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INDUSTRIAL DEVELOPMENT ORGANIZATION

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

Belgaum Foundry 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 Belgaum, Karnataka, 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 Belgaum Foundry 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

3D	Three Dimension
AC	Air Conditioner
BEE	Bureau of Energy Efficiency
BEMCIEL	Belgaum Manufacturers Cooperative Industrial Estate Limited
BFC	Belgaum Foundry Cluster
BIS	Bureau of Indian Standards
BLDC	Brushless Direct Current
CAGR	Compound Annual Growth Rate
CD	Compact Disc
CI	Cast Iron
CII	Confederation of Indian Industry
CMM	Coordinate Measuring Machine
CO_2	Carbon Dioxide
CUF	Capacity Utilization Factor
DBC	Divided Blast Cupola
DG	Diesel Generator
DISCOM	Distribution Company
ERP	Enterprise Resource Planning
FRP	Fibre Reinforced Plastic
GEF	Global Environment Facility
GHG	Green House Gas
GI	Galvanized Iron
HESCOM	Hubli Electricity Supply Company Limited
HSD	High Speed Diesel
HVLS	High Volume Low Speed
Hz	Hertz
IE	International Efficiency
IIF	Institute of Indian Foundrymen
LDO	Light Diesel Oil
LED	Light Emitting Diode

LT	Low Tension
MNRE	Ministry of New and Renewable Energy
MSME	Micro, Small & Medium Enterprises
O&M	Operation and Maintenance
OES	Optical Emission Spectrometer
PF	Power Factor
PID	Proportional-Integral-Derivative
PV	Photovoltaics
R&D	Research and Development
RCC	Reinforced Cement Concrete
SEC	Specific Energy Consumption
SEGR	Specific Energy Generation Ratio
SG Iron	Spheroidal Graphite Iron
UNIDO	United Nations Industrial Development Organisation
VFD	Variable Frequency Drive
VMC	Vertical Machining Centre

Unit of Measurement

cfm	Cubic Feet Minute
°C	Degree Celsius
gm	Grams
GJ	Giga Joules
HP	Horse Power
kg	Kilogram
kg/cm^2	Kilogram Per Square Centimetre
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	Kilo Watt Peak
MT	Metric Tonne
ppm	Parts per million
psi	Pounds Per Square Inch
INR	Indian Rupees
TCO_2	Tonnes of Carbon dioxide
THD	Total Harmonic Distortion
TOE	Tonnes of Oil Equivalent
TPD	Tonnes Per Day
TPH	Tonnes Per Hour

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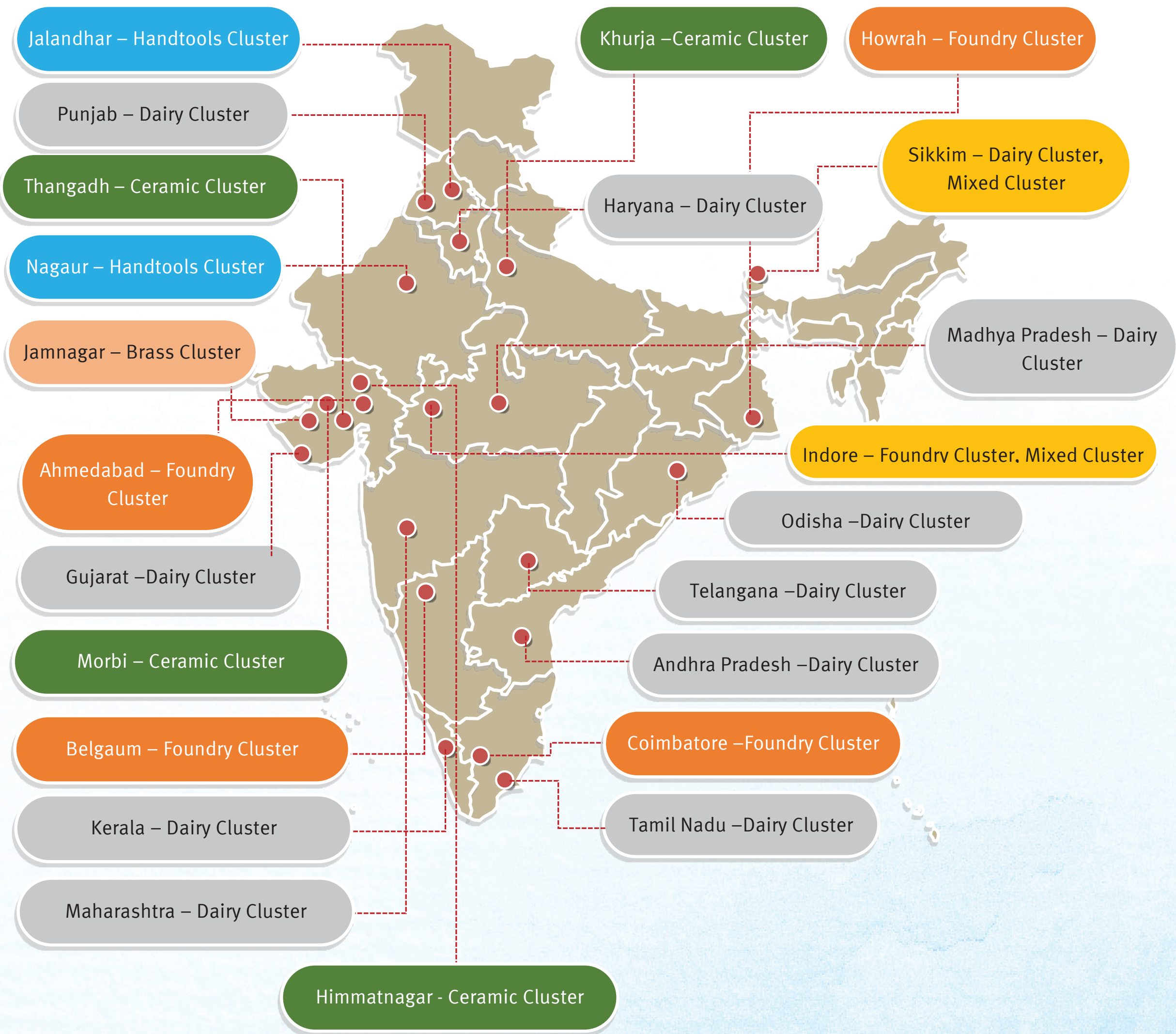
About Project & Technology Compendium

About the Project

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 CO2 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

The foundry industry is the one of the fast-growing industrial sectors in India, and one of the important industries having a bearing on the socio-economic development of the country. There are more than 5,000 foundry units in India, having an installed capacity of approximately 7.5 million tonnes per annum. The majority (nearly 95%) of the foundry units in India fall under the category of small-scale industry. The foundry industry is an important employment provider, with direct employment to about half a million people.

The Indian foundry industry is facing some developmental challenges to increase global competitiveness on the following fronts: capital expenditure, energy cost, availability of raw material, green technologies, and quality improvement. Over the years, there has been significant technology improvement in process and utilities areas, and foundries have been able to improve the energy efficiency in their operations. However, the foundry sector can still be more competitive and environment-friendly in their operations, and energy efficiency is critical to achieve these goals.

This technology compendium is prepared with the objective of accelerating the adoption of energy efficient technologies and practices in the foundry industry. It focuses on foundry equipment upgrades, new technologies, and best practices for improving energy efficiency. The technologies and case studies that have been included in the compendium provide necessary information to enable the foundry sector to refer and implement them in their operations. The case studies are supported with technology background, baseline scenario, merits and challenges, technical and financial feasibility along with the details of technology providers. This compendium is expected to assist the foundry industry in improving their energy efficiency and competitiveness.

- The objective of the compendium is to act as a catalyst to facilitate foundries towards continuously improving their energy performance, thereby achieving world class levels (with a thrust on energy & environment management).
- The compendium includes general energy efficiency options as well as specific case studies on applicable technology upgradation projects, 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 to the foundry sector for energy efficiency, it will be difficult to include all the energy conservation aspects in this manual. However, an attempt has been made to include a high number of common implementable technologies across all the foundry units.
- The user of the compendium has to fine-tune the energy efficiency measures suggested in the compendium to their specific plant requirements, in order to achieve maximum benefits.
- The technologies collated in the compendium may not be necessarily the ultimate solution as energy efficiency through technology upgradation is a continuous process and will eventually move towards better efficiency with advancement in technology.

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 Belgaum Foundry 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 foundry 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 projects at the first place, and ensure accelerated implementation.

Chapter 1 of the compendium provides an overview of Indian Foundry Industry and Belgaum Foundry Cluster.

Chapter 2 focuses on a brief overview of foundry process and also includes technology status / mapping of the foundry cluster.

Chapter 3 focuses on the importance of energy efficiency in foundry industry, and some of the common measures applicable in different sections of the foundry unit. The energy efficiency measures are included for more than 90% of energy consumption areas in a foundry plant, such as the melting and molten metal handling systems, sand moulding systems, utilities and utilization of renewable energy. The chapter also includes some of the best practices and key indicators that the plant should follow and monitor to maintain the energy efficiency levels in different energy consuming areas.

Chapter 4 provides detailed case studies for some of the high impact and implementable energy efficient technologies in foundry units. In this chapter, 21 case studies have been included in areas such as furnaces, molten metal handling systems including ladle, sand moulding systems, utilities, renewable energy, etc. These technologies are described in detail, such as baseline scenario, proposed scenario, merits, demerits, etc., and wherever possible, a case reference from a foundry unit that has implemented the technology has been included. In most of the examples, typical energy saving data, GHG emission reduction, investments, payback period, etc., have been highlighted.

The Belgaum Foundry 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.

Table 1: Summary of energy conservation measures

S. No.	Technologies	Ease of Implementation			Priority of Activity (based on payback)		
		Easy	Moderate	Difficult	Short	Medium	Long
1	Installation of LID Mechanism for Induction Furnace	▲				▲	
2	Automation of heat treatment process		▲			▲	
3	Replacement of SCR based Induction furnace with IGBT Induction Furnace		▲				▲
4	Replacement of cupola furnace with EE Induction Furnace			▲			▲
5	Replacement of normal cupola furnace with divided blast furnace			▲		▲	
6	Replacement of existing raw water pump with energy efficient pump		▲			▲	
7	Replacement of Existing motors with energy efficient (IE3) motors		▲				▲
8	Replacement of all old reciprocating air compressors with new energy efficient screw air compressor		▲			▲	
9	Optimization of Air compressor VFD performance through PID loop optimization		▲		▲		
10	Replace LDO firing circuit by biomass gasifier based producer gas firing circuit		▲			▲	
11	Improve power factor by Installing KVAR compensator		▲			▲	
12	Installation of VFD for compressor			▲		▲	

S. No.	Technologies	Ease of Implementation			Priority of Activity (based on payback)		
13	Replacement of conventional sand plant with energy efficient sand plant			▲			▲
14	Installation of FRP blades for cooling tower fans	▲			▲		
15	Installation of Energy Management System		▲				▲
16	Installation of electric grinders in place of pneumatic grinders to save energy in a foundry unit	▲			▲		
17	Energy conservation by modifying compressed air line system in a foundry		▲				▲
18	Installing timer for sand plant process in a foundry	▲			▲		
19	Reduce energy consumption by modifying the lining of ladle in a foundry.		▲			▲	
20	Installation of Rooftop Solar PV System			▲			▲
21	Installation of Solar-Wind Hybrid System			▲			▲

Indian Foundry Industry

1. Indian Foundry Industry

1.1. Background

India is the third largest producer of castings in the world. Casting production in India reached a value of 11 Million tonnes in 2018, and is expected to expand at a compound annual growth rate (CAGR) of around 12.7% until 2023. Grey Iron (GI) castings hold the biggest share, with approx. 68%[1] of the total castings produced. As of 2018, aluminium castings contributed to around 15% of the total castings production in the country. The following graph highlights the growth in production of GI and SG Iron castings in the past decade.

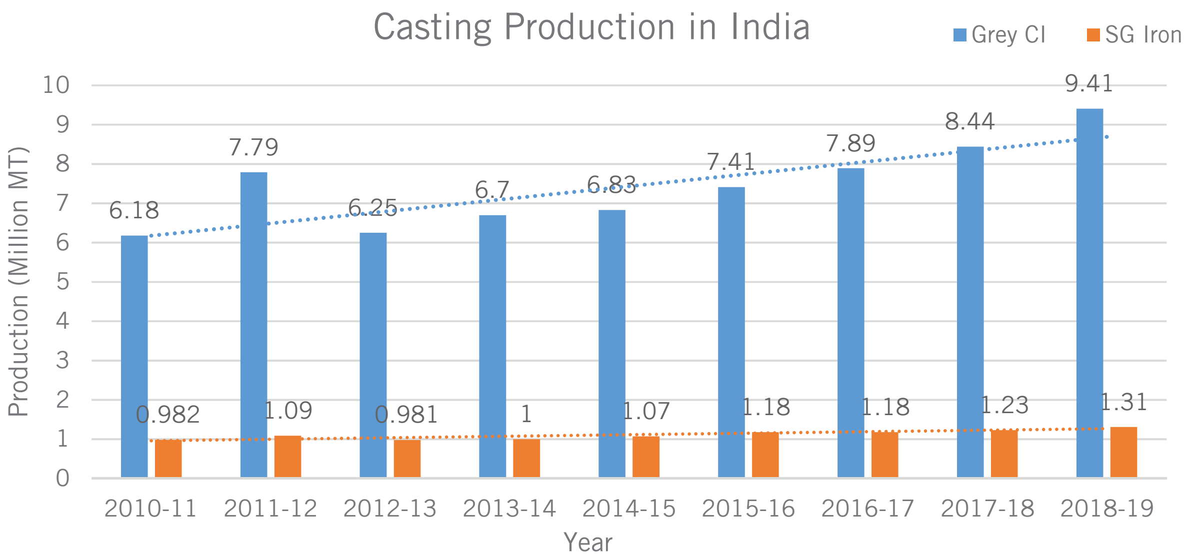


Figure 1: Growth in casting production in India

Figure 2: Foundry clusters in India

[1] *http://www.foundryinfo-india.org/profile_of_indian.aspx*

The Indian Foundry sector has a turnover of around USD 19[2] billion, with exports amounting to around USD 3.06 billion. The Indian Foundry sector manufactures metal cast components for applications in a wide range of industrial segments, including Auto, Tractor, Railways, Machine Tools, Sanitary, Pipe Fittings, Defence, Aerospace, Earth Moving, Textile, Cement, Electrical, Power machinery, Pumps, Valves, Wind Turbine Generators, etc.

The major foundry clusters in India are located in Agra, Ahmedabad, Batala, Belgaum, Coimbatore, Chennai, Faridabad, Gurgaon, Howrah, Hyderabad, Indore, Jalandhar, Kolhapur, Kolkata, Ludhiana, Mumbai, Pune, Rajkot, Solapur, etc. Each of these foundry clusters is known for catering to some specific end-use markets. For example, the Kolhapur and the Belgaum clusters are known for automotive castings, the Coimbatore cluster is famous for pump-sets castings, the Rajkot cluster is known for diesel engine castings, the Howrah (Kolkata) cluster for sanitary castings, and so on.

The automobile sector is the most major consumer of castings produced in India. A graph of sector-wise major consumers of castings is given below.

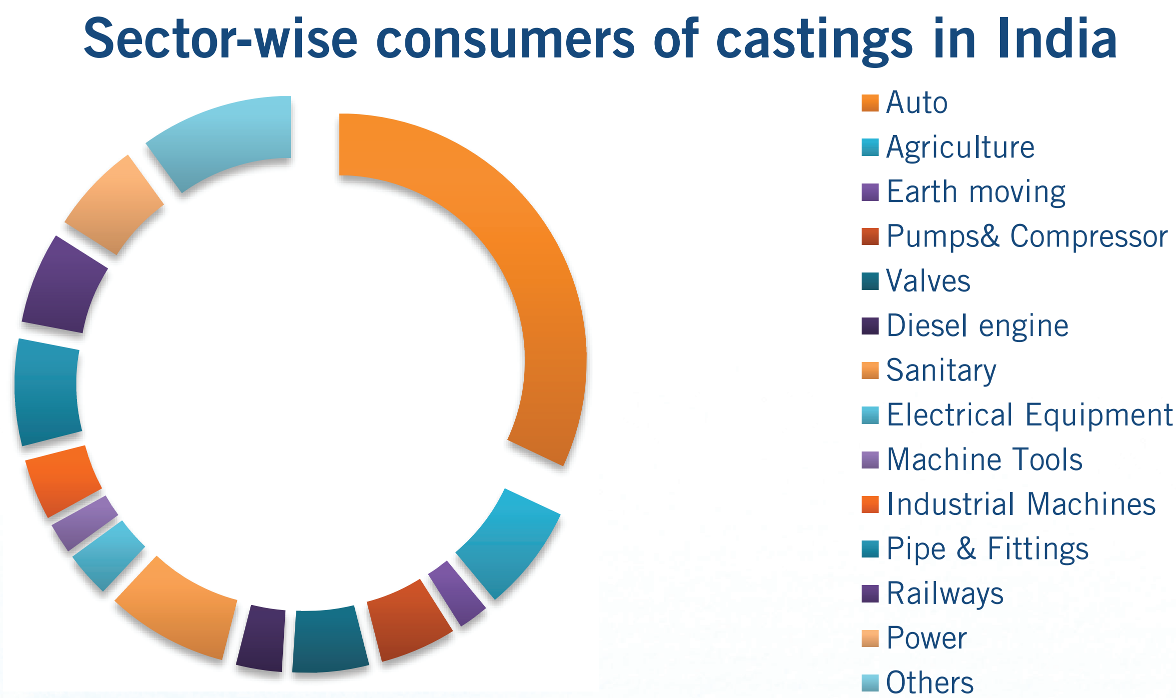


Figure 3: Sector-wise consumers for castings in India

[2] *http://www.foundryinfo-india.org/profile_of_indian.aspx*

1.2. Foundry Sector Growth Prospects

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.

1.3. Foundry Cluster in Belgaum

Belgaum (also known as Belagavi) is one of the old, strong, prominent and cultured historical places nestled high in the Western Ghats in Karnataka. It has an enviable heritage and lies in the zone of cultural transition between Karnataka, Maharashtra, and Goa. Belgaum is also known as the foundry hub of north Karnataka.

Belgaum is a pioneer in the development of foundry industrial sector in Karnataka, manufacturing iron & steel castings catering to the needs of General Engineering, Machine Tools, Automobiles, Tractor Components, Pumps, and Motor Body Castings. The foundry industry in Belgaum has its origins dating back to the 1940s, when the first cupola was set up for manufacturing agricultural implements for local farming community. The industry grew rapidly between 1950 and 1960 with a surge in demand for castings for machine tools, diesel oil engines, electric motors and pump sets. The growth of automobile industry in and around Pune and the setting up of public sector plants such as BHEL and HMT in Bengaluru gave further boost to the demand for castings from the Belgaum cluster.

Belgaum has the presence of more than 150 foundries. Ashok Iron Works is the only large foundry in the cluster and the other units belong to the category of Micro, Small & Medium Enterprises (MSMEs). Foundries in Belgaum cluster are located in five major industrial areas/ estates as follows.

Table 2: Industrial area in Belgaum

S. No.	Industrial Area / Estate
1	Udyambag Industrial Estate
2	Belgaum Manufacturers Cooperative Industrial Estate Limited (BEMCIEL)
3	Macche Industrial Estate
4	Honaga Industrial Estate
5	Navage Area

The total output from the foundry cluster in Belgaum is more than 1.6 lakh tonnes of casting per annum, valued at about INR 700 crores. Exports from the cluster are worth INR 350 crores. The foundry industry in Belgaum provides employment to about 12,000 people.

A majority of the foundries in the cluster produce cast iron (CI) castings, although the share of SG (spheroidal graphite) iron has been rising steadily in the recent years. Automobile components account for the major share of castings produced in the cluster. Apart from this, the foundries also produce castings which are used in pumps and valves, gears, machine tools, elevators, food processing, and other industrial applications.

Some of the salient features of the foundry cluster in Belgaum are as follows:

1. It ranks first in terms of casting production in Karnataka.

2. It ranks among the top 10 largest producers of castings in India.
3. It is the only foundry cluster in the country with a facility to reclaim sand to the tune of 10,000 tonnes per month.

In Belgaum, two industry associations, namely Belgaum Foundry Cluster (BFC) and Institute of Indian Foundryman (IIF), Belgaum Chapter, are working together for providing environment-friendly and world class infrastructure facilities to the foundry units in and around Belgaum, with the overall objective of making these units excellent in performance as well as internationally competitive. BFC and IIF are also providing services in enhancing foundry operations, improving energy efficiency and resource management, as well as market facilitation for foundry products.

1.3.1. Belgaum Foundry Cluster (BFC)

Belgaum Foundry Cluster (BFC) was formed in 2004 with the objective of supporting foundries in Belgaum and nearby areas to enhance their competitiveness, and also for achieving excellence through world class common infrastructure.

As a result of continuous efforts, BFC has set up the following facilities for the benefit of foundries:

1. Optical Emission Spectrometer (OES) for analysing chemical components in metal casting.
2. 3D Coordinate Measuring Machine (CMM) for inspection of casting with high accuracy measuring system.
3. Vertical Machining Centre (VMC) for making patterns, dies and other machining work.
4. Casting simulation, 3D modelling and Enterprise Resource Planning (ERP) software for foundries.
5. Sand reclamation plants for reclaiming thermal sand (2 TPH @ 95% reclamation), green sand (10 TPH @ 85% reclamation), CO_2 / silicate sand (3 TPH @ 80% reclamation) and no-bake sand (3 TPH @ 85% reclamation).

1.3.2. Institute of Indian Foundrymen (IIF)

The Institute of Indian Foundrymen (IIF) was set up in 1950 to promote education, research, training and development among Indian foundrymen 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, Mumbai and Chennai.

The activities of IIF are wide ranging and include the following:

- To serve as a point of reference to the Government of India for the Foundry sector.
- To publish the monthly 'Indian Foundry Journal', which contains monographs on various aspects of foundry industry.
- To participate in the preparation of standards for foundry materials, products and test methods by the Bureau of Indian Standards (BIS).
- To promote export of foundry products and related services.
- To provide technical services to member companies.
- To coordinate Research and Development (R&D) work on foundry related subjects.
- To conduct technical meetings, seminars and workshops through Regional Branches and Chapters.

The IIF Belgaum Chapter actively promotes technical information exchange and networking among the foundry industries in the cluster. It works closely with BFC and is located within the premises of BFC.

1.3.3. Opportunities and Challenges in Belgaum Foundry Cluster

Opportunities:

1. Good scope for export of castings to the European countries.
2. Good potential to market in other segments of domestic market.
3. Market can be increased under common brand name and publicity through various means like common brochures, catalogues, CDs, and websites.
4. The new environmental policies of the Government of India need cleaner technology or eco-friendly process; energy savings will have impact on the cost of castings.
5. Major foundries can go for small size sand reclamation plant.
6. Setting up of common raw material depot will enable the foundry units to get raw material at reasonable price.

Challenges:

1. China could be a strong competitor; it is making rapid technological advancements and is competitive in terms of quality, prices, and delivery schedules.
2. Shortage of skilled man power.
3. Slowdown in global economy.
4. Non-availability of good quality scrap.

Foundry Process

2. Foundry Process

2.1. Process Flow Overview in Foundry

The major steps in the production process of castings include mould sand preparation, charge preparation, melting, pouring, knockout and finishing. The steps are briefed below.

i. **Mould sand preparation:** Fresh sand is mixed with bentonite and other additives and mixed in muller to make green sand.

ii. **Moulding:** The mould sand is pressed by machines or manually on the pattern to prepare the mould. The upper and lower halves of mould are assembled together to prepare the complete mould.

iii. **Charging:** Charging is the process of weighing and adding the raw material to furnace for melting. Raw material includes pig iron, scrap, foundry returns and other alloys.

iv. **Melting:** The metal charge is melted either in a cupola or induction furnace. The typical temperature requirement is around 1,500°C for CI casting, 1,650°C for steel casting, and 750°C for aluminium casting.

v. **Pouring:** Once the melting is completed, the molten metal is poured into the sand moulds that were prepared in the first stage, using a ladle operated either manually or automatically with the help of cranes. The poured material is then allowed to cool down and harden.

vi. **Knock-out:** After the moulds are left for cooling for the required time, the castings are knocked out from the mould either manually or using a machine.

vii. **Finishing:** The finishing operation involves removal of runners/ risers shot blasting and cleaning of the castings.

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

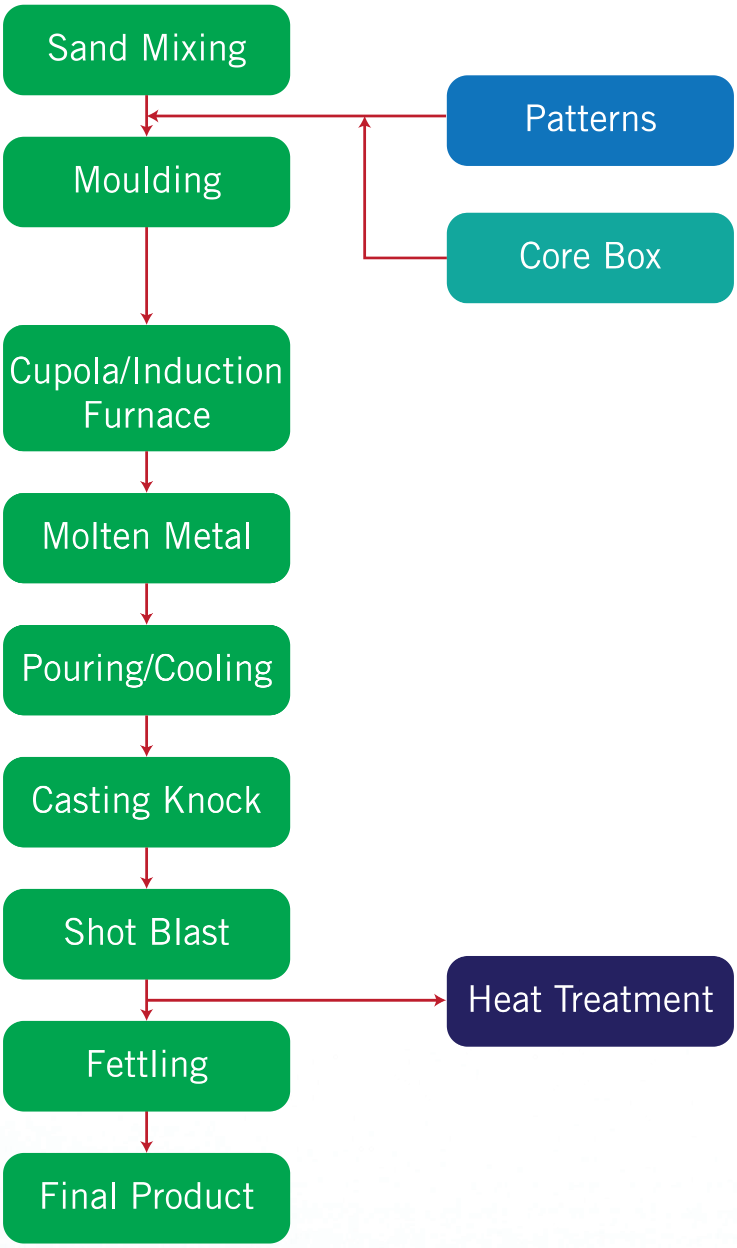


Figure 4: Foundry process flow

2.2. Foundry Technologies

Various types of equipment and technologies that are widely used in the foundry process are detailed below:

- Sand mullers
- Intensive mixers
- Shell moulding machine
- Core oven
- Melting furnaces
- Knockout machine
- Shot blast machine

Sand Plant

Sand moulds are commonly used in iron foundries for producing castings of desired shape. A pattern of the object to be cast is formed initially. Generally, hard woods, metals or resins are used for making patterns by pattern makers. In the sand plant, coal dust and organic binders like bentonite powder or dextrin are added to silica sand. These components are mixed well with the help of mixer. In order to minimise the use of fresh sand, the moulding sand from previous pouring is also recycled and water and organic binders are added to it before it is reused.

Sand mullers are used for sand preparation. These usually come in a small size of around 300 kg per batch, with a typical connected drive of 10 kW and cycle time of about 7–10 minutes.

Figure 5: Sand handling in foundries

Moulding Section

In this section, different activities such as mould making, casting, pouring of molten metal, knockout, decoring processes and preparation of ladles or buckets are performed. While making the mould, two portions of mould boxes are used, the upper part of which is called cope and the lower part is called drag. In both the boxes, mixture of prepared sand is poured with the help of shovel or by using automated moulding machine. The sand is then properly rammed into it and pattern/ cores are placed properly. Both the portion of boxes are kept accurately one above other, fixed with fastener. The box is then passed ahead for pouring the molten metal. Molten metal is carried from the furnace with the help of ladles, which are operated with the help of cranes/ pully system. Generally, the ladle, whose weight is around 500 kg, is handled by two workers. At the time of pouring, the temperature of molten metal ranges between 1,450°C and 1,500°C. The molten metal is then poured into the moulds. After 4-5 hours of cooling process, mould boxes are carried forward for knock-out. In the knock-out process, mould boxes are kept on the vibrator, so that the mould breaks down and the castings inside the moulds are removed. The castings are cleaned for further use.

Figure 6: Moulding section in foundries

Core Shop

Cores are made and inserted into the mould, for making the internal configuration of a hollow casting. The core must be strong enough to withstand the casting process; however, at the same time, it should be removed easily from the casting during the knockout stage. Core mixture comprises of sand, binders, linseed oil & dextrin to give necessary strength; which is then dried in an oven to produce a core. Curing of cores is achieved by chemical reaction and heating the cores at temperature of 260°C to 300°C with the help of a core furnace for about three to five minutes. Core box, consisting of baked cores, is then removed from furnace and allowed to cool. Inner cavity of cores and outer margins with surplus material are removed and cores are finished.

Figure 7: Core making

Furnace Section

In this section, charging of material, melting of the charge, removal of slag and refining processes are carried out. For charging the furnace, raw material such as pig iron, CI scrap, steel, limestone, coke, etc., are used. The quantity of material depends upon the capacity of furnace. Earlier, coke-based cupola furnaces have been used for the purpose of melting. Nowadays, a large majority of foundries use induction furnaces for melting, which is resulting in cost and fuel savings.

Melting temperature is controlled manually/ automatically. The required temperature is generally achieved within 30 minutes in the case of electric arc furnace. Once the required temperature is achieved in the furnace, slag is removed manually. The entire furnace is then lifted slowly and the molten metal is poured into the ladle. The ladle is then carried towards mould boxes for pouring the molten metal and making castings of desired dimensions. 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 in the foundry

Fettling Shop

The main activities of fettling shop include shot blasting, fettling and grinding. In these processes, castings are cleaned to remove sand and other material left from moulding processes, any extra metal and rough surfaces. In shot blasting processes, castings are kept in the shot blasting machine and small steel shots/ balls present strike the castings from all sides, so that castings are cleaned and the sand is removed. In the process of shot blasting, a large amount of silica and coal dust is generated. During grinding and fettling, rough and unwanted surfaces of castings are removed so that the castings become smooth and clean.

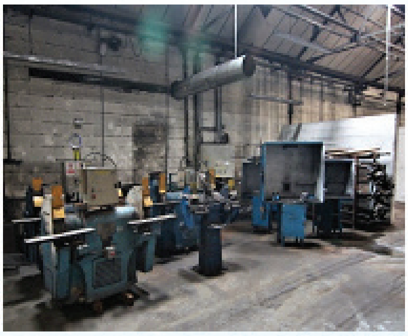
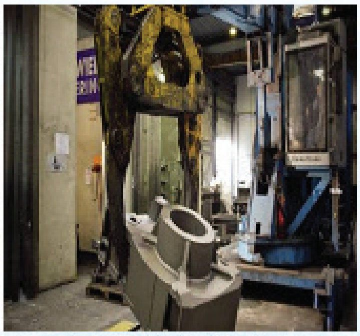




Figure 9: Fettling section in foundry

2.3. Energy Consumption in Foundry

The energy cost accounts for around 15% of the total cost of production which is 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 3: 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

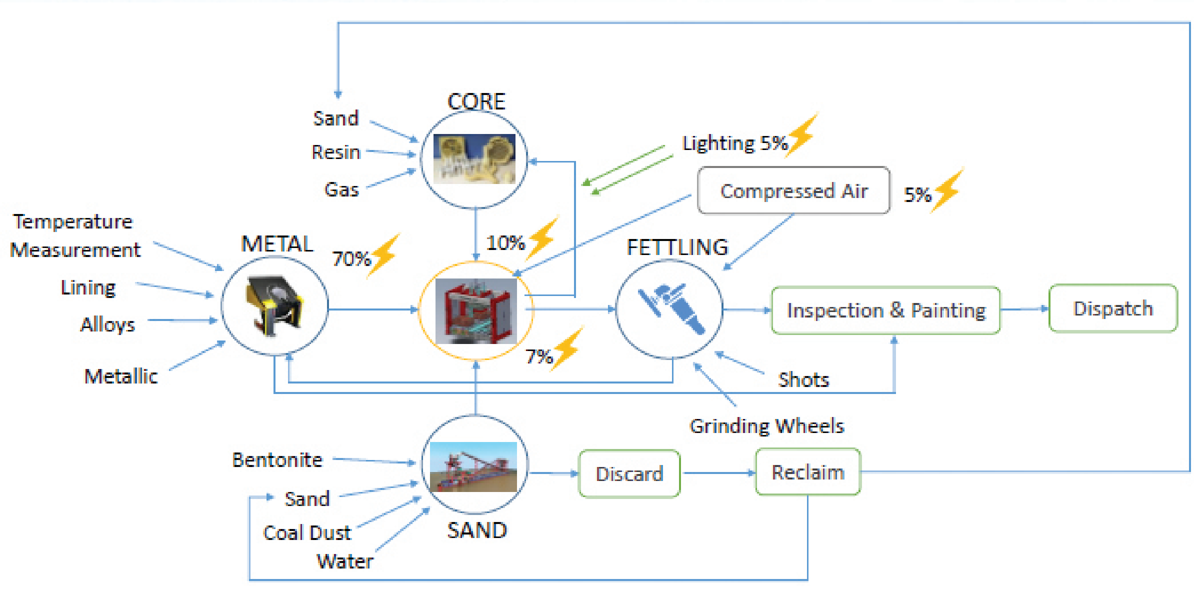


Figure 10: Energy consuming areas in foundries

ENERGY PROFILE OF FOUNDRY SECTOR

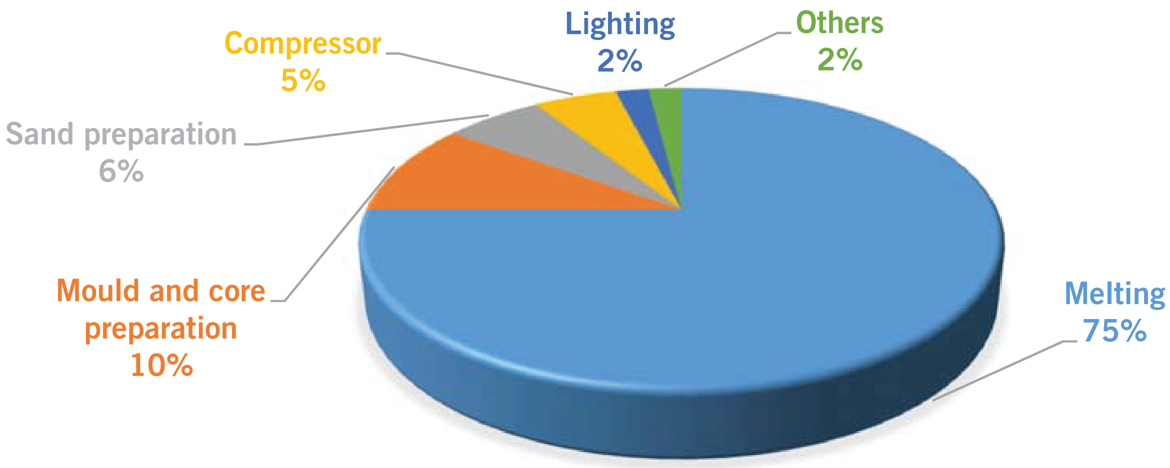


Figure 11: Typical energy consumption in foundries

2.4. Technology Status in Belgaum Foundry Cluster

The foundry industry in Belgaum dates back to the 1940s. Since then, a lot of technological improvements have been made in the cluster, especially in melting, sand handling & moulding, and utility sections.

The technology status in Belgaum Foundry Cluster is detailed in the following table.

Table 4: Technology status in Belgaum foundry cluster

S. No	Area	Current Status
1	Energy Sources	Electrical and thermal energy are the major energy consumed in the foundry units. For an induction furnace-based foundry, entire energy consumption is through electricity, except for diesel consumption in DG sets in case of power cuts. All the units in Belgaum foundry cluster have grid connection. Some of the units have DG sets also for power backup. Electrical Energy: Hubli Electricity Supply Company Limited (HESCOM) is one the power distribution companies (DISCOM) in the State of Karnataka and it serves the district of Belgaum. Cost of power for foundry units in Belgaum is around INR 8/ kWh. Power procurement through open access is also practiced in some of the units having demand greater than 1 MW. Coke: In case of cupola-furnace based units, energy for melting is met through coke consumption. A few foundries are also using diesel/ LPG for core drying, ladle preheating and sand drying. Biomass gasifier-based solutions are also emerging for these applications.
2	Melting/ Furnace	More than 70% of the foundry units present in Belgaum Foundry Cluster are using induction furnace for melting process. Some units use a combination of cupola and induction furnaces and few units use only cupola. The transition from cupola to induction/ electric furnace in many of the units 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. Typically, an induction furnace-based foundry unit consumes 900-1,200 kWh of electricity per tonne of castings. About 90% of the castings produced from Belgaum come from induction furnace-based units. 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/ tonne of castings. Very few foundry units have converted to the energy efficient 'Divided Blast Cupola' (DBC).
3	Sand Handling & Mould preparation	Sand handling plant is the second largest energy consumer in foundry. Both pneumatic and electrical machines are available in the cluster for sand handling and mould preparation. A few small foundries are using hand moulding also.
4	Renewable Energy	Renewable energy penetration, for power generation, is very much limited in the cluster. One 30 kW rooftop solar PV system has been installed in a machine shop (part of a foundry). Hence, there is good potential available for solar PV installation in various foundries. Some units are also purchasing electricity from renewable sources through open access.

S. No	Area	Current Status
5	Others	The other equipment and technologies to support foundry are electrical distribution, compressed air systems, and pumping.
5a	Electrical Distribution	Power Factor: Most of the units have installed APFC for power factor improvement. For harmonics control, the units have also installed harmonic filters. There are certain opportunities available in electrical distribution such as installation of energy efficient transformers, optimal loading of transformers, installation of energy efficient motors (IE3 & above), installation of VFD, soft starters, auto star delta conversion, etc.
5c	Compressed Air	Compressed air is used in foundry units for different equipment and also for cleaning. The units either use screw compressors or reciprocating compressor to meet their compressed air requirements.
5c	Pumping	The pumping system is used for induction furnace coil cooling. Some pumps are old and there is scope for improvement by installation of high efficiency pumps. In cooling towers, there is scope for improving the effectiveness and also for replacement of metallic blades with FRP blades.

As part of the Phase-I of the GEF-UNIDO-BEE initiative, the following energy conservation measures have been implemented in some of the foundry units in Belgaum:

Table 5: Energy efficient technologies implemented in Belgaum - Melting & pouring

Technologies implemented
Melting
Reduction of radiation losses from induction furnace
Modifying melting practice / layout
Staggering of furnace operation
Maintaining furnace cooling tower temperature using temperature controller
Replacement of ordinary mixer with continuous mixer
Replacement of cupola with Divided Blast Cupola (DBC)
Replacement of coil cooling pump
Pouring of molten metal
Ladle insulation
Improvement in ladle lining
Biomass gasifier for ladle preheating
Installation of crane for metal pouring

Table 6: Energy efficient technologies implemented in Belgaum – Moulding, finishing & utilities

Technologies implemented
Mould & core making
Modification in shell core making process
Modifying the design in shell core making
Core making in-house
Modifying casting hangers
Finishing of the product
Auto shut down of shot blast machine
Installation of timer on shot blast machine
Utilities / Others
Energy efficient air compressor system
Air compressor optimization
Power factor improvement
Energy efficient pumps

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Energy Efficiency Opportunities

3. Energy Efficiency Opportunities

3.1. Energy Efficiency in Foundry

Foundry is one of the most energy intensive metallurgical industries. The major part of the energy consumed in a foundry is in the melting units. Energy also contributes to the major cost input to the production of castings. Besides, high energy consumption is bringing up the threat of climate change and global warming. Therefore, it becomes very much necessary to look into various means by which energy consumption in melting units can be minimized considerably.

Over the years, there has been significant technology improvement in foundry process and utilities and significant energy efficiency improvement has been achieved in their operations. However, various opportunities exist for foundries to improve their energy efficiency, become competitive and have environment-friendly operations.

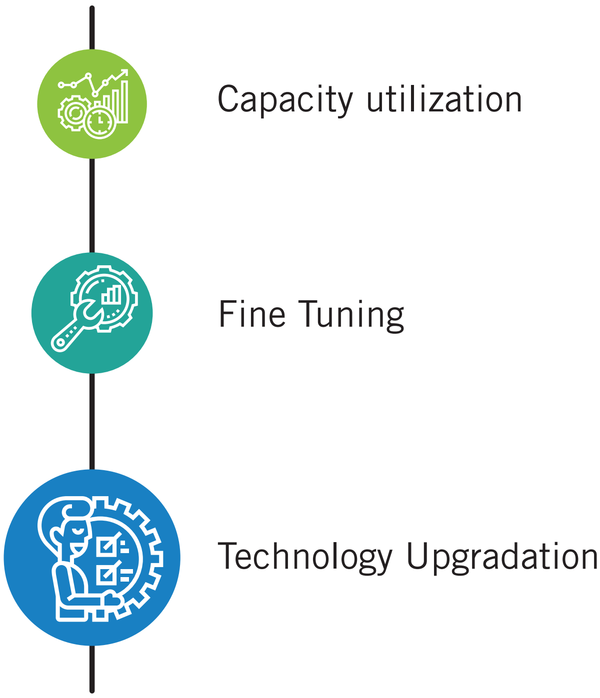

Figure 12: Energy efficiency approach in foundry

Energy efficiency at equipment or component level can be achieved by adopting various new technologies, preventive maintenance, optimum utilization, or replacement of old equipment with new and energy efficiency equipment. In addition to improving energy efficiency at equipment or component level, the foundry industry in India has made significant improvements in process level efficiency through various measures such as process control & optimization, online energy monitoring system, automation and implementation of new and efficient process in melting, sand handling and moulding. Apart from energy savings, these measures have also resulted in productivity and quality improvement. Further, IoT-based interventions are expected to move the industry towards ‘Smart Foundry’.

3.2. Energy Efficiency Measures

There are various energy consuming areas within a foundry unit. They can be classified as:

- Primary energy consuming areas such as electricity in induction furnace and coke in cupola furnace.
- Secondary energy consuming areas such as sand handling and moulding systems, compressor, cooling tower, pump, lighting systems, etc.

Following figures provide an overview of energy usage in an induction furnace-based foundry and a cupola furnace-based foundry.

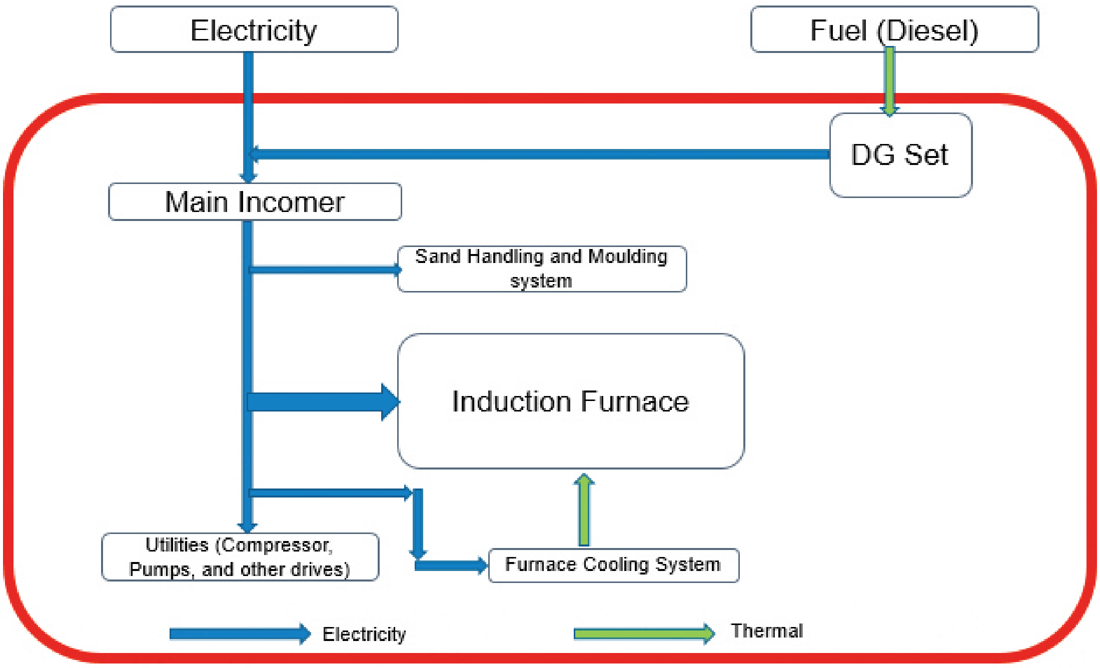

Figure 13: Overview of energy usage – Induction furnace

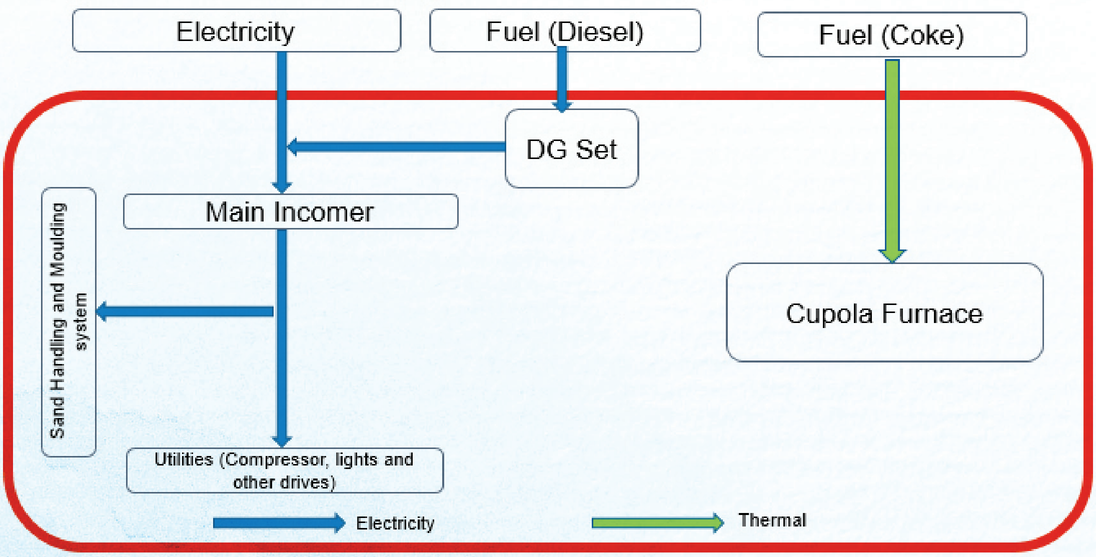

Figure 14: Overview of energy usage – Cupola furnace

The following section provides an overview of some of the key energy efficiency measures in major energy consuming areas in a foundry unit. Some of the latest applicable technologies are also covered in further sections.

3.2.1. Energy Efficiency in Induction Furnace

Induction furnaces are becoming widely used in the foundry industry, replacing the old cupola technology. The two main types of induction furnace are coreless furnace and channel furnace. The important component of coreless induction furnace is the coil, which consists of a hollow section of heavy duty and high conductivity copper tubing which is wound into a helical coil. The coil is water-cooled to avoid it from overheating and the water being recirculated and cooled in a cooling tower. Coreless furnaces are traditionally designed to operate at mains frequency of 50 Hz and is commonly used to melt all grades of steels, irons and different types of non-ferrous alloys.

The channel induction furnace consists of a refractory lined steel shell which contains the molten metal. Attached to the steel shell and connected by a throat is an induction unit which forms the melting component of the furnace. The induction unit consists of an iron core in the form of a ring around which a primary induction coil is wound. Channel induction furnaces are commonly used for melting low melting point alloys.

The working of induction furnace is based on the principle of electromagnetic induction. The basic concept is same as that of a transformer but with a single turn short circuited secondary winding. The charge to be heated and melted forms the secondary while the hollow water-cooled copper coils excited by the AC supply from the primary. In the core type furnaces, there must always be a sufficient molten metal in the furnace in order to maintain the electric path. This is called the molten heel. In the coreless induction furnaces, the primary coils surround a refractory crucible in which the charge to be melted is added. The eddy currents induced by the primary winding generate heat in the charge. Since there is no core, a large current is required to overcome the reluctance between the coils and the charge and results in a very low pf. The coil is surrounded by a laminated magnetic yoke to provide a return path for the flux to prevent stray losses and improve the pf.

Induction melting furnaces are inherently more efficient than cupolas. In an induction furnace, power consumption depends on the following three efficiencies:

1. Furnace efficiency: In furnace manufacturer's control.
2. Scrap efficiency: In market control (recovery of scrap to molten metal).
3. Operating efficiency: In user control.

Overall efficiency can be considered as the product of all the three efficiencies. The specific energy consumption (SEC) is to be in the range of 580–620 kWh per tonne by different induction furnace manufacturers in India.

Melting cycle time, melting temperature and loading percentage are the critical parameters for induction furnace, which can lead the overall efficiency of furnace in both directions.

Major energy losses in an induction furnace are mapped below.

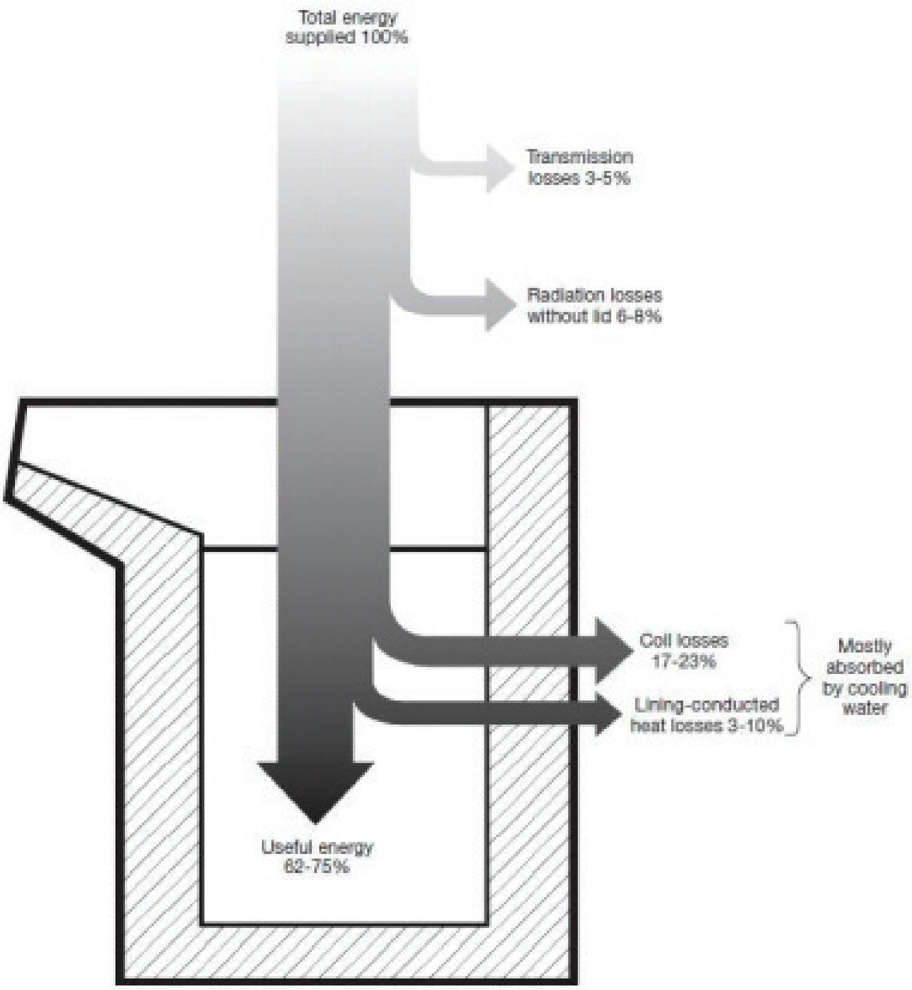

Figure 15: Energy losses in induction furnace

Adopting the following energy conservation measures will optimize specific energy consumption and allow efficient operation of the induction furnace.

Table 7: Energy conservation measures in induction furnace

S. No.	Energy Conservation Measures in Induction Furnace
1	Properly defining the tapping/ pouring temperature **Every 70°C consumes 27 kWh/ tonne in iron melting**
2	Removing sand, dirt, oil, grease and other impurities from charge **Every 3% slag would consume 6% additional power**
3	Accurate weighing of raw material
4	Using optimum size of single piece metal/ scrap Size of the metal should not be more than 1/3 of diameter of furnace crucible
5	Avoiding the use of sharp edge feed
6	Ensure charging the furnace to its capacity
7	Avoiding introduction of wet feed in the charge
8	Installing scrap bailing machine

S. No.	Energy Conservation Measures in Induction Furnace
9	Removing the sand from runner and risers through turn blasting/ shot blasting
10	Installing charge preheater system **Fuel-fired vibrating feeder may be used for preheating the charge and removing dust, oil and other impurities from it.**
11	Installing lid mechanism for furnace crucible (manual / hydraulic) **500 kg crucible melting at 1,450°C with no lid cover leads to radiation heat loss of up to 25 kWh per tonne of molten metal**
12	Avoiding build-up of slag on furnace walls
13	Ensuring flux consumption to be less than 1 kg per tonne of metal
14	Installing temperature measuring device and avoid super heating of metal
15	Using ladle preheater (Using molten metal to preheat ladle is quite energy intensive and expensive)
16	Providing sufficient insulation (Glass wool / ceramic wool / insulation paint) in ladle to minimize temperature drop
17	Provide optimum lining for furnace
18	Installing energy monitoring system (kW monitoring) for furnace
19	Installing coil cooling system control
20	Installing harmonic filters for furnace
21	Replacing conventional induction furnace with energy efficient IGBT furnace
22	Replacing refractory bricks with linings for ladles
23	Using advanced capacitance control
24	Installing energy efficient coils
25	Installing spectrometer for molten metal analysis

3.2.2. Energy Efficiency 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.

Table 8: Energy conservation measures in cupola furnace

S. No.	Energy Conservation Measures in Cupola Furnace
1	Replacing conventional cupola with divided blast cupola (DBC) DBC will result in reducing coke consumption by 20-30%
2	Installing coke-less cupola
3	Replacing cupola furnace with energy efficient induction furnace
4	Providing insulation (e.g., paint) on cupola surface
5	Installing high performance castable refractories for cupola
6	Installing combustion air preheating system
7	Recovering waste heat from furnace flue gases and using it for preheating combustion air
8	Installing energy efficient combustion air blower
9	Maintaining optimum excess air by installing VFD in blower 10% drop in excess air amounts to 1% saving in fuel consumption in furnace
10	Maintaining the size / weight of raw material Weight of a single piece of metal should be limited to 1% of the hourly melting rate
11	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%
12	Ensuring that the vents in the cupola bottom doors are open
13	Installing energy efficient burner
14	Using alternative fuels in cupola
15	Reducing the length of spout (louvers)

Some of the operating tips for cupola furnace are as follows:

Table 9: Operating tips for cupola furnace

Dos	Don'ts
Ensure that the bottom sand is free from moisture and clay content	Don't hold the molten charge inside cupola. It consumes energy as well as changes the metallurgical properties of different batches
Measure the bed coke height with a calibrated gauge. If needed, add green coke to bring the height to the required level	Once charging starts, do not stop till, (i) the cupola shaft is filled with the charging material, (ii) the cupola is lit up, and (iii) the blower and tuyere are switched on
While charging, ensure that the diagonal dimension of a single piece of metal is less than 1/3rd the hearth diameter	Don't use wet inoculants
Use light section scrap for filling up, to increase the initial tap temperatures	Don't allow very heavy raw material pieces weighing more than 1% of the hourly melting rate, in the cupola
Dry and thoroughly preheat all runners and ladles daily	

3.2.3. 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 optimise energy consumption in mould and core making process and heat treatment.

Table 10: Energy conservation measures in sand handling, moulding and core making

S. No.	Energy Conservation Measures in Sand Handling, Moulding & Core Making
1	Installing energy efficient sand handling plant
2	Installing biomass gasifier for sand and core drying application
3	Using transvector nozzle for mould cleaning
4	Ensuring sand in free from metal pieces
5	Optimizing the operation of shot blast machine by installing timer for cycle time
6	Converting pneumatic system to electrical system for sand conveying in knockout

3.2.4. Energy Efficiency in Utilities

Apart from specific process related energy efficiency opportunities, there are many common opportunities existing in utilities and electrical sections.

Energy Efficiency in Motors

Motors serve as the drivers for compressors, pumps, fans, blowers, etc. Various energy saving opportunities available in motors are listed below:

Table 11: Energy conservation measures in motors

S. No.	Energy Conservation Measures in Motors
1	Installing energy efficient motors (IE3 & above)
2	Increasing motor loading by installing motor of appropriate capacity
3	Installing energy efficient gear box
4	Star to delta conversion
5	Replacing belt driven motors with direct couple one
6	Installing kVAR compensator for individual motors

Energy Efficiency in Compressor

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%.

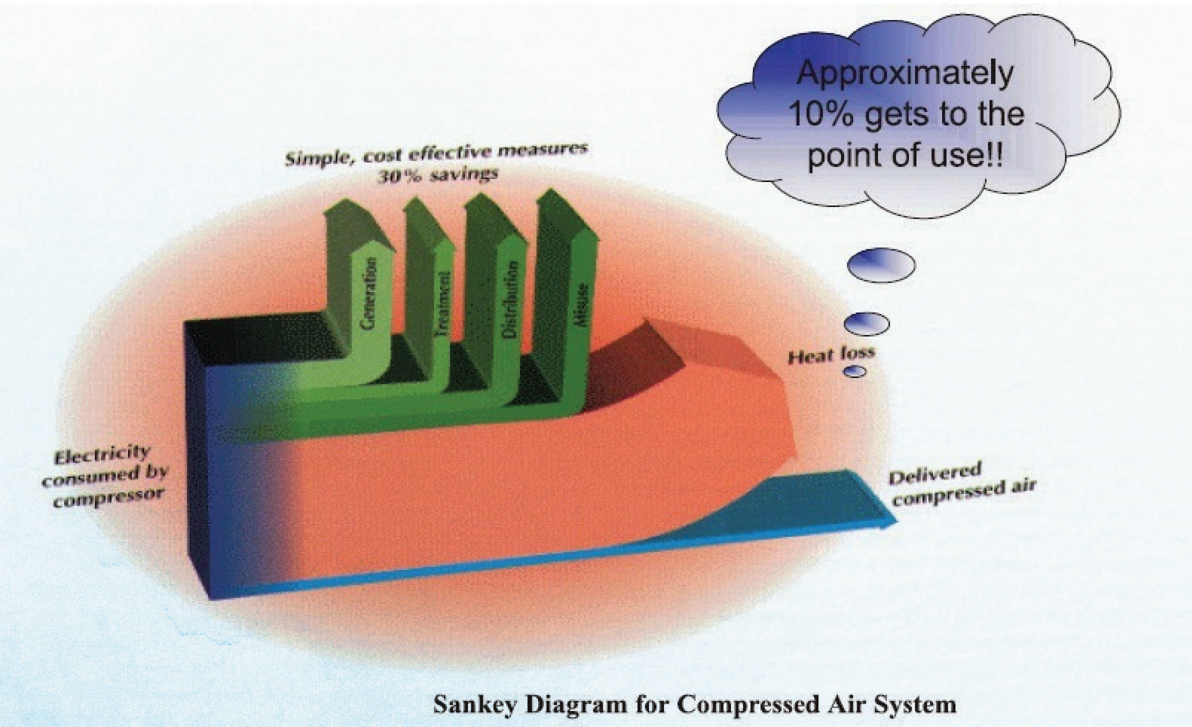

Figure 16 Sankey diagram for air compressor

Various energy saving opportunities available in compressed air system are listed below:

Table 12: Energy conservation measures in compressed air system

S. No.	Energy Conservation Measures in Compressed Air System
1	Installing optimum capacity compressor
2	Replacing reciprocating compressor with screw compressor coupled with VFD
3	Installing VFD for existing screw compressor
4	Optimizing the performance of VFD by PID loop optimization
5	Locating the compressor in such a way that cold ambient air goes to compressor Every 40°C rise in the inlet air temperature results in an increase in energy consumption by 1% (to achieve an equivalent output)
6	Install auto drain valve for compressor receivers
7	Installing aluminium piping in place conventional metallic compressed air piping
8	Providing appropriate ventilation in compressor room
9	Minimizing the compressed air leakage
10	Optimizing compressed air generation pressure Higher the compressed air pressure, the more expensive it is to provide the air. Increase in air discharge pressure by 1 kg/ cm^2 above the desired value will result in an increase in the requirement of input power by about 4–5%.
11	Installing energy efficient air dryer
12	Installing Intelligent flow controller (IFC) for compressed air system

Energy Efficiency in Electrical Distribution System

Energy efficiency opportunities in electrical distribution system are listed below.

Table 13: Energy conservation measures in electrical distribution system

S. No.	Energy Conservation Measures in Electrical Distribution System
1	Installing automatic power factor (PF) control (for maintaining PF close to 1)
2	Installing harmonic filters
3	Installing energy monitoring system
4	Installing energy efficient transformers
5	Optimizing Low Tension (LT) voltage in transformer
6	Installing dedicated transformer for induction furnace

Energy Efficiency in Cooling Tower

Cooling tower is used for cooling the heating coils in induction furnace. Interventions possible for improving efficiency of cooling tower are listed below.

Table 14: Energy conservation measures in cooling tower

S. No.	Energy Conservation Measures in Cooling Tower
1	Installing energy efficient pump for cooling water system
2	Install VFD for pumps
3	Impeller trimming in pumps
4	Replacing conventional metallic blades with Fibre-Reinforced Plastic (FRP) FRP blades for cooling tower fan
5	Install water-less cooling tower

Energy Efficiency in Other Systems

Energy efficiency opportunities in other systems in foundry are listed below.

Table 15: Energy conservation measures in other systems

S. No.	Energy Conservation Measures in Other Systems
Lighting System	
1	Replacing conventional lightings with Light Emitting Diode (LED)
2	Installing occupancy sensor for lighting systems
Air Conditioning (AC) System	
1	Install energy saver for split ACs
Diesel Generator (DG)	
1	Operating DG at optimum load
2	Conducing regular SEGR (Specific Energy Generation Ratio) trials to monitor DG performance
3	Cleaning DG air filters regularly
Blowers	
1	Installing energy efficient blower
2	Replacing V-belts with flat belts in pulley driven blowers
3	Reducing pulley size in blowers
4	Installing VFD for blowers

S. No.	Energy Conservation Measures in Other Systems
	Fans
1	Installing VFD for fans
2	Replacing conventional ceiling fans with BLDC fans
3	Install High Volume Low Speed (HVLS) fan (has preinstalled VFD)
	Others
1	Installing VFD for cranes

3.2.5. Renewable Energy

Renewable energy technologies are playing an increased role in meeting power requirement of the industry. Shadow-free roof area available in foundries can be utilised for power generation by installing solar photovoltaic (PV) system. Some of the general features / requirements of rooftop solar PV system are as follows:

Table 16: General features of rooftop solar PV system

S. No.	Features / Requirements	Values
1	Shadow free roof area required	10 sq. m. or 100 sq. ft. per kWp
2	Roof suitable for Solar PV system	RCC/ GI/ tin shed (Asbestos may not be suitable)
3	Orientation of the roof	❖ South facing roof is most suitable ❖ Installation may not be feasible beyond 5 degree slope
4	Solar PV module installation	❖ Modules are installed facing South ❖ Inclination of modules should be equal/ closer to the latitude of the location for maximum energy generation
5	Cost of the rooftop solar PV system	The Ministry of New and Renewable Energy (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 solar 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
6	Useful life of the system	25 years
7	Annual energy generation from rooftop solar PV system	❖ 18% Capacity Utilization Factor (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

Small scale rooftop based solar-wind systems are also available for power generation.

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Energy Efficient Technologies Case Studies

4. Energy Efficient Technologies – Case Studies

The energy efficiency measures mentioned in the previous chapters are some of the measures implemented in foundry units. The following chapter focuses on some of the above-mentioned technologies which are promising and have been implemented in a few foundry units, and have wide scale replication potential in the Belgaum Foundry Cluster (Case Study). In most of the examples, typical energy saving data, investments, payback period, etc., have been highlighted. As these case studies are included to provide confidence to foundries to implement technologies, the applicability of these measures may vary from unit to unit, and further technical and financial analysis would be required for individual foundry units. The following case studies are mentioned in detail in the subsequent section:

Table 17: Case studies for foundry sector

Sr.No	Technologies
1	Installation of LID Mechanism for Induction Furnace
2	Automation of heat treatment process
3	Replacement of SCR based Induction furnace with IGBT Induction Furnace
4	Replacement of cupola furnace with EE Induction Furnace
5	Replacement of normal cupola furnace with divided blast furnace
6	Replacement of existing raw water pump with energy efficient pump
7	Replacement of Existing motors with energy efficient (IE3) motors
8	Replacement of all old reciprocating air compressors with new energy efficient screw air compressor
9	Optimization of Air compressor VFD performance through PID loop optimization
10	Replace LDO firing circuit by biomass gasifier based producer gas firing circuit
11	Improve power factor by Installing KVAR compensator
12	Installation of VFD for compressor
13	Replacement of conventional sand plant with energy efficient sand plant
14	Installation of FRP blades for cooling tower fans
15	Installation of Energy Management System
16	Installation of electric grinders in place of pneumatic grinders to save energy in a foundry unit
17	Energy conservation by modifying compressed air line system in a foundry
18	Installing timer for sand plant process in a foundry
19	Reduce energy consumption by modifying the lining of ladle in a foundry.
20	Installation of Rooftop Solar PV System
21	Installation of Solar-Wind Hybrid System

4.1. Case Study 1: Installation of Lid Mechanism for Induction Furnace

Baseline scenario

K & K Foundry Pvt. Ltd, Kolhapur has started foundry operation in 1996 and is producing low & medium size casting commodity for automobile and compressor manufacturing. The unit has installed one Dura-Line furnace of capacity 750 kg. The opening of 750 kg induction furnace is circular with 460 mm diameter. Since one of the major heat losses in any induction furnace is radiation loss through opening, it is required to close the opening with insulating material and thus reduce radiation loss. In a typical induction furnace, radiation heat loss through opening will be 5-6% of the total electricity consumption.

Details of the present operating condition of the furnace are given below:

Table 18: Lid mechanism for induction furnace

S. No.	Implementation Details	UOM	Value
1	Furnace capacity	kg	750
2	Furnace opening area	m^2	0.17
3	Temperature of the opening	°C	1,500
4	Ambient temperature	°C	33.6
5	Total heat loss per heat	kWh	24.45

Proposed system

The opening heat losses for one batch (heat) were calculated, and it is recommended to use a lid mechanism for the opening, with hydraulic operation. During the detailed study post implementation, it was observed that the plant has reduced radiation heat loss through the opening. The temperature at the opening before implementation of lid mechanism was 1,500°C, and after the implementation was 465°C. Temperature drop is a clear indication of reduction in radiation loss through the opening. By successfully implementing this project, the plant has achieved energy savings of nearly 83,727 kWh.

Figure 17: Induction furnace without lid mechanism

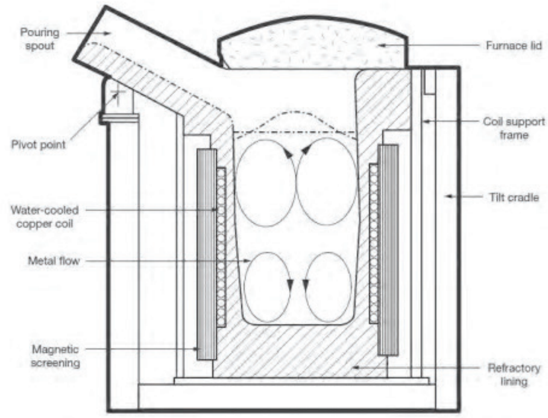

Figure 18: Induction furnace with lid mechanism

Merits:

- ❖ Reduces significant heat losses.
- ❖ Provides additional operation safety.

Limitations:

- ❖ Additional capital investment for creating lid handling system.

Cost Benefit Analysis:

The expected electricity savings to be achieved by the installation of a lid mechanism is 83,727 kWh per annum. The annual monetary saving for this project is INR 5.30 lakhs, with an investment of INR 3.50 lakhs, and a payback period of 6 months.

Table 19: Cost benefit analysis - Lid mechanism

S. No.	Implementation Details	UOM	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	kWh/day	21	
6	Operational days in a year	Day/year	300	
7	Annual saving potential	kWh/yr	83,727	

S. No.	Implementation Details	UOM	Before Implementation	After Implementation
8	Annual cost saving	INR Lakhs	5.30	
9	Investment required	INR Lakhs	3.50	
10	Simple payback	Months	6	
11	Emission factor	kg CO_2/kWh	0.82	
12	Annual reduction in CO_2 emissions	MT	68.65	
13	Annual Savings in TOE	TOE	7.2	
14	IRR	%	180.75	
15	NPV at 70% Debt	INR Lakhs	25.25	

Technology Supplier Details:

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4.2. Case Study 2: Automation of Heat Treatment Process

Baseline scenario

Omkar Foundries, Sangli, (Maharashtra) was established in 1982 and is producing various grades of steel and other metal alloys. The foundry has a heat treatment furnace installed which is HSD-fired and used for normalizing, tempering and water quenching purposes. Each has a different cycle time and temperature requirements. It was found that the fuel and air were un-controlled. This was leading to excess fuel consumption.

Proposed system

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.

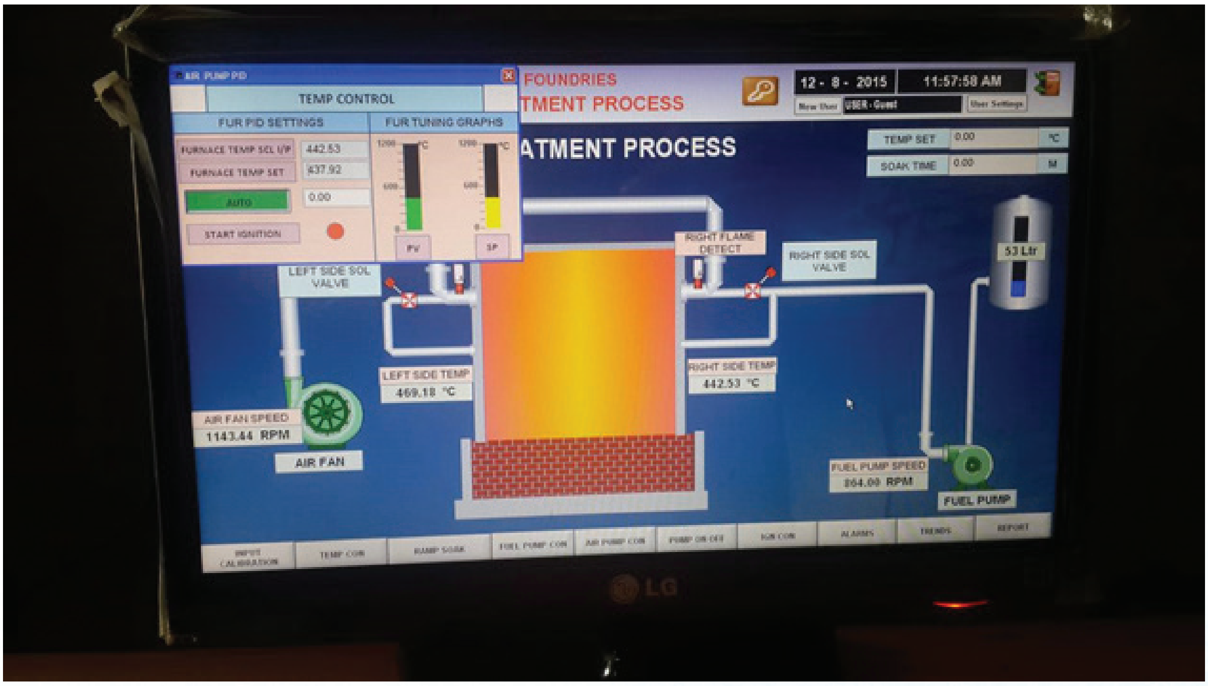

Figure 19: Automation of heat treatment process

Merits:

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

Limitations:

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

Cost Benefit Analysis:

The expected annual monetary saving for this project is INR 0.85 lakhs, with an investment of INR 2.05 lakhs, and a payback period of 29 months.

Table 20: Cost benefit analysis for automation in heat treatment process

Implementation Details	UOM	Before Implementation	After Implementation
Observed parameters			
Cost of FO	INR/Ltr	53	50
Diesel Consumption	Ltr	8,400	0
Annual Production from furnace	Tonnes/year	176	176
Diesel savings	Litres/day	17.00	
Annual Diesel savings	Litres/year	1,700.00	
Annual Savings in TOE	TOE	1.68	
Emission factor	kg CO_2/litre	2.6	
Annual reduction in CO_2 emissions	MT	3.9	
IRR	%	60.28	
NPV at 70% Debt	INR Lakhs	3.37	

Technology Supplier Details:

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4.3. Case Study 3: Replacement of SCR-based Induction Furnace with IGBT Induction Furnace

Baseline scenario

Marvelous Metals Pvt Ltd, Kolhapur is a manufacturers and exporters of Cast Iron components and subassemblies. The unit has installed three induction furnaces. One of them, Induction Furnace II, is of 500 kg capacity for melting. The calculated specific energy consumption was 656 kWh per Metric Tonne of melting, which was higher in comparison with 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 to use in an economical and reliable way.

Energy consumption details are given below:

Table 21: IGBT induction furnace

Measurements	UOM	Value
Capacity of furnace	Kg	500
No. of batches per day	Nos	27
Minutes per batch	-	52
Production of Furnace	Tonne/day	13.5
Operating hours per day	Hrs/day	23.4
Specific Energy Consumption	kWh/Tonne	656
Annual production	MT/Year	3,994
Annual Consumption	kWh/year	2,620,064

Proposed system

It was recommended to replace the existing induction furnace with a new IGBT-based induction furnace. New IGBT furnace has 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.

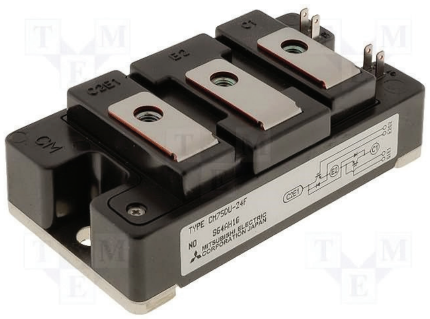

Figure 20: IGBT

Merits

- The biggest advantage of IGBT is the possibility to turn it on and off with control signal, meaning less electronic components and circuitry as well as less 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.

Figure 21: SCR

Cost Benefit Analysis

The achieved savings by installation of new IGBT induction furnace is 2,15,276 units of electricity per annum. The annual monetary saving for this project is INR 13.62 lakhs, with an investment of INR 27.75 lakhs, and a payback period of 25 months.

The details of the measurements and calculations are given below:

Table 22: Cost benefit analysis for replacement of SCR by IGBT furnace

Implementation Details	UOM	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	Tonne/day	13.5	13.5
Operating Hours per day		23.4	23.4
Specific Energy Consumption	kWh/Tonne	656	602.1
Annual Production	MT/Year	3,994	3,994
Annual Consumption	kWh/year	2,620,064	2,404,787.4
Annual Savings	kWh/year	2,15,276.6	
Unit Cost	INR/kWh	6.33	
Annual Savings	INR in Lakhs	13.62	

Implementation Details	UOM	Before Implementation	After Implementation
Investment	INR lakhs	27.75	
Payback	Months	25	
Emission factor	kg CO_2/kWh	0.82	
Annual reduction in CO_2 emissions	MT	176.52	
Annual Savings in TOE	TOE	18.51	
IRR	%	69.73	
NPV at 70% Debt	INR Lakhs	56.46	

Technology Supplier Details

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4.4. Case Study 4: Replacement of Cupola Furnace with EE Induction Furnace

Baseline scenario

Shilp Enterprises, Siroli, Maharashtra plant was operating with a cupola furnace. Cupola furnace installed in 2001 was used for melting metal and had a melting rate of 2.2 MT/hour. The cupola was operated at temperature 1,465°C and molten metal (MS-grade) pouring temperature was around 1,300-1,350°C. The operating hours of the cupola was low around 3-4 day per week. The coal to metal ratio is 1:5.88 which was very less as compared to the design ratio (1:10).

Cupola furnace is the least energy efficient technology for melting applications, and is an old technology. Production capacity of the plant was 3,000 tonnes/yr. Cupola furnace used coke as the thermal source. Manpower requirement for operation and maintenance was also difficult for cupola furnace. Maintain operating parameters like molten metal temperature, furnace pressure and oxygen level was a difficult task for cupola furnace. The plant has decided to replace the conventional cupola furnace with an energy efficient induction furnace, which uses electricity as the source of fuel.

Proposed system

The plant team was advised to purchase high efficiency induction furnace of 1,250 kW and 500/1,500 kg

Merits

- ❖ Energy efficient
- ❖ Easy operation
- ❖ Lower requirement of manpower
- ❖ Reduced losses
- ❖ Lower environmental impact

Limitation

- ❖ High cost of electricity

Cost benefit analysis

The annual monetary saving for this project is INR 26.70 lakhs, with an investment of INR 80.17 lakhs.

Table 23: Cost benefit analysis for replacement of cupola furnace by induction furnace

Implementation Details	UOM	Before Implementation	After Implementation
Metal melted	Tonnes/yr	3,040	3,040
Coke consumption	kg coke/ MT metal	170	
Calorific value of Coke	kCal/kg	6,000.00	
Annual fuel consumption	kg/yr or kWh/yr	5,15,000	19,51,680
Annual cost	Lakhs/year	169.95	143.25
Savings	Lakhs/year	26.69	
Investment	INR Lakhs/yr	80.17	
Emission factor for electricity	kg CO_2/kWh	0.82	
Emission factor	kg CO_2/kg coke	2.8	
Annual Savings in TOE	TOE	304	
IRR	%	49.76	
NPV at 70% Debt	INR Lakhs	98.55	

Technology Supplier Details

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4.5. Case Study 5: Replacement of Conventional Cupola Furnace with Divided Blast Furnace

Baseline scenario

M K Iron Foundry, Kolhapur plant was operating with a conventional type cupola furnace. The plant had decided to reduce the coke consumption with minimal investment. The coke consumption was 150 kg coke per tonne of material.

Proposed system

The plant decided to replace the existing inefficient cupola furnace with a 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 22: Conventional cupola

Figure 23: Divided blast cupola

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).

Cost Benefit Analysis

TThe annual monetary saving for this project is INR 0.90 lakhs, with an investment of INR 4.48 lakhs, and a payback period of is 60 months.

Table 24: Cost benefit analysis for replacement of conventional cupola furnace by DBC furnace

Implementation Details	UOM	Before Implementation	After Implementation
Cost of coke	INR/kg	30	30
Melting	Tonnes/yr	100	100
Coke for melting per tonne of metal	Tonnes	150	120
Coke consumption per year	Tonnes/yr	15	12
Coke savings	Tonnes/yr	3.0	
Annual cost savings	INR Lakhs	0.9*	
Investment	INR Lakhs	4.48	
Simple payback period	Months	60	
Emission factor	kg CO_2/GJ	96	
GCV of coke	kcal/kg	7,000	
Annual reduction in CO_2 emissions	MT	87.8	
Annual savings in TOE	TOE	2.51	
IRR	%	30.81	

** 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.*

4.6. Case Study 6: Replacement of Existing Raw Water Pump with Energy Efficient Pump

Baseline scenario

Melting Centre Pvt Ltd, Kolhapur 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%. 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 to the performance of the cooling water system associated with furnace coil and panel.

Proposed system

Since the operating efficiency of pump is low, the plant decided to replace the existing raw water pump with an energy efficient pump.

The highly efficient pump will consume less power than low efficiency pumps, which will lead to energy saving. Energy efficient pumps offer higher efficiency than conventional pumps and consume less power, thereby leading to significant energy savings. The new pumps installed have an overall efficiency of 53%. The pump–system curve is illustrated graphically below. The point where the system and the pump curve meet is known as the Best Efficiency Point (BEP).

The operating efficiency is highest and the radial bearing loads are lowest for a pump at this point. At or near its BEP, a pump operates most cost effectively in terms of both energy efficiency and maintenance. In practical applications, operating a pump continuously at its BEP is not likely, because pumping systems usually have changing flow rate and system head requirements and demands. Selecting a pump with a BEP that is close to the system's normal operating range can result in significant operating cost savings.

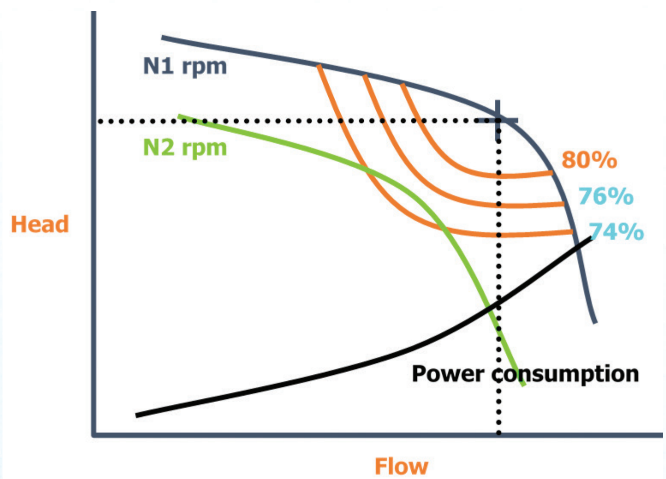

Figure 24: Pump performance curve

Merits:

- Higher efficiencies
- Reduced power consumption
- Optimum flow and head

Limitations:

- High initial investment

Cost Benefit Analysis

The expected energy savings to be achieved by installation of new energy efficient pumps is 9,864 units annually. The annual monetary saving for this project is INR 0.77 lakhs, with an investment of INR 0.53 lakhs, and a payback period of 8 months.

Table 25: Cost benefit analysis for pump replacement

Implementation Details	UOM	Before Implementation	After Implementation
Cost of Electricity	(INR/kWh)	7.83	7.83
Power Consumption	kw	3.34	1.97
Operating Period	Hrs/annum	7,200.00	7,200.00
Annual savings	(kW hr/yr)	9,864.00	
Annual cost saving	INR Lakhs	0.77	
Investment required	INR Lakhs	0.53	
Simple payback	Months	8	
Emission factor	kg CO_2/kWh	0.82	
Annual reduction in CO_2 emissions	MT	8	
Annual Savings in TOE	TOE	0.85	
IRR	%	174.36	
NPV at 70% Debt	INR Lakhs	3.66	

Figure 25: Photo and specifications of new pump

4.7. Case Study 7: Replacement of Existing Motors with Energy Efficient (IE3) Motors

Baseline scenario

AKP Ferrocast 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.

Proposed system

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

Table 26: Motor efficiency class defined by IEC

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

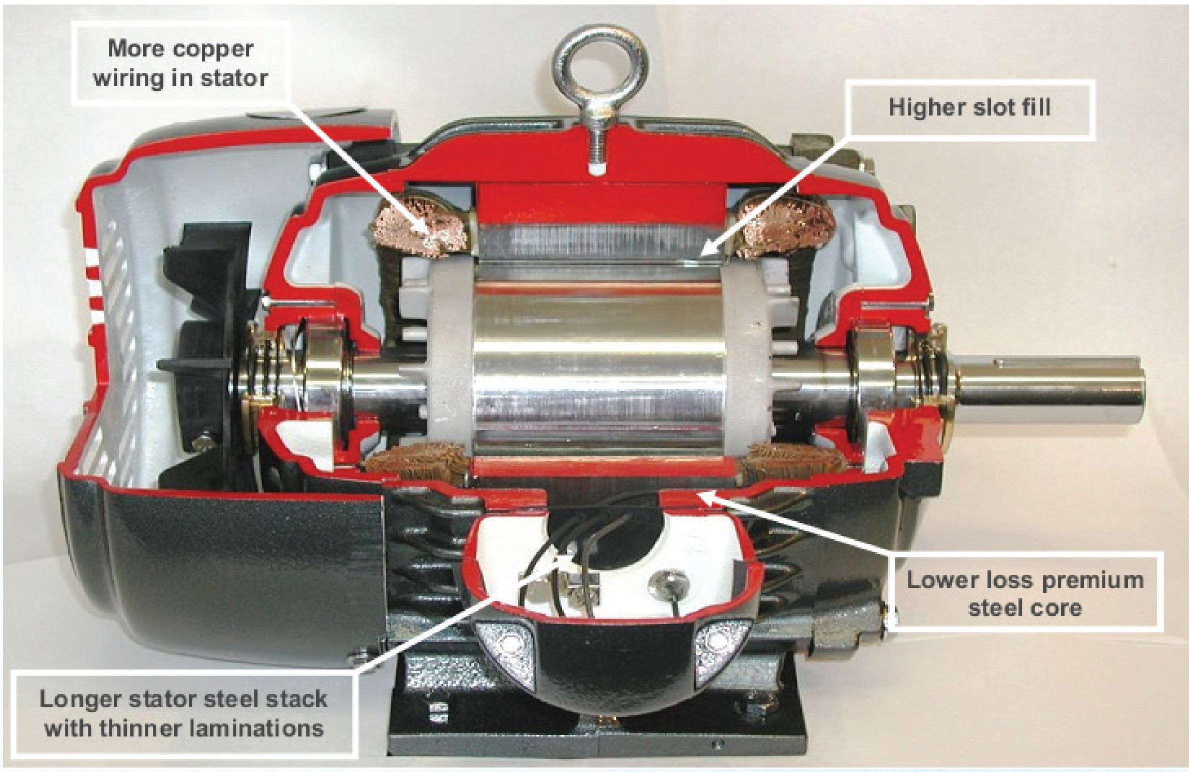

Figure 26: Internal details of IE3 motor

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.

Cost Benefit Analysis

The expected energy savings to be achieved by replacing three old motors with IE3 motors is 4,907 units annually. The annual monetary saving for this project is INR 0.29 lakhs, with an investment of INR 0.44 lakhs, and a payback period of 18 months.

Table 27: Cost benefit analysis for motor replacement

Particular	UOM	Value
Total quantity of motors across rating	Nos.	3
Estimated energy savings	kWh/annum	4,907
Grid power cost	INR/kWh	6.00
Energy saving per annum	INR/annum	29,442
Capital cost of motor (Including cost of transportation)	INR	34,285
EESL PMC @ 10%	INR	3,428
Capital cost of motor (Including transportation and EESL PMC)	INR	37,713
Estimated total project cost	INR	44,502
Simple Payback	Months	18
Emission factor	kg CO_2/kWh	0.82
Annual reduction in CO_2 emissions	MT	4.02
Annual Savings in TOE	TOE	0.42
IRR	%	89.42
NPV at 70% Debt	INR Lakhs	1.29

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.

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.

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.

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4.8. Case Study 8: Replacement of Reciprocating Air Compressors with New Energy Efficient Screw Air Compressor

Baseline scenario

Compressor is one of the major energy consumption equipment in any foundry units. Compressed air is highly energy intensive as only 30-40% of the electrical energy consumption is converted into air, and the balance is lost as unusable heat energy. In general, if the compressed air systems are not well managed, there are high energy losses.

In Prabhat Casting, Belgaum, before installing new compressor, in previous studies it was observed that two 50 HP reciprocating compressors were used alternatively, which were replaced by one 40 HP screw compressor, which acts as a base compressor and is often in loading condition. Compressor loading and unloading patterns are recorded.

Proposed system

Matches compressor output with demand by varying motor speed. The power consumption reduces in line with the reduction in demand. This helps in eliminating the frequency of load-unload cycle and also the power wasted from the energy bill.

A fixed speed compressor operates on a load unload band of at least 8-10 psi around the working pressure whereas with VFD, compressor can be operated within a band of 2 psi. Since the compressor is not operating under higher than working pressure requirements, there is substantial energy saving. For every 2 psi reduction in operating pressure, there is 1% power saving.

Principle of operation/methodology

In a fixed speed compressor with star-delta starter, starting current is as high as three times the full load current (FLC). With VFD starting current is less than the FLC. This helps to avoid using heavy rated components, such as fuses, MCCB, Cable size, generator rating, isolators, etc.

Benefits

- Low starting current.
- High efficiency.
- Improved power factor.
- Reduced maximum demand.

Limitation

- High capital cost.

How reduction in specific energy is achieved

In new compressor implementation, arresting pressure drop and air leakages is done by ring main and addition of air receiver tank, which helps to reduce air pressure from 7.2 bar to 6.8 bar. Reduction in set pressure and arresting leakages gives energy savings of up to 10-15% from the present consumption.

The air compressor is running towards the desired set pressure. Loading and unloading of the air compressor is minimized.

Photographs of the system / project

Previous installation of reciprocating compressor

Figure 27: Old reciprocating compressor

New compressor installed.

Figure 28: New screw compressor

Cost Benefit Analysis

The expected energy savings to be achieved by installing crew compressor is 43,680 units annually. The annual monetary saving for this project is INR 3.90 lakhs, with an investment of INR 6 lakhs, and a payback period of 18 months.

Table 28: Cost benefit analysis for installation of new screw compressor

Details	UOM	Value
Technical details	Capacity Operating Parameters Assumptions (if any)	Free air delivery 206 cfm Working pressure: 7 Bar
Investment	INR lakhs	7.5 (With Air dryer)
Energy savings	% energy reduction, energy savings (kWh / Annum)	43,680 kWh
Monetary benefit from energy savings	INR lakhs / annum	3.90
Other Savings / Benefits		No foundation / Cooling Tower for water cooled
Payback	Months	17-18
Emission factor	kg CO_2/kWh	0.82

Details	UOM	Value
Annual reduction in CO_2 emissions	MT	35.82
Annual Savings in TOE	TOE	3.99
IRR	%	73.09
NPV at 70% Debt	INR Lakhs	16.33

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4.9. Case Study 9: Optimization of Air Compressor VFD Performance through PID Loop Optimization

Baseline scenario

Air compressor is a crucial utility equipment in any foundry. Fluctuations in compressor operation (variation in load kW) due to variation in compressed air usage (a lot of batch operations, varying load in plant) is a critical task for any foundry. In most of the foundries, compressor will be controlled with VFD to optimize the operation and avoid the unloading compressor.

AQUA ALLOYS, Shinoli (MH) has implemented the Compressor PID loop optimization tool to reduce the compressed air consumption in plant.

Originally the compressor was running on no load for 40% of the time. VFD is installed to efficiently manage the load fluctuation by regulating the compressor motor RPM (by varying input frequency).

Issues

Even though overall kW load reduced by 15% after VFD installation, the compressor load was oscillating with high fluctuations (From 750 rpm to 1,500 RPM every 3 minutes to maintain the pressure of 90 PSI).

Reasons

Sub optimal VFD response to dynamic load which can be optimized by proper tuning of VFD settings.

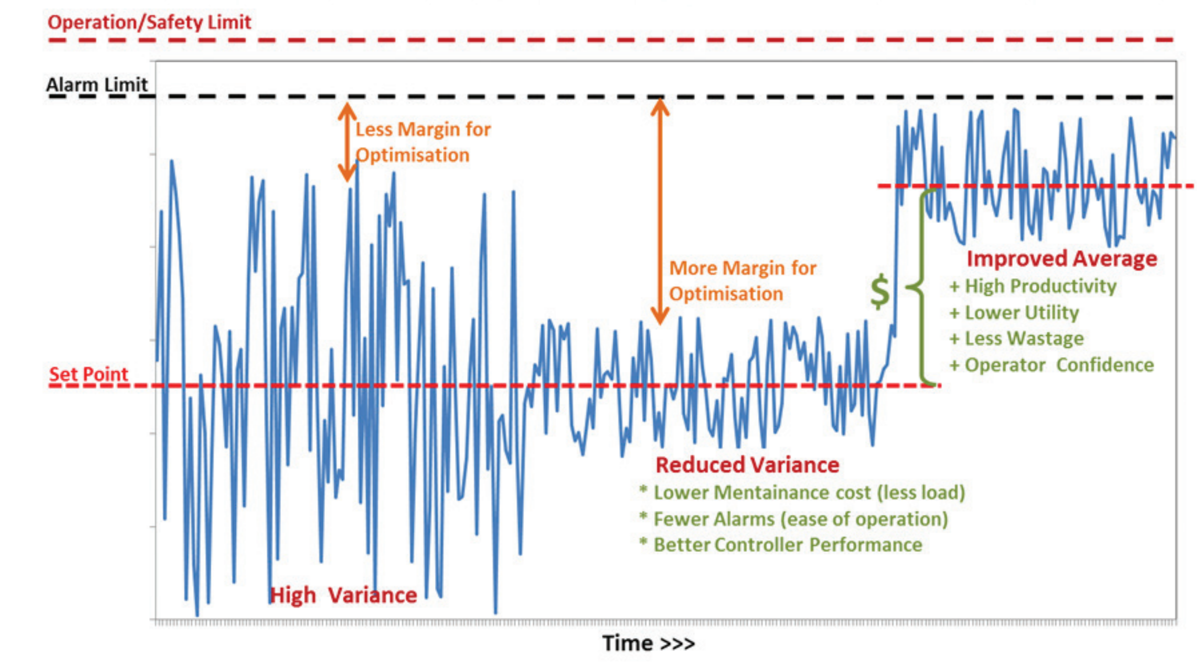


Figure 29: PID loop optimization

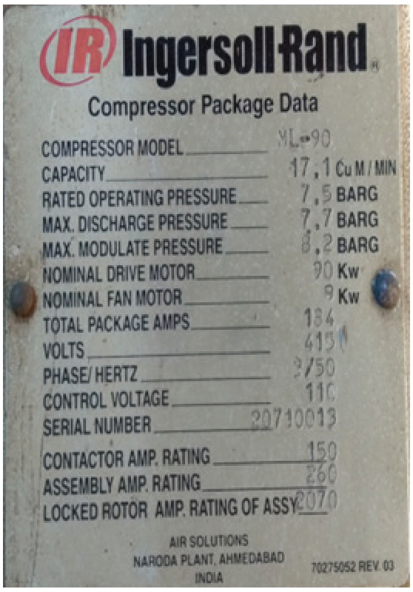


Figure 30: Air compressor specifications

600 CFM capacity with 90 kW motor

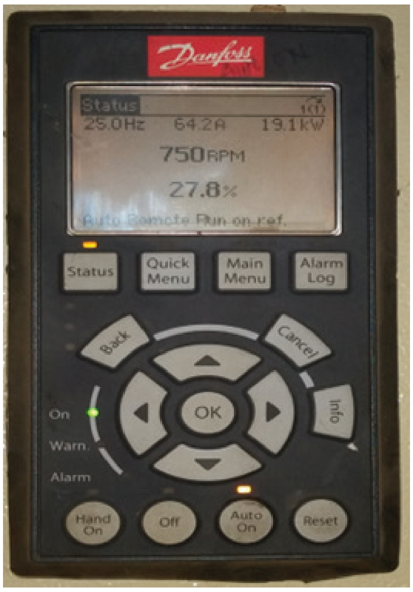


Figure 31: VFD make

Danfoss, FC302-N90k

Proposed system

There are two layers of controller settings in VFD panel:

- Process PID, which decides required RPM based on actual air pressure (w.r.t. SP 90 psi)
- System PID, which changes input frequency (Hz) to maintain the motor RPM.
- Both these PID controllers have three parameters to adjust in the Panel Gain Factor, Integral Time and Derivative Time.

Diagnosis:

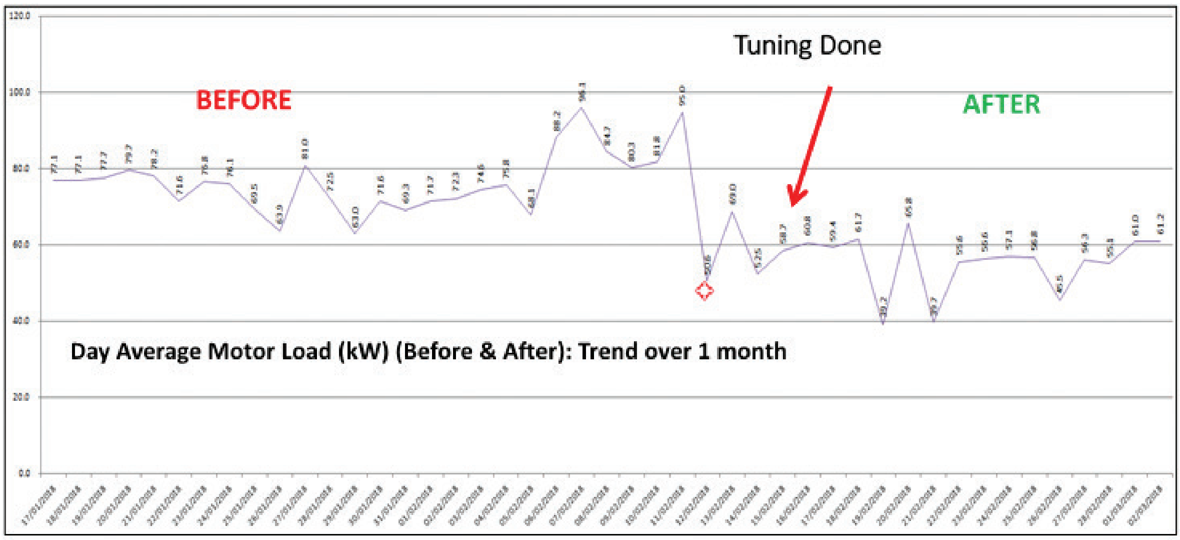
'OPTIMakx' software based assessment showed that **Process PID** settings in the VFD panel are aggressively set and hence response is very sharp and sudden.

Action:

Gain settings was reduced without changing other settings of Process PID.

Cost Benefit Analysis

Slower and smoother response of VFD to load changes. Larger fluctuation range (20 kW to 90 kW) reduced by 50% (between 40 kW to 70 kW), and period of fluctuation increased to 15 minutes from 3 minutes.



17% Lower kW @ 90 kW compressor >> 200 units/day savings

Figure 32: Compressor PID loop performance

Table 29: Cost benefit analysis for air compressor VFD performance through PID loop optimization

Month	Compressor Total Units	Production (tonnes)	Compressor Specific Power (units/tonne)
Oct 2017	42,940	216	198.79
Nov 2017	47,735	250	190.94
Dec 2017	50,221	260	193.16
Jan 2018	48,923	248	194.73
Overall (BEFORE)	189,819	974	194.88
Changes implemented on 12th Feb 2018			
Mar 2018	40,100	282	163.47
April – July 2018	162,419	985	164.89

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4.10. Case Study 10: Replace LDO Firing Circuit by Biomass Gasifier-based Producer Gas Firing Circuit

Baseline Scenario

Altech Alloys India Pvt Ltd, Kolhapur unit had an LDO-fired heat treatment furnace for baking the sleeves. The specific energy consumption was calculated to be 101.4 litre/batch.

Table 30: Baseline scenario for heat treatment furnace

Parameters	UOM	Value
Capacity	Tonnes	
Cost of Firewood	INR/kg	-
GCV of Fuel	kCal/kg	10,700
Operating Hours	Hrs/Year	3,600
Fuel consumption	litres/batch	101.40
Dry weight	kg/batch	695.98
Heat Supplied	kCal/batch	933,083
Heat Required	kCal/batch	222,521
Annual Consumption	litres/yr	60,840
Cost Incurred	INR/batch	4,360
Annual cost incurred	INR/yr	2,616,000

Proposed system

Biomass gasifier is a known eco-friendly technology for heating solution. Biomass gasifier technology is with emission factor of zero and uses biomass chips to produce producer gas as a fuel for the heat treatment furnace.

The plant team has successfully implemented the proposed system for heat treating the cores. The fuel used to produce syngas is firewood. The fuel injection burner is still the same. It is understood from the plant team that the feeding into the gasifier is manual and in total of 450 kg is fed. The gasifier is running at a fuel burning rate of 80 kg/hr. Totally, three batches are made in a day as each batch runs for 8 hours. The temperature required inside the furnace is 110°C for baking of cores. As per the plant team, the core making operation requires high flame for 6 hours and for the remaining 2 hours the furnace runs at low flame. The control of the flame length is done manually using valve control.

The savings in fuel is visible and is recorded on a daily basis. The initial power consumption was due to LDO pump, flame firing pump and air circulation blower but now the power consumption is due to air circulation blower and gasifier blower. However, as per the plant team, the quality of the cores has deteriorated a bit, as with firewood being the fuel to the gasifier, there is formation of wood dust which is entering the furnace and is contaminating the surface of the cores. This is causing the loss of time in production as cores have to be cleaned.

Merits

- Eo-friendly
- Simple payback will be less than a year
- Easy availability of local biomass

Limitation

- Additional man power requirement
- Less calorific vale of producer gas

Areas of application:

1. Foundry sand drying
2. Foundry core drying
3. Preheating of furnace charge material
4. Aluminium Melting (Scrap/Dross melting)
5. Aluminium extrusion billet pre-heating
6. Heat treatment furnace
7. Hot air generator

Typical composition of producer gas

Carbon monoxide (CO)	20-22%
Hydrogen (H_2)	15-20%
Methane (CH_4)	2-3%
Carbon dioxide (CO_2)	9-11%
Nitrogen (N_2)	45-54%
Water vapour (H_2O)	10-15%
Heavy hydrocarbon (HC)	0.2-0.4%

Cost benefit analysis

Replacement of LDO-based firing circuit by biomass gasifier resulted in an annual saving of INR 8.4 lakhs, with an investment of INR 3.9 lakhs. Simple payback for the project is 6 months.

The details of the measurements & calculations are given below:

Table 31: Cost benefit analysis for biomass gasifier

ECM – Implementation Details	UOM	Before Implementation	After Implementation
Design Parameters			
Capacity	Tonnes		1.0
Cost of Firewood	INR/kg	-	7.75
GCV of Fuel	kcal/kg	10,700 (Diesel)	2,500 (Biomass gas)
Operating Hours	Hrs/Year	3,600	3,600
Fuel consumption	litres/batch; kg/ batch	101.40	382
Dry weight	kcal/batch	695.98	704.66
Heat Supplied	kcal/batch	9,33,083	9,55,000
Heat Required	kcal/batch	2,22,521	2,22,521
Annual Consumption	litres/yr & kg/yr	60,840	2,29,200
Cost Incurred	INR/batch	4,360	2,960
Annual cost incurred	INR /yr	26,16,000	17,76,000
Annual cost Savings	INR	8,40,000	
Investment	INR	3,92,700	
Simple Payback period	Months	6	
GCV of diesel	kcal/kg	10,700	
Emission factor	kg CO_2/litre	2.6	
Annual reduction in CO_2 emissions	MT	158	
Annual Savings in TOE	TOE	45.25	
IRR	%	246.56	
NPV at 70% Debt	INR Lakhs	40.78	

Figure 33: Biomass gasifier

Technology Supplier Details:

1. Phoenix

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4.11. Case Study 11: Improve Power Factor by Installing KVAR Compensator and APFC

Baseline Scenario

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. The more the reactive current drawn from the supply, the 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.

Proposed System

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 (I^2R) 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

- ❖ Reduced distribution losses across the infrastructure that translate into cost savings.
- ❖ Reduced kW demand charge; the motor draws and frees capacity in the electric distribution system, freeing up extra space in supply panel. Improved voltage regulation and phase imbalance due to reduced voltage drop; reduced operating cost of machinery.
- ❖ Improved Power Factor of induction motor; works on all line-start and soft-start inductive loads such as motors, compressors, pumps, furnace, fans, blowers, etc.

Cost Benefit Analysis

The expected monetary savings to be achieved by installation of kVAr compensator is INR 1.1 lakhs, with an investment of INR 1.2 lakhs, and a payback period of 13 months.

4.12. Case Study 12: Installation of VFD for Compressor and ID Fan

Present scenario

IH Casting, Belgaum has installed a screw compressor to cater the requirements in the moulding & instrumentation section. The maximum working pressure of the compressed air in the system is in the range of 6-7 kg/cm².

It can be seen that the compressor is in loading and unloading mode. Whenever the requirement of compressed air comes down, the compressor starts unloading. Unloading also consumes power, but it will not give any useful work output. Normally, power consumption during unloading will be 1/3 of the loading power. Also, since the compressor is of screw type, the losses during unloading are higher in comparison with that for a reciprocating system.

Concept of VFD

Any compressor is designed to go into load & unload conditions. The load & unload pressures for any compressed air system are set such that the average pressure delivered will be the required system pressure. The higher set point of the compressor therefore is a loss. Also, in the present scenario, the installed compressor is of much higher capacity than compared to the system requirement, which is clear from the 64% unload that the compressor is operating with.

In these two conditions, the most suitable option is to go for a variable frequency drive (VFD). The difference between the normal & VFD condition in a compressor is as shown below:

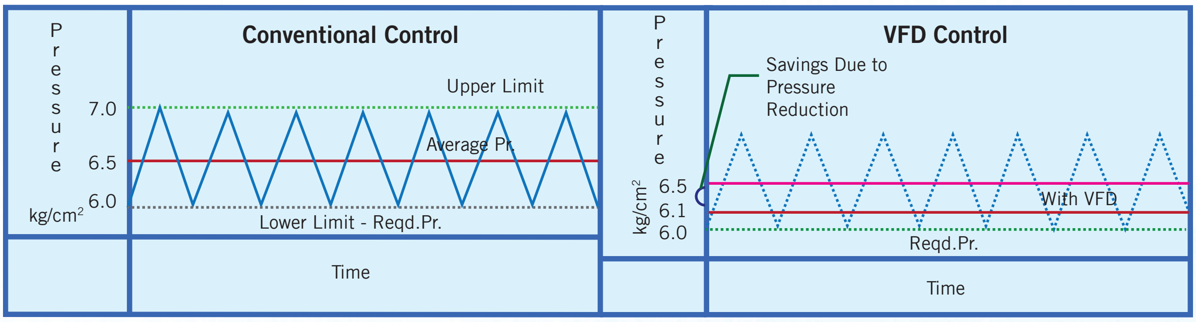

Figure 34: Depiction of conventional control and VFD control

As can be seen from the figure, the VFD can be given a set point equal to that which is required in the system. The additional power that the compressor consumes over the required pressure will be the savings achieved.

Basic VFD Operation

- Convert AC power to DC power
- Filter DC power
- Invert DC power to variable voltage and frequency AC power

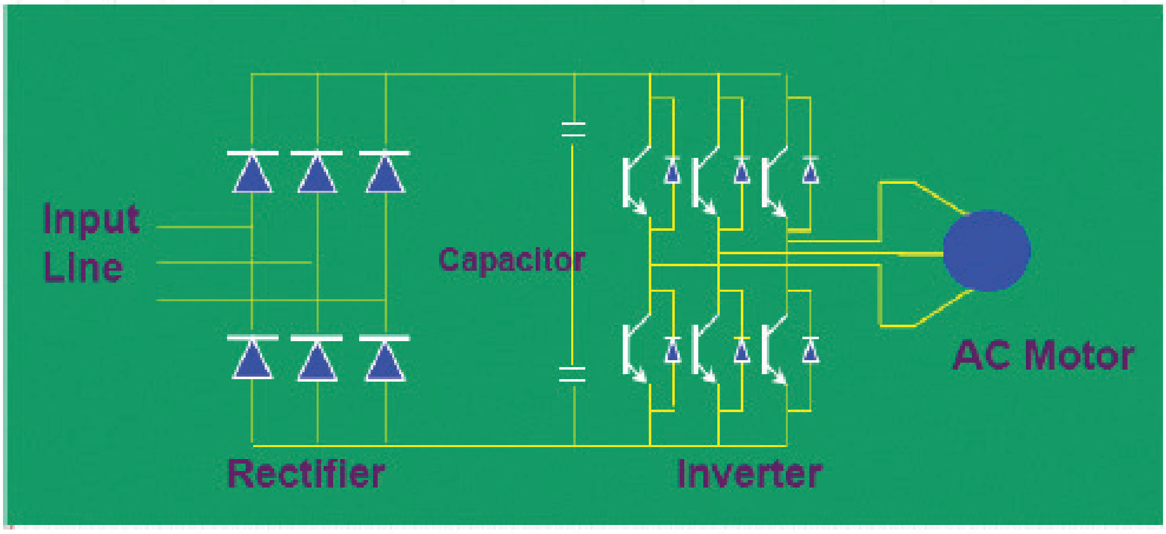

Figure 35: VFD operation

Typical energy savings by installing VFD in a screw compressor will be in the range of 25% to 85%, based on the unloading percentage and unloading power.

Merits

- Improves Power Factor.
- Lower KVA.
- Improves Speed Control.
- Energy Saving Mode.
- Catch Spin Function.
- Electronics Bypass for Change Over.
- PID Control.
- Benefits of VFD.
- Multiple Overload According Applications.
- Optimum Excitations Controls.
- Built in PLC Functions.

Limitation

- Harmonics.
- Power loss in VFD will be 2-3%.

Proposed System

It is recommended to install VFD and operate it with a closed loop for all the above listed compressors, to avoid the unloading of compressors. The feedback for VFD can be given as required receiver pressure. By installing VFD, the compressor can be operated in a pressure bandwidth of ±0.1 bar. Saving potential of 1.55 kWh is available by means of installation of VFD in the compressor.

Major VFD installations in Belgaum

Table 32: Major VFD installations in Belgaum

Sr.No.	Company	Capacity	Application
1	IH Casting, Belgaum	30 HP	Screw compressor
2	Gokul Ferrocast Pvt Ltd	50 HP	Screw compressor
3	AKP Foundry, Belgaum	25 HP	Blower
4	Flawless casting, Belgaum	15 HP	Screw compressor
5	AKP Foundry, Belgaum	50 HP 2 Nos	Screw compressor
6	Belgaum Ferrocast Pvt Ltd	100 HP	Dust collector blower
7	Belgaum Ferrocast Pvt Ltd	15 HP	Sand cooler

Cost Benefit Analysis

Installation of VFD in screw compressor resulted in an annual saving of INR 0.45 lakhs, with an investment for INR 1.15 lakhs. Simple payback for the project is 30 months.

Parameter	UOM	Value
Power consumption before installing VFD	kW	8.28
Power consumption after installing VFD	kW	6.23
Average saving per hour	kWh	1.55
Average saving per day	kWh/day	18.39
Average saving per month	kWh/month	478
Average saving per year	kWh	5,736
Electricity cost	INR/kWh	8
Annual monitory saving	INR Lakhs/Year	0.46
Investment	INR Lakhs/Year	1.15
Payback	Months	30

Parameter	UOM	Value
Emission factor	kg CO_2/kWh	0.82
Annual reduction in CO_2 emissions	MT	4.7
Annual Savings in TOE	TOE	0.49
IRR	%	58.44
NPV at 70% Debt	INR Lakhs	1.80

Table 33: Saving calculation for VFD in compressor

IH Castings. Sy. No. 336/2/2, Udyambag Belaum - 590008						Date: 15-04-2019	
COMPARISION OF COMPRESSOR POWER CONUMPTION							
Date	Start Time	End Time	Total Hrs	Hrs	No of heats	Compressor units	Units / Hour
Before VFD							
18-03-2019	8:45 AM	7:14 PM	10 hr 31 min	10.50	8	85.6	8.152
19-03-2019	8:00 AM	6:08 PM	10 hr 08 min	10.00	8	84.0	8.400
23-03-2019	9:20 AM	7:20 PM	10 hr 00 min	10.00	7	78.5	7.850
25-03-2019	9:45 AM	5:25 PM	7 hr 20 min	7.33	6	64.0	8.731
Average							**8.280**
After VFD						**28-03-2019**	
04-04-2019	7:05 AM	6:35 PM	11 hr 30 min	11.50	9	81.8	7.113
05-04-2019	6:00 AM	6:50 PM	12 hr 50 min	12.83	10	96.3	7.502
08-04-2019	8:00 AM	7:40 PM	11 hr 40 min	11.66	9	72.0	6.175
09-04-2019	7:00 AM	6:36 PM	11 hr 36 min	11.50	9	75.0	6.522
10-04-2019	7:00 AM	7:00 PM	12 hr 00 min	12.00	9	75.9	6.325
11-04-2019	7:30 AM	7:00 PM	11 hr 30 min	11.50	8	85.0	7.391
12-04-2019	7:00 AM	8:10 PM	12 hr 10 min	12.16	9	74.0	6.086

Table 34: Compressor loading with and without VFD

	Load	Unload
Ampere check without VFD	40 Amps	20 Amps
Ampere check with VFD	29 Amps	17 Amps

Technology supplier

1. Apex Industries (Dealers of 'CG Power' drives)

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4.13. Case Study 13: Replacement of Conventional Sand Plant with Energy Efficient Sand Plant

Present scenario

Sand handling & moulding is the second highest energy consumer in a foundry. A conventional sand handling and mould making system was installed in the unit. Conventional sand plant and moulding system requires a large number of drives. Major processes involving in sand handling are: sand mixing, sand cooling, sand conveying, and dust collection.

Typical energy saving opportunities in sand handling system

Sand Mixing:

- Efficiently reaching each grain of sand.
- Full power required only for 10 to 20% of the total cycle time when properties of sand are achieved.

Sand Conveying:

- Bucket Elevator – 75 to 90 m/min speed, lesser sand per metre, higher carrying load (buckets).
- Belt Conveyor – 30 to 60 m/min speed, higher sand per metre, no additional load.

Sand Cooling:

- Mixer Cooler reduces duplication of energy to move sand while cooling.
- Energy used in proportion to the temperature of sand.
- Number of handling machines reduced.

Dust Collection:

- Bucket Elevator throws sand with high velocity, leading to dust generation.
- More transfers generate more dust.
- Sand Cooler and Sand Mixer both require dust collection energy in conventional plant.

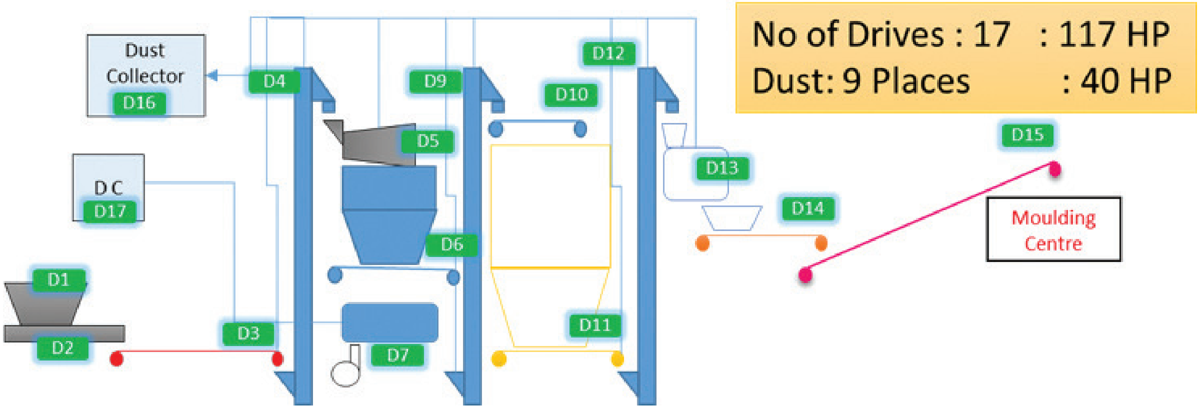

Figure 36: Conventional sand plant

Proposed system

Varsha Iron Works, Belgaum has installed energy efficient sand plant.

Major benefits achieved:

- Weight reduction, consistency & rejection control – In-line simulation.
- Power & manpower savings.
- Low & safe maintenance – all at eye look.
- Online support from rhino – SCADA system.
- Healthy and pollution-free environment – In-line with OHSAS.
- Increase in power of our furnace will double the production.

Investment

- High Pressure Moulding, Mixer-Cooler, Online Sand Controller, Boxes, Automatic Mould Handling, Pouring @ INR. 3-3.5 Cr for 400 TPM Plant.

Figure 37: Energy efficient sand plant

Figure 38: Operating conventional sand plant

Figure 39: Energy efficient sand plant

Table 35: Cost benefit analysis for energy efficient sand plant

Particular	UOM	Value
Energy Saved by Machine	kWh/Month	2,900
Energy saved in material	kWh/Month	4,800
Total energy saving	kWh/Month	7,700
Total cost saving	INR/Month	48,600
Total annual saving	Lakhs/year	5.83
Investment	Lakhs	25*
Payback	Months	51
Emission factor	kg CO_2/kWh	0.82
Annual reduction in CO_2 emissions	MT	75.76
Annual Savings in TOE	TOE	7.95
IRR	%	18.10
NPV at 70% Debt	INR Lakhs	35.78

**Cost is considered only for moulding machine*

Technology supplier

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4.14. Case Study 14: Installation of FRP Blades for Cooling Tower Fans

Present scenario

In AKP Foundries, the existing cooling towers incorporate induced axial flow fans with metallic blades. It is well known that metallic blades are heavier and need comparatively greater starting torque. The measured power of fan was 0.70 and 0.66 kW respectively for cooling tower of furnace.

Proposed System

It is recommended to change the cooling tower fan blades from metallic to Fibre Reinforced Plastic (FRP). Usage of FRP blades instead of aluminium blades results in about 25% savings.

Figure 40: FRP blade

Benefits

- Better aerodynamic properties
- Lower weight
- Higher efficiency
- Less power consumption
- Single piece profile blades
- Uniform stress loading
- Longer service life

Cost Benefit Analysis

The estimated annual energy savings is 2,448 kWh, equivalent to a monetary saving of INR 0.15 lakhs. The investment requirement is INR 0.08 lakhs with a simple payback period of 0.5 years.

Table 36: Cost benefit analysis for FRP blades for cooling tower fans

Particular	UOM	Fan 1	Fan 2
Fan operating power	kW	0.70	0.66
Approximate reduction in power by installing FRP	%	25%	25%
Energy saving	kW	0.18	0.17
Operating period	Hrs/annum	7,200	7,200
Annual energy saving	kWh	1,260	1,224

Particular	UOM	Fan 1	Fan 2
Cost saving per year	INR Lakhs	0.08	0.07
Investment	INR Lakhs	0.04	0.04
Simple payback	Months	6	7
Emission factor	kg CO_2/kWh	0.82	0.82
Annual reduction in CO_2 emissions	MT	1.03	1.00
Annual Savings in TOE	TOE	0.11	0.11
IRR	%	230.7	205.11
NPV at 70% Debt	INR Lakhs	0.39	0.34

Technology supplier

1. Encon Group

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4.15. Case study 15: Installation of Energy Management System

Present scenario

There was no energy monitoring system in Veeresha casting Pvt Ltd, Kohlapur. Energy monitoring is the first step in energy conservation. Energy monitoring can give a clear idea about the trend of energy cost and specific energy consumption. Energy monitoring of any equipment can also be considered as performance monitoring.

Proposed System

Veeresha casting has installed an energy monitoring system to monitor the operation of furnace and auxiliary equipment. It was proposed that by means of the energy monitoring system, the plant team can collect data and use that for analysing.

The unit installed energy monitoring system in November 2014. They started to analyse the data from January 2015 onwards.

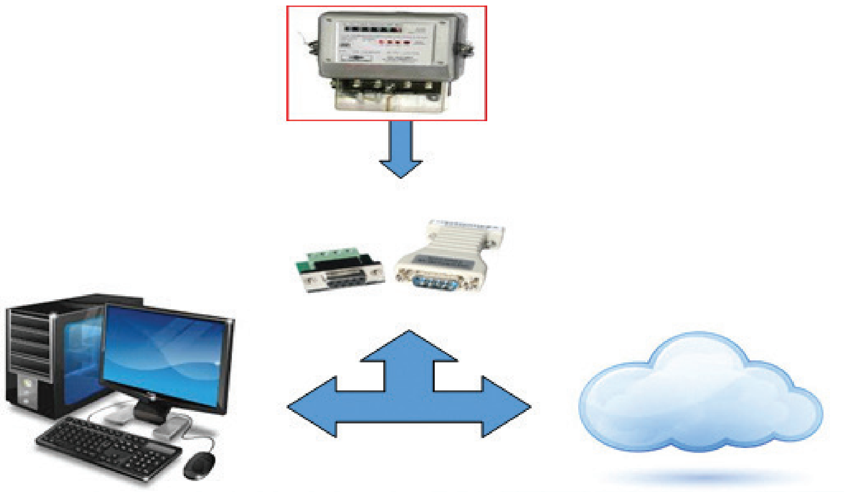

Figure 41: Advance energy management system

Benefits

- Benchmarking energy consumption.
- Reduction in distribution losses.
- Reduction in peak demand.
- Eliminating inefficient equipment operation.
- Root cause analysis.
- Measurement & Verification.
- Improvement in the efficiency of machines.
- Health check of electrical equipment.

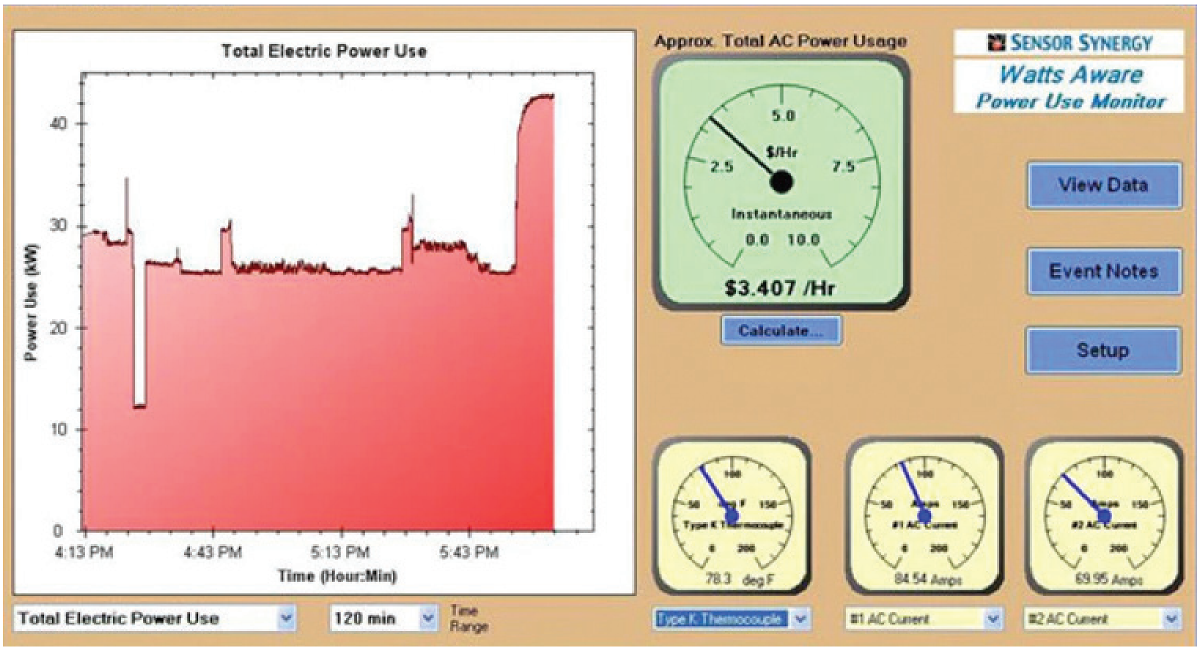

Figure 42: Energy monitoring system for induction furnace

Cost Benefit Analysis

The estimated annual energy savings is 6,792 kWh, equivalent to a monetary saving of INR 0.53 lakhs. The investment requirement is INR 0.88 lakhs, with a simple payback period of 20 months.

Table 37: Cost benefit analysis for energy management system

Particular	UOM	Before Implementation	After Implementation
Electricity Cost	INR/kWh	7.80	7.80
Material Charged	MT/yr	2,892.00	
Material charged from 29 to 31 Jan	MT		17.52
Power Consumption from 29 to 31 Jan	kWh		10,420.09
SEC	kWh/MT	597.00	594.65
Savings	kWh/MT	2.35	
Annual energy Savings	kWh/yr	6,792.86	
Annual Savings	INR/Year	52,984.34	
Investment	INR/Year	87,727.00	
Payback	Months	20	
Emission factor	kg CO_2/kWh	0.82	
Annual reduction in CO_2 emissions	MT	5.6	

<table>
<tr><th>Particular</th><th>UOM</th><th>Before Implementation</th><th>After Implementation</th></tr>
<tr><td>Annual Savings in TOE</td><td>TOE</td><td colspan="2">0.58</td></tr>
<tr><td>IRR</td><td>%</td><td colspan="2">83.5</td></tr>
<tr><td>NPV at 70% Debt</td><td>INR Lakhs</td><td colspan="2">2.29</td></tr>
</table>

4.16. Case Study 16: Installation of Electric Grinders in Place of Pneumatic Grinders

Present scenario

Pneumatic type grinders were installed in Pioneer Engineering Industries Ltd, Madhya Pradesh to remove residues from the surface of the products. These tools are driven by compressed air and compressed air is highly energy intensive as only 10-30% of energy reaches the point of end-use, while the rest is converted to unusable heat energy. Electrical tools need no such conversion and are efficient. So, using electrical tools in the industry instead of pneumatic tools will eliminate the process of conversion of electrical energy into compressed air, leading to significant energy savings.

Proposed

Pneumatic grinders were used to remove residues from the surface of the products. These were replaced with electric grinders to reduce energy consumption.

Figure 43: Grinders in foundry

Benefits

- ❖ Increased energy savings.
- ❖ Reduced energy costs.

Limitation

- ❖ Excess time requirement.

Cost Benefit Analysis

The estimