Installed Capacity (CFM)	97	201
4	Power Consumption (kW)	18.9	30
5	Hour of Operation per day (hr)	22	8
6	Total Operation Hours (hr/year)	6,820	2,480

S.No.	Implementation Details	Before Implementation	After Implementation
7	Annual Power Savings (kWh)	70,901	
8	Annual energy savings	6	
9	Annual reduction in CO_2 at 0.82 emission factor	58 MT	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
6.41 Lakh	7.28 Lakh	14 Months

Technology Supplier Details:

Poona Pneumatic Company,
Gat no.411 & 412, Medankar Complex,
Pune Nashik Highway, Medankarwadi, Chakan,
Distt. Pune-410501
Phone: 9130064432

Local Technology Supplier Details:

Shree Mahalaxmi Enterprises
Shop No-10, Harshadeep Tower,
Indira Complex, Navalakka
Indore - 452001 India
Phone: 9329023183
Email: rballoor@gmail.com

Applicable Sectors:

Foundry, Autocomponents, Pharma & Food processing

Case Study 3: Voltage Optimization at Incomer

Plant: OK Auto Components, Faridabad

Implementation Details: The three phase voltage maintained in the plant was measured as 451 Volts. Actual recommended voltage levels for all the drives were around 405 to 415V. Applying higher voltage results in more magnetisation losses in the drives & transformers creating energy losses. Losses will be higher if the under loading percentage of drives increases. Hence, it is suggested to install servo stabilizer at mains to adjust the voltage. The unit has implemented this ECM and a new servo stabilizer is installed. During the M&V visit the study of the Voltage was done and measurements were taken. The average voltage recorded was 405 Volt.

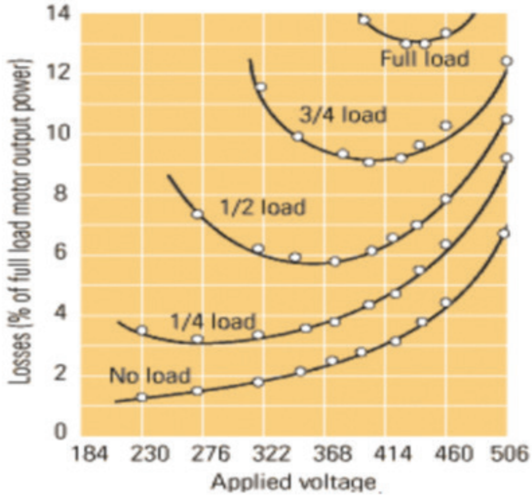

Figure 19: Motor Losses with variation in applied voltage

Merits:

- ❖ Lowers magnetisation losses and improves efficiency
- ❖ Easy to install and maintain

Limitations:

- ❖ Energy savings will be relatively less when all the drives are with VFD

S.No	Implementation Details	Before Implementation	After Implementation
1	Average Three phase voltage (V)	451.0	405.0
2	Reduction in Three phase voltage (%)	10.2	
3	Reduction in Energy Consumption (%)		0.19
4	Annual energy consumption - Three Phase (kWh/yr)	4,55,294	3,67,155
5	Annual Saving (kWh/Annum)		88,139
6	Net Saving from Voltage Regulation (5 Months)		36,725
7	Unit Cost (INR/kWh)	6.53	7.5
8	Annual energy savings (TOE/Yr)	7.57	
9	Annual reduction in CO_2 at 0.82 emission factor	72 MT	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
6.41 Lakh	8.50 Lakh	16 Months

Technology Supplier Details:

Poona Pneumatic Company,
Gat no.411 & 412, Medankar Complex,
Pune Nashik Highway, Medankarwadi, Chakan,
Distt. Pune-410501
Phone: 9130064432

Local Technology Supplier Details:

Shree Sharda Electronics
2nd Floor, Sharma Complex, 6/1, Maharani Road Behind
Hotel Gulmohar Regency, Opposite Ellora Plaza, Indore-452007
Phone: 8048750283

Applicable Sectors:

Foundry, Autocomponents,Readymade Garments, Pharma & Food processing

Case Study 4: Installation of solar rooftop PV system

Plant: Amul Fed Dairy, Gandhinagar

Implementation Details: The unit is purchasing electricity from grid for the power requirement in plant. The contract demand of the plant is 260 kVA with electricity price of Rs 7.0/kWh with an average load of 150 kW to 200 kW. The unit has enough roof top area which can be utilized to install solar PV for self-generation of electricity rather than purchasing from grid.

As per the site specifications, the unit has a potential of installing 20 kWp solar roof top which can generated around 0.40 lakh units of electricity annually. The proposed system will be A Grid Tied Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches.

Figure 20: Solar PV Installation

PV Array is mounted on a suitable structure. Grid tied SPV system is without battery and should be designed with necessary features to supplement the grid power during day time. In grid connected rooftop or small SPV system, the DC power generated from SPV panel is converted to AC power using power converter and is fed to the grid either of 33 kV/11 kV three phase lines or of 440V/220V three/single phase line depending on the local technical and legal requirements. These systems generate power during the day time which is utilized by powering captive loads and feed excess power to the grid. In case, when power generated is not sufficient, the captive loads are served by drawing power from the grid.

Latitude : 23.25 Longitude : 72.65

Annual Average : 5.75 kWh/m^2/day

Monthly Average

JAN	4.82
FEB	5.74
MAR	6.62
APR	7.29
MAY	7.57
JUN	6.60
JUL	4.81
AUG	4.53
SEP	5.77
OCT	5.86
NOV	5.00
DEC	4.50

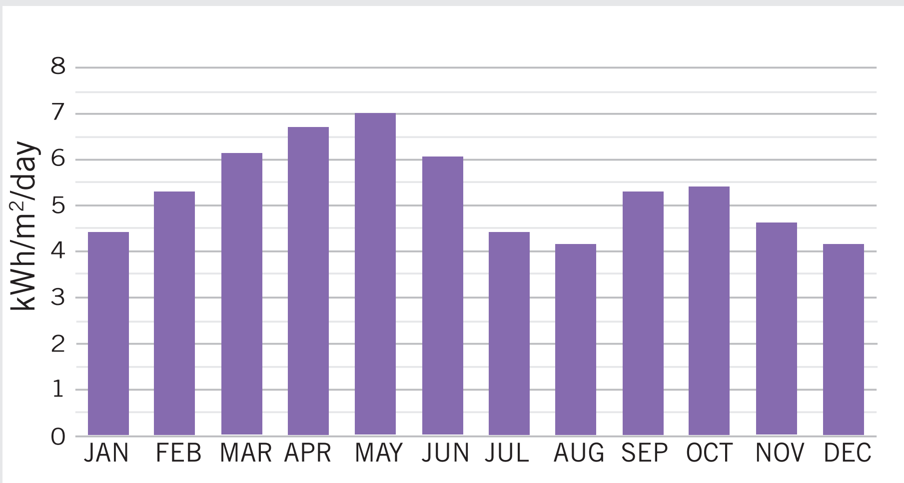

Figure 21: Annual Solar Irradiance of the site

Merits:

- PV panels provide clean – green energy. During electricity generation with PV panels there is no harmful greenhouse gas emissions thus solar PV is environmentally friendly.
- Technology development in solar power industry is constantly advancing which can result in lower installation costs in future.
- PV panels have no mechanically moving parts, except in cases of sun-tracking mechanical bases; consequently, they have far less breakages or require less maintenance than other renewable energy systems (e.g. wind turbines).

Limitations:

- The initial cost of purchasing a solar PV system is high which includes paying for solar panels, inverter, batteries, and wiring and for the installation.
- Efficiency of the system drops which results in lesser generation of energy.
- The area required for installing for large PV system is huge and it uses lot of space.

Table 2: Project Details

S. No.	Features / Requirements	Values
1	Shadow free roof area required	10 sq. m or 100 sq. ft per kWp
2	Orientation of the roof	South facing roof is most suitable Installation may not be feasible beyond 5 deg slope
3	Module installation	Modules are installed facing South Inclination of modules should be equal / closer to the latitude of the location for maximum energy generation
4	Cost of the rooftop solar PV system	MNRE issues benchmark cost for Grid Connected Rooftop Solar PV system and the cost for general category states for 2019-20 are as follows. This includes cost of the equipment, installation and O&M services for a period of 5 years. ❖ Above 1 kWp and up to 10 kWp: INR 54,000 / kWp ❖ Above 10 kWp and up to 100 kWp: INR 48,000 / kWp ❖ Above 100 kWp and up to 500 kWp: INR 45,000 / kWp Based on discussion with few project developers, average cost of the system (as per market conditions) are as follows: ❖ For 10 kWp system, INR 49,000 / kWp ❖ For 50 kWp system, INR 42,500 / kWp ❖ For 100 kWp system, INR 37,000 / kWp
5	Annual energy generation from Rooftop Solar PV system	18% CUF in 1st year i.e. 1,578 kWh / kWp / year 0.7% degradation every year for the useful life of the system On an average, 1,452 kWh / kWp / year would be generated over the useful life
6	Annual CO_2 Emission Reduction	32.8 MT
7	at 0.82 emission factor	

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
2.60 Lakh	19.0 Lakh	88 Months

Technology Supplier Details:

Varizone Solar Pvt. Ltd.
Shop no. 2/3, Amrut Nagar, Hari Nagar-2, Opp. Swaminaryan Temple, Udhna, Surat
Phone: +91 9426111113
Email: varizonesolar@gmail.com

Local Technology Supplier Details:

Bhavya Renewable Energy, C/HD-52, Sukhliya, INDORE-452010,
Phone: +91 9644 36 36 36
Email:info@bre.ind.in

Applicable Sectors:

Foundry, Autocomponents,Readymade Garments, Pharma & Food processing

Case Study 5: Installation of Solar-Wind Hybrid System

Plant: Manufacturing Facility

Implementation Details: The unit is purchasing electricity from grid for the electrical energy requirement. The contract demand of the plant is 450 kVA with an electricity price of INR 6.5/ kWh and average operating load is 260 kW to 300 kW.

Renewable energy is deemed to be the best substitute for conventional fossil fuel. Implementation of renewable energy posts various challenges such as capital cost and consistency of power output, the latter can be solved by the installation of Solar – Wind hybrid system. The plant has enough roof top area which can be utilized to install solar-wind hybrid to harness solar energy and wind energy in order to generate electricity

The Solar-Wind Hybrid system is also known as solar mill. The Solar mill generates:

- ❖ Daytime energy from the sun and wind energy
- ❖ Day & Night energy from the wind
- ❖ Energy even on cloudy days
- ❖ More energy on hot sunny days due to cooling effect on solar panels by wind.

Figure 22: Solar Wind Hybrid System

It consists of three vertical axis wind turbines coupled to three permanent magnet generators. Automatic mechanical braking is provided once the wind speed goes beyond the cut-off speed. On board smart electronics include dynamic Maximum Power Point Tracking (MPPT). It uses wind and solar resources on a 24/7/365 basis, allowing access to energy and very little interruption of services. The design life of solar mill is 25 years.

In grid tied system, the bank of batteries is connected to one or more Direct Grid micro-inverters which connect to the user's electrical panel. The inverters push power back to the grid efficiently when the batteries become fully charged

In off grid storage, the batteries can be used to supply power to electrical devices in off grid settings. This electrical energy can power DC powered devices through a voltage converter, or can power AC devices through an inverter.

Cut in speed for this system is min 2.5 m/sec and as average wind speed in Indore is of 4 m/ sec it's most suitable for applications in Indore region also.

Merits

- ❖ Power generation during day time as well as night time.
- ❖ Reliable-Power generation even on cloudy days.

❖ A compact hybrid solar mill to meet a portion of the plant's load after detailed study with vendors.

❖ Power generation stats at 2-5 m/s and mechanical braking occur beyond 18 m/s.

Limitations

❖ Initial higher investment.

Latitude : 23.05 Longitude : 72.55

Annual Average : 5.82 kWh/m²/day

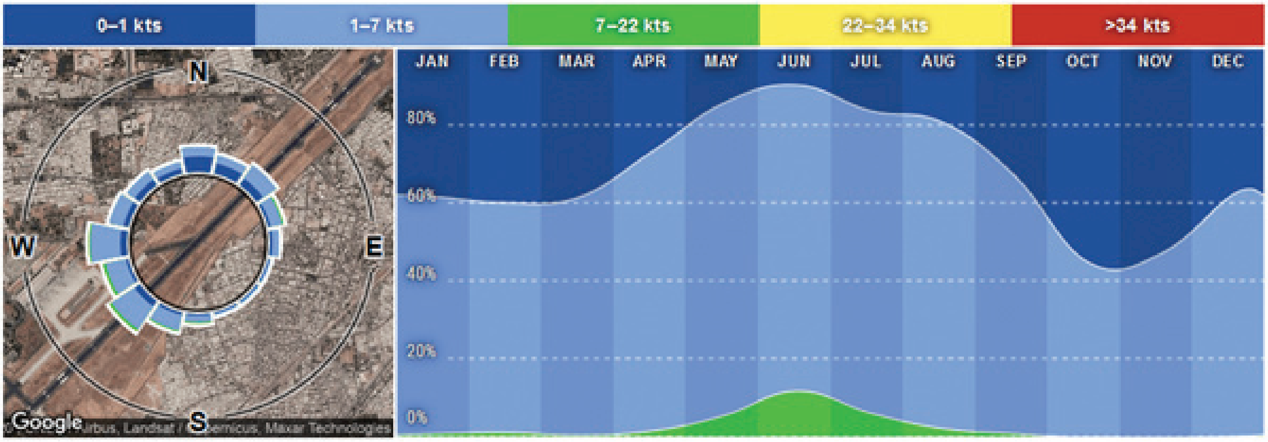

Figure 23: Average winds in and around Ahmedabad area

Latitude : 23.05 Longitude : 72.55

Annual Average : 5.82 kWh/m²/day

Monthly Average

JAN	6.47
FEB	7.27
MAR	7.14
APR	6.78
MAY	7.28
JUN	5.50
JUL	2.64
AUG	2.51
SEP	5.14
OCT	6.92
NOV	6.35
DEC	6.03

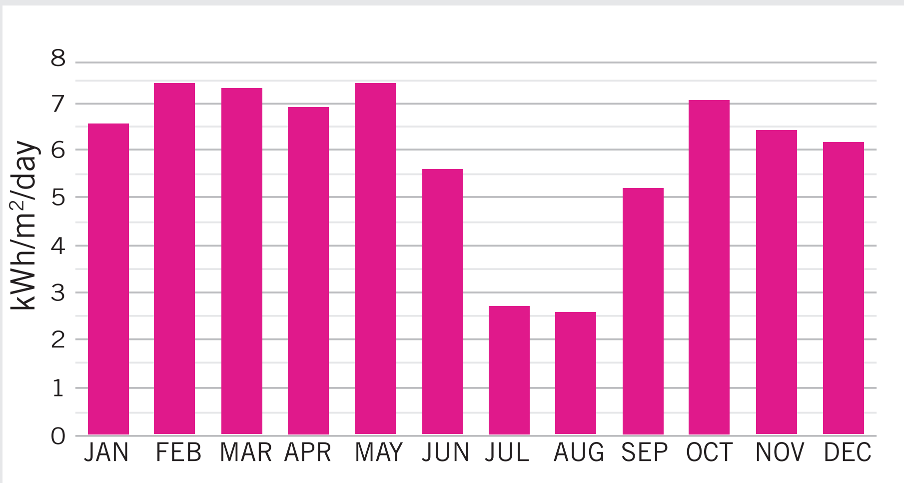

Figure 24: Average direct solar irradiance of site

S.No	Implementation Details	UOM	
1	Installed Capacity of Solar-wind Mill	kWp	50
2	Average generation per day per kWp	kWh	6.0
3	Area Required	m^2	60
4	Annual operating days	Days	365
5	Electricity Tariff	INR/kWh	6.5
6	Average Annual Energy Saving on conservative basis	kWh	1,09,500
7	Annual Energy Savings	TOE	9.41
8	Annual Reduction in CO_2 at 0.82 Emission factor	MT	89

Cost Benefits:

Annual Savings

7.11 Lakh

Investment

50.0 Lakh

Simple Payback Period

84 Months

Technology Supplier Details:

Windstream Technologies

G2-SSH Pride, Plot 273, Road No-78, Jubilee Hills, Hyderabad 500096

Email: bhaskars@windstream-inc.com

Phone: +91 99599 18782

Applicable Sectors:

Foundry, Autocomponents,Readymade Garments, Pharma & Food processing

Case Study 6: Improve power factor by installing KVAR compensator and APFC

Plant: Reputed foundry unit in Kolhapur

Implementation Details: The unit has a contract demand of 500 KVA and operating power factor is 0.85. Major equipment in the foundry is an induction furnace. For induction motor to operate it requires reactive current from the source for producing the magnetization effect. More the reactive current drawn from the supply higher will be the distribution losses across the feeder. It is always better to provide the reactive current locally to reduce the distribution losses in the plant.

Effects of Lower power factor:

- Max Demand increases for the same load.
- Draws more current.
- Copper loss in transformer increases.
- Loss in the distribution cable increases.

Figure 25: KVAR Compensator

It is recommended to install a reactive current injector locally near to the load end to reduce the reactive current drawn from the supply. An innovative product called kVAr compensator can be installed near to load end to improve the PF of motor and thereby reduce the magnetization current drawn from supply. The kVAr compensator works by reclaiming, storing and then supplying locally the reactive power element of electricity to inductive motors and loads. As the electrical equipment operates, this reactive power is ‘pulled and pushed’ to and from the kVAr compensator by the motor. Reactive power is then recycled by the kVAr compensator which can supply it on the spot without having to draw it from the grid. This leads to reduction in electric demand and improvement in the power factor and thus, the operating costs.

From a technical point of view this is the best solution, as the reactive energy is produced at the point where it is consumed. Heat distribution losses (I2R) are therefore reduced in all the lines, resulting in real power reduction. The kVAr required for the motor to maintain the PF close to unity is found out by using a sizing kit. It helps in fixing and selecting the correct size of kVAr unit required to make the inductive load wok in most efficient way.

Merits:

- Max utilization of transformer and other equipments capacity.
- Demand reduction savings.
- Reduces distribution losses in the distribution system if compensated at load end.
- Incentives from electricity board.

Limitations:

- Improper sizing leads to negative effects.
- Initial high cost compared to static capacitor banks.

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
1.10 Lakh	1.20 Lakh	13 Months

Alternate Technology Supplier Details:

Inphase power technologies
No 59, Kachohalli, Machohalli Industrial Area
Magadi Main Road, Chikka Gollarahatti, Bangalore-560091
Phone: +91-7760693303
Email: sales@inphase.in

Local Technology Supplier Details:

Bharmal Traders
20, Udhyog Puri, Nemawar Road, Indore, MP
Phone: 9827023499
Email: sales@bharmaltraders.com

Applicable Sectors:

Foundry, Pharma, Autocomponents, Readymade Garments, Food processing

Case Study 7: Replacement of aluminium blades of cooling tower fan by FRP blade

Plant: Caspro Metal Industries Pvt Ltd, Kolhapur

Implementation Details: There are two cooling towers in the plant in operation. Both the cooling towers were having Aluminium as the material for their fan blades. A suggestion was made to replace these Aluminium blades with energy efficient FRP blades. FRP blades have better aerodynamic properties compared to Aluminium, having lower weight but still providing similar flow and pressure as that of Aluminium. This feature helps in reduction of power consumed by the fan motor in cooling tower.

Merits:

- Less maintenance.
- Lower power consumption.
- Better aerodynamic properties.

Limitations:

- A little high on cost.

During the M&V activity conducted at the plant it was observed that the plant has replaced the blades of both these fans by FRP material.

Figure 26: FRP Cooling Tower Fan

S.No.	Implementation Details	Before Implementation	After Implementation
1	Operating Hours	7,200	7,200
2	Power consumption by fan (kW)	4.5	3.65
3	Energy Cost (INR/kWh)	8.5	6.5
4	Annual savings due to change of fan, (kWh/Year)	6,120	
5	TOE savings/yr	0.52	
6	Annual reduction in CO_2	5 MT	
7	at 0.82 emission factor		

Cost Benefits:

Annual Savings	Investment	Simple Payback Period
0.39 Lakh	0.06 Lakh	2 Months

Alternate Technology Supplier Details:

Encon Engineers
2b/17, Shivkripa, N.C. Kelkar road, Dadar (west), Mumbai-400 028 (India)
Phone : 022 2430 6578
Email : encon@encongroup.in

Local Technology Supplier Details:

Mahakal Cooling Towers
No. 220, Kailash Kuti, Talawali Chanda
Indore - 453771, Madhya Pradesh, India
Phone: 08048026414

Applicable Sectors:

Foundry, Pharma, Autocomponents

Case Study 8: Replacement of existing motors with energy efficient (IE3) motors

Plant: A foundry unit in Kolhapur

Implementation Details: The plant team identified a total of 36 motors from sand plant, pump house and fitting shop for replacement. All the motors in the plant were old and operating at a low efficiency range. The motors were rewinded multiple times.

To begin with, the plant replaced three old motors with energy efficient IE-3 motors.

Table 3: Classification of Motors as per IEC

New efficiency classes defined by IEC	
Super premium efficiency	IE4
Premium efficiency	IE3
High efficiency	IE2
Standard efficiency	IE1

Motor replacement is done through EESL's National Motor Replacement Program.

EESL's National Motor Replacement Program

Riding high on the success of 'Demand Aggregation' model in energy efficient products, EESL aims to create an infrastructure to fuel supply for High Efficient Motors (HEMs) adhering to IE-3 standard through upfront investment, awareness creation, capacity building of manufacturers, and developing success cases to convince decision makers.

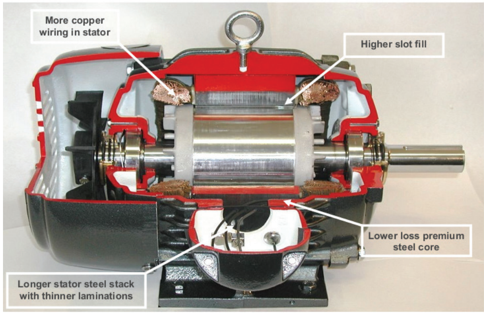

Figure 27: Energy Efficiency Induction Motor Construction

After a good consultation with various stakeholders, EESL has designed the Motor Replacement Programme to encourage the use of energy efficient motors adhering to E-3 standard by the end users. The motors replacement programme shall offer appropriate technical specifications, keeping in mind key customer pain points, viz., high initial costs, high operating and maintenance costs, and quality of the products.

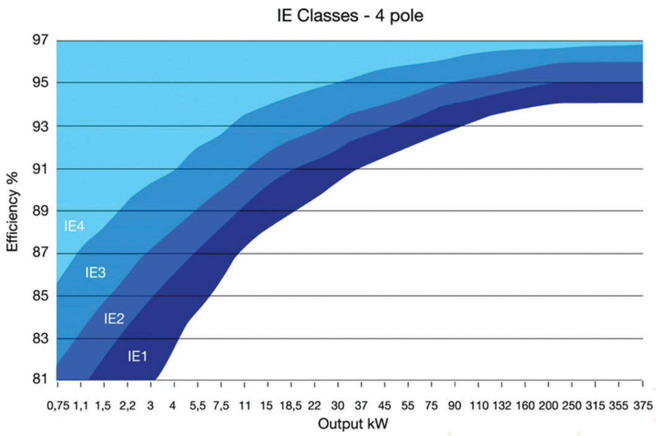

Figure 28: Efficiency Variation Graph for Various kW Ratings of EE Motors

In the initial phase, EESL has targeted the 3-phase LT induction motors in the capacity range of 1.1 kW to 22 kW, preferably directly-coupled with loads like pumps, fans, blowers, air compressors, etc.

After successful completion of first phase of NMRP and after getting input from industries, vendors and other stakeholders, EESL has released the second phase of NMRP with motors ranging from 0.75 kW to 75 kW.

Benefits

- Lower eddy current losses.
- Reduction in copper losses.
- Higher efficiency.
- Use of lower loss silicon steel.
- Longer core.
- Thicker wires & thinner laminations.

Limitations:

- High cost.
- No alternative use for old motor.

S. No.	Particular	UOM	Value
1	Total quantity of motors across rating	Nos.	3
2	Estimated energy savings	kWh/annum	4,907
3	Grid power cost	INR/kWh	6.00
4	Energy saving per annum	INR/annum	29,442
5	Capital cost of motor (Including cost of transportation)	INR	34,285
6	EESL PMC @ 10%	INR	3,428
7	Capital cost of motor (Including transportation and EESL PMC)	INR	37,713
8	GST @ 18%	INR	6,788
9	Estimated total project cost	INR	44,502
10	Annual Energy Savings	TOE	0.42
11	Annual reduction in CO_2 at 0.82 emission factor	MT	4

Expected Cost Benefits:

Annual Savings	Investment	Simple Payback Period
0.29 Lakh	0.44 Lakh	18 Months

Alternate Technology Supplier Details:

EESL

Mr Gopinath

Engineer, EESL

8095037607

Applicable Sectors:

Foundry, Pharma, Autocomponents, Food processing, Readymade Garments

Case Study 9: Installation of light pipe to harness daylight

Plant: Indian Railways Production Unit

Implementation Details: In the above mentioned production facility, during day time artificial lights were glowing to meet the lux level requirement.

Table 4: Artificial lighting details of the facility

Description	STL(40W)	T5(28W)	LUX
Generator office	2	2	124
Stores	12	1	106
Computer room	4	0	134
Inverter section	16	8	217
Pump section	16	8	124
Total	50	19	705

After discussion with the technology supplier, it was suggested to install 15 light pipes in the identified area and switch off the discharge lamps during the day time. This will help in maintaining good level of illumination during the day time without electrical energy.

Light pipes:

These are primarily used for illuminating deep interior spaces where windows do not have provision for illuminating indoor environment. Light pipe consists of mainly three parts (collector, transmission pipe, and diffuser).

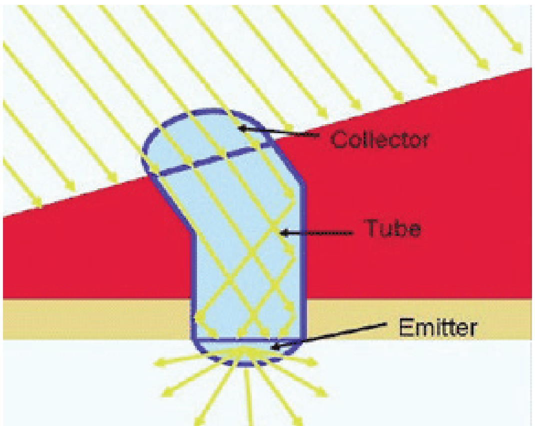

Figure 29: Light Pipe Components

- ❖ Collector comprises of a Dome which functions to collect sunlight from all angles and transmitting maximum possible sunlight into the tube. Generally, Polycarbonate or Acrylic materials are used for the Domes.
- ❖ Light is then refracted through the collector and transmitted into the tube. Reflective material such as anodized aluminum with silver coating are used on the inner surface of the tube.
- ❖ Diffuser plate is placed at the other end of the tube, which functions to evenly distribute light inside the room.

Both direct and diffuse radiation falling on receiving end of the pipe can be channelled, after multiple reflections off the inner walls, and used at the exit. The inner surface of the light pipes are made with a material having high spectral reflectivity for all angle of incidences and all wavelengths of considered spectrum width. Any variation in spectral reflectivity of pipe surface leads to change in spectral distribution of transmitted radiation. In the areas where roof mounting is not feasible due to practical considerations, wall mounting of light pipes can also be done.

Benefits

- Clean lighting with high CRI.
- Depreciation benefit can be claimed as this will come under solar category.
- Superior design allows maximum light and minimum heat energy from sunlight.

Limitations:

- For mass replacement, disposal of conventional lights is difficult.
- Initial installation involves major work on the roof.

Description	Value	Unit
No of light pipes to be installed	25	
Total lighting load	9.0	kW
Unit Cost	7.2	INR/kWh
Annual lighting energy saved	31,500	kWh
Annual Energy Savings	2.70	TOE
Annual reduction in CO_2 at 0.82 emission factor	25.83	MT

Figure 30: Light Pipe Installation

Expected Cost Benefits:

Annual Savings	Investment	Simple Payback Period
2.27 Lakh	5.00 Lakh	26 Months

Technology Supplier Details:

Eviewglobal
Plot Number SM 231, M.T. Sagar Industrial Area, Gokul Road, Hubli-580030
Phone : 9769421112
Email : rajiv@eviewglobal.com

Applicable Sectors:

Foundry, Autocomponents, Food processing.

6. Conclusion

Indore mixed cluster is keen to adopt various emerging technologies to reduce the overall energy consumption and increase their productivity. The main objective of all these units is to provide quality products to consumers and also remain competitive in the market.

This compendium highlights energy efficiency improvement opportunities in major process areas of all subsectors under the scope, and other areas like compressors, motors, cooling towers, pumps, renewable energy etc. The identified technologies can be categorized into three levels, namely, Type A, Type B and Type C, based on the investment, as follows:

Type A: Small Investment

- Replacing old in efficient lighting with energy efficient lighting system.
- Replacement of Existing Motors with Energy Efficient (IE3) Motors.
- Replacement of aluminium blades of cooling tower fan by FRP blade.
- Replacement of existing raw water pump with energy efficient pump.
- Automation in heat treatment process.
- Hydroxy Fuel Substitution in Industrial Furnaces.
- Reduction in furnace oil consumption by relining of melting furnace to reduce heat losses.
- Replacement of conventional cupola with divided blast cupola furnace.
- Improve power factor by Installing KVAR compensator and APFC.

Type B: Medium Investment

- Installation of solar rooftop PV system.
- Lid Mechanism for 750 kg Duraline Furnace.
- Replacement of all old reciprocating air compressors with new energy efficient screw air compressor.
- Voltage Optimization at Incomer.
- Installation of Solar-Wind Hybrid System.
- Fuel Switching from HSD to Natural Gas for Painting Oven, Boiler (Water Heater) & Pre-treatment tank.
- Installation of Light Pipe to Harness Daylight.

Type C: High Investment

- Replacement of SCR-based Induction furnace with IGBT Induction Furnace
- Replacement of existing FO-fired furnace with Induction Furnace

Table 5: Summary of Energy Conservation Measures

S.No.	Technologies	Ease of Implementation			Priority of Activity		
		Easy	Moderate	Difficult	Short	Medium	Long
1	Fuel Switching from HSD to Natural Gas for Painting Oven, Boiler (Water Heater) & Pre - treatment tank		✱			✱	
2	Lid Mechanism for 750 kg Duraline Furnace	✱			✱		
3	Replacement of existing FO fired furnace with Induction Furnace			✱	✱		
4	Automation in heat treatment process		✱				✱
5	Reduction in furnace oil consumption by relining of melting furnace to reduce heat losses	✱			✱		
6	Replacement of SCR-based Induction furnace with IGBT Induction Furnace			✱		✱	
7	Replacement of normal cupola with divided blast cupola furnace			✱			✱
8	Hydroxy Fuel Substitution in Industrial Furnaces		✱		✱		
9	Replacement of existing raw water pump with energy efficient pump	✱			✱		
10	Replacement of all old reciprocating air compressors with new energy efficient screw air compressor		✱			✱	
11	Voltage Optimization at Incomer	✱				✱	
12	Installation of solar rooftop PV system			✱			✱
13	Installation of Solar-Wind Hybrid System		✱				✱
14	Improve power factor by Installing KVAR compensator and APFC	✱				✱	
15	Replacement of aluminium blades of cooling tower fan by frp blade	✱			✱		

S.No.	Technologies	Ease of Implementation	Priority of Activity
16	Replacement of Existing Motors with Energy Efficient (IE3) Motors	✱	✱
17	Installation of Light Pipe to Harness Daylight	✱	✱

The energy efficiency & renewable energy projects detailed in the case studies in this compendium indicate that there is a good potential for benefits in both low hanging and medium-to-high investment options. Units can implement the low hanging fruits (with smaller investments) faster, as with minimum or no investments, several savings can be achieved. However, for the high investment projects, a detailed review in the form of DPR can be prepared.

The Indore Mixed Cluster should view this manual positively and utilize the opportunity to implement best operating practices and energy saving ideas during design and operation stages. Through this compendium, some of the emerging & key technologies that are highly replicable in the cluster have been identified. We are sure this will support the industries in Indore Mixed cluster to implement the Renewable Energy & Energy Efficiency projects, and support their journey towards achieving world class standards.

Table 6: Technology supplier details

Sl No	Name	Address	Contact details
Technology : Induction Furnace			
1	Inductotherm (India) Pvt. Ltd.	Subha Sri Sampada Complex, Raj Bhavan Road, Somajiguda, Somajiguda, Hyderabad, Telangana 500082	Mr Sachin Patel Sr Sales Engineer (Melting Sales) 9372852323 spatil@inductothermindia.com
2	Electrotherm	31, Dr. AS Rao Nagar Rd, Lakshmipuram Colony, Rukminipuri Colony, Kapra, Secunderabad, Telangana 500062	Mr Ravindra Nikhade Manager (Sales & Marketing) 9665021921 ravi.nikhade@electrotherm.com enp.pune@electrotherm.com
3	Plasma Induction	330/1p,Hajipur,Nr JKLaxmi Cement,Ta. Kalol,Dist. Gandhinagar,Via Ahmedabad Vadsar Road,382721	Mr Saikat Das Sales & Services Engg. 9327955314 kolkata@plasmainduction.co.in
4	Indo Power	56a/4 phase, I,Road no B, Phase I, Vatva, Ahmedabad, Gujarat 382445	Mr Manoj Kumar Director 9824412949 info@indopower.in indopowerenggs@gmail.com
5	EMT Megatherm Pvt. Ltd.	1no, Taratala Rd, Taratala, Kolkata, West Bengal 700088	Mr S F Rodrigues Manager 9163700116 s.f.rodrigues@megatherm.com

Sl No	Name	Address	Contact details
6	ABP Induction Systems Pvt. Ltd.	E-120, Unit-II, GIDC Manjusar Industrial Area ,Opp. Du Pont factory, Savli, Gujarat 391775	Mr Gautam Mehta Manager Sales 9723815153 gautam.mehta@abpinduction.com
7	Oritech Solutions	Plot No. 4 & 4P, Swastik Industrial Estate,Bavla Highway, Sari Ta. Sanand, opp. Aarvee Denim, Changodar, Gujarat 382220	Mr Jatin Kuhad Sr Engineer (Customer Support) 8320897410 info@oritech.in
8	The Wesman Engineering Company & Pvt. Ltd.	8, Mayfair Rd, Park Circus, Ballygunge, Kolkata, West Bengal 700019	Mr G Nagaraju Management Executive (Sales and Service) 8184833533 g.nagaraju@wesman.com
9	Abhay Induction Tech Pvt. Ltd.	plot no. 12/C , New Ahmedabad Estate, opp. Big Basket, Moraiya, 382213	Mr Manoj N Bhandari V.P (Sales & Projects) 7228957233 info@aitpl@gmail.com
10	Pioneer Furnaces Pvt. Ltd.	Plot No. 146-148, G.I.D.C., Anand, Vitthal Udyognagar, Gujarat 388121	Mr M K Raijada GM (Sales & Mktg) 9869026899 mkr@pioneerfurnaces.com
Technology : Divided Blast Cupola			
1	Kelsons Group	Plot No. G-35, MIDC, Shiroli, Maharashtra 416122	Mr K Ravikumar CMD 9822112162 rbkkelsons@gmail.com
2	Vijay Engineers & Fabricators	C-3 & C-4/1/2, MIDC, Shiroli, Beside Police Station, Kolhapur-416122, Maharashtra, India.	9850485504 78880 34203 response@vijayfoundryequipment.com
3	Vitthal Enterprise	No. 36-37, Gajanand Estate, Nagarwel Hanuman Road, Rakhial, Ahmedabad - 380023, Gujarat	Mr. Vasant Panchal 9825285536 info@vitthalenterprise.com
Technology : Crucibles Refractories Insulations			
1	Grindwell Norton Limited (Ceramics)	Place No 20, Sindhi Colony, S P Road, Sindhi Colony, Secunderabad, Telangana 500003	Mr Suni Kumar Jain Head - Application Engineering 9811309092 sunil.jain@saint-gobain.com
2	Shreyas Hi-Tek Associates	103, Venkatadri Nivas, New Income Tax Layout, II Block,, 3rd street, Near Nagarbhavi Circle, Nagarbhavi,, Bengaluru, Karnataka 560072	Mr E Prabhakaran Chief Executive 9487133710 shreyashitek.chennai@gmail.com
3	Zircar Refractories Ltd.	402, 4th Floor, Campus Corner Nr. St. Xavier's College, Vijay Cross Rd, Navrangpura, Ahmedabad, Gujarat 380009	Mr Indrasen Reddy Sr. Sales Engineer 7574887686 hyderabad@zircarrefractories.com

Sl No	Name	Address	Contact details
4	Ruby Mica Company Limited	Barganda Rd, Argaghat, Giridih, Jharkhand 815301	Mr Ankit Bagaria Director 9431144955 ankitbagaria@gmail.com
5	Raghuvanshi Refractories	Shree Chambers,3rd Floor Opp.M.E.M School, Porbandar-360575	Mr Dhaval Raichura Executive Partner 9825231055 dhaval@raghuvanshirefractories.com
6	Eirich India Pvt. Ltd.	119 ABC, Government Industrial Estate, Charkop Rd, Charkop Industrial Estate, Kandivali West, Mumbai, Maharashtra 400067	Mr Kantharaju B R Sales Manager - Foundry 8433908818 kantharaju.br@eirich.in
7	Calderys India Refractories Ltd.	Door No. 376 A, Old No 201, Lloyds Road Gopalapuram 600086 Tamil Nadu, Chennai	Mr Sujit Kar General Manager (Foundry - India) 9836190098 sujit.kar@calderys.com
8	CarprefIndia Private Limited	Plot # 3&4, S.S. Nagar Extension, Anna Main Road, Thirumullaivoyal Chennai Chennai TN 600062 IN	Mr S Naresh Kumar National Sales Manager 9600088486 naresh.kumar@capital-refractories.com
Technology : Moulding Machines			
1	Kelsons Group	Plot No. G-35, MIDC, Shiroli, Maharashtra 416122	Mr K Ravikumar Mr K Ravikumar 9822112162 rbkkelsons@gmail.com
Technology : Energy Efficienct Sand Plants			
1	Rhino Machines Pvt. Ltd.	Plot No 1A & 1B, GIDC Phase II, GJ SH 83, Vithal Udyognagar, Anand, Gujarat 388325	Mr Manish Kothari Managing Director 9227124977 rhino.mk@gmail.com
2	Castomech Technology (a Group of Plasma Induction Company)	Hajipur, Kalol, Gandhinagar, Gujarat	Mr Anand Goswami 9662023323 7778025435 sales@castomech.com
3	The Wesman Engineering Company & Pvt. Ltd.	8, Mayfair Rd, Park Circus, Ballygunge, Kolkata, West Bengal 700019	Mr G Nagaraju Management Executive (Sales and Service) 8184833533 g.nagaraju@wesman.com
4	Kelsons Group	Plot No E - 22, 23 & 26, MIDC, Village : Shiroli, Kolapur-416 122	Mr K Ravikumar Mr K Ravikumar 9822112162 rbkkelsons@gmail.com
Technology : Automation Process Control Sensors (Temperature / Carbon / Silicon Analysis)			

Sl No	Name	Address	Contact details
1	ACI Automation Pvt. Ltd.	Door No. 9, Plot No. 71, CBI Colony Main Road, OMR, Kandanchavadi, Chennai, Tamil Nadu 600096	Mr P Senthilkumar Executive Director 9790969430 senthil.kumar@aciautomation.com info@aciautomation.com
2	Ajay Syscon Pvt, Ltd.	8/20, Erandawane, Off, Karve Nagar Rd, Pune, Maharashtra 411004	Mr Pravin Shirke Asst. Manager - Marketing, Sales & Service 9970499922 pravin.shirke@ajaysyscon.com
3	New Star Infotech (a Group of Plasma Induction Company)	Hajipur,Nr JKLaxmi Cement,Ta. Kalol,Dist. Gandhinagar,Via Ahmedabad Vadsar Road,382721.	Mr Ravi Kundariya 8140400109 ravi@newstarinfotech.com info@newstarinfotech.com
	Technology : Shot Blasting Machine & Steel shots		
1	Patel Furnace & Forging Pvt. Ltd.	Plot No. A/2-510, Makarpura, GIDC, Vadodara, Gujarat 390010	Mr Nilesh Vaja Manager - Sales 9737061333 sales@pshotblast.com info@pshotblast.com
2	Narmada Technocast	B/14,Shri ram estate, Nr. Anup Eng, Soni ni chawl char rasta, Odhav , Ahmedabad-382415.	Mr Krupang Dudani 9979066447 narmadaindo8@gmail.com
	Technology : Compressors		
1	Atlas Copco	No. 8B, 8th Floor, 1-10-39 to 44, Gumidelli Towers, Begumpet Main Road, Hyderabad, Telangana 500016	Mr Latesh Manager - Marketing 9346280052 latesh.k@in.atlascopco.com
2	Vertex Pneumatics Pvt. Ltd. (Dealers of Atlas Copco)	3,16th cross, lakkasandra, Gopalappa Layout, Opp. Chowdeshwari temple, Bengaluru, Karnataka 560030	Mr B S Shrikanth Swamy Sales Engineer 9686656101 sales@vertexpneumatics.com service@vertexpneumatics.com
3	Prakash Sales Agencies (Authorised Dealers of ELGI)	39, Corporation Complex, Goaves, Belgaum, Karnataka 590011	Mr Amit Sathaye 9449053626 psa_bgm@dataone.in psabgm@gmail.com
4	Beko Compressed Air Technologies Pvt Ltd	Plot No.43, CIEEP, Gandhi Nagar, Balanagar, Hyderabad, Telangana 500037	Mr Madhusudan Masur Executive Director 040-23081106 Madhusudan.Masur@bekoindia.com
	Technology : Compressed Air Solutions (1. FLOW SENSOR , 2. DEWPOINT SENSOR , 3. LEAK DETECTOR, 4. SMART MONITORING SOFTWARE)		
1	Systel Energy Solutions (INDIA) Pvt. Ltd.	12, Venkata Lakshmi Nagar, Chellandy Amman Nagar, Singanallur, Tamil Nadu 641005	Ms. Sasi Kala Sales Coordinator 90477 78715 support@systel.asia

Sl No	Name	Address	Contact details
2	Beko Compressed Air Technologies Pvt Ltd	Plot No.43, CIEEP, Gandhi Nagar, Balanagar, Hyderabad, Telangana 500037	Mr Madhusudan Masur Executive Director 040-23081106 Madhusudan.Masur@bekoindia.com
Technology : Aluminium Piping for compressed air			
1	Godrej & Boyce Mfg Co. Ltd.		Mr Kiron Pande Asst VP kcp@godrej.com
2	Pneumsys Advance Energy Solutions	1-143, Street No 6, Srinivasa Colony, Boduppal, Hyderabad, Telangana 500092	Mr Girish K Project Sales Manager (South) tsmsouth@pneumsysenergy.com
3	Legris Parker	Victoria Ranigunj, Bolaram Nagar, Rani Gunj, Secunderabad, Telangana 500003	Mr Joy Dewan National Manager Transair joy.dewan@parker.com
Technology : VFD			
1	Apex Industries (Dealers of 'CG Power' drives)		Mr Deelip Mulay Chief Executive 9850060698 8855003009 apexindustries92@gmail.com dilipmulay@gmail.com
2	Siemens Ltd	Siemens Limited Birla Aurora, Level 21, Plot No. 1080, Dr. Annie Besant Road, Worli, Mumbai – 400030 India	Mr Prathish T M Manager (Drives & Automation) 7259400100 prathish.t_m@siemens.com
Technology : Blowers			
1	Techflow Enterprises Pvt. Ltd.	Plot 803/B, Near Canal, Kubadthal Village, Via Kunjad-Kathlal Highway, Ahmedabad, Gujarat 382430	Mr Rashmin Patel Manager - Sales 8238044155 rashmin.patel@techflow.net
Technology : PID Loop Optimisation			
1	AKXA Tech	Plot# 122 1&2 Shinoli (BK), Taluk: Chandgad, Kolhapur, 416508	Mr Raghuraj Rao 9243209569 9731043921 raghuraj.rao@akxatech.com
Technology : Energy Efficient Pumps			
1	Grundfos	Grundfos Pumps India Pvt 823/4, first floor, Chaitra complex, 13th Cross, Near JSS Circle, Jayanagar 7th block west, Bangalore- 560 070.	Mr Mehul Rana Manager Sales 9725045271 mehul@Grundfos.com

Sl No	Name	Address	Contact details
2	Shakti Pumps	Shakti Pumps (India) Limited, Plot No. 401, 402, & 413, Industrial Area Sector - 3, Pithampur, Dist. Dhar - 454774 (M.P.) India	Mr Tarun Songaria Deputy Manager - Industrial Sales 7389911004 tarun.songaria@shaktipumps.in
		Technology : Cooling Tower	
1	Flow Tech Air Pvt Ltd	B-105, Mehrauli - Badarpur Rd, Block B, Vishwakarma Colony, Pul Pehlad Pur, New Delhi, Haryana 110044	Mr Ritwick Das Vice President - Sales & Marketing 7838978768 ritwickdas@flowtechair.com
		Technology : FRP Blades	
1	Encon Group	2 / 3, Ashirwad, N. C. Kelkar Road, Dadar West, Mumbai-400028, Maharashtra, India	Mr Rai Manager - Marketing 9324294400 akrai@encongroup.in
		Technology : Energy Efficienct Motors	
1	Siemens Limited	Siemens Limited Birla Aurora, Level 21, Plot No. 1080, Dr. Annie Besant Road, Worli, Mumbai – 400030 India	Mr Siddu Mareguddi Territory Manager 8105592066 siddu.mareguddi@siemens.com
2	Energy Efficiency Services Limited	Energy Efficiency Services Limited NFL Building, 5th & 6th Floor, Core – III, SCOPE Complex, Lodhi Road, New Delhi – 110003	Mr Gopinath B V Engineer (Tech) 9482376407 gopinath@eesl.co.in
		Technology : PF Improvement	
1	P2Power	A-95, Block A, Sector 80, Noida, Uttar Pradesh 201305	Mr Shwetank Jain Founder 9910911774 shwetank.jain@p2power.com
		Technology : KVAR Compensator	
1	Athena Cleantech		Mr Sanjeev Reddy Regional Sales Head South 9440259863 sanjeev@cleantech.com.sg
		Technology : Biomass Gasifier	
1	Phoenix	Phoenix products D- 87, Industrial Estate, Near KPTCL Sub Station Udyambag, Belgaum - 590 008 Karnataka - INDIA. Ph. No. 0831-2440700	Mr Sameer Kanabargi 9448480724 phoenix_bgm@hotmail.com
		Technology : Solar PV	

Sl No	Name	Address	Contact details
1	Orb Energy:	95, Digital Park Rd, 2nd Stage, Yeswanthpur, Bengaluru, Karnataka 560022	Mr Prabhakar A Manager - Projects (PV) 9480153394 a.prabhakar@orbenergy.com
2	Thermax Ltd		Mr Akshay Sonkusare Sales Engineer 9711120055 Akshay.Sonkusare@thermaxglobal.com
3	Sunshot Technologies	A-302, GO Square, Wakad Rd, Kaspate Wasti, Wakad, Pimpri-Chinchwad, Maharashtra 411057	Mr Niraj Jain Marketing Head 7021153736 niraj.jain@sunshot.in
4	Sunedison Infrastructure Limited	11th floor, Bascon Futura SV IT Park, Venkatnarayana Road, T.Nagar, Chennai-600017.	Mr Vikram Dileepan Director aseen.p@sunedisoninfra.com
5	Fourth Partner Energy	Fourth Partner House, Plot No. N46, House No. 4-9-10,, HMT Nagar, Nacharam, Hyderabad, Telangana 500076	Mr Devaraj South Head – BD 8870014206 suseendhar@fourthpartner.co
		Technology: Light Pipe	
1	E-View Global	Mumbai	Mr Rajiv Gupta Director 9769421112 rajiv@eviewglobal.com
		Technology: Hydroxy Fuel Generator	
1	Kankyo Group of Companies	Chennai	Mr Devanand Chairman & Maniging Director 9962500069 dev@kankyo.global
		Technology : Wind - Solar Hybrid	
1	EnergyHive	Energyhive Renewables LLP 5/82, Blue Beach Road, Neelankarai, Chennai 600041 Tamilnadu, India	Mr Venugopal Director 9884370945 venu@energyhive.in
2	Windstream Technologies	SSH Pride, Plot 273, G2, Rd Number 78, Prashasan Nagar, Jubilee Hills, Hyderabad, Telangana 500096	Mr Venu Gopal Timmaraju Senior VP - Manufacturing 7036297093 vtimmaraju@windstream-inc.com

For more details, please contact

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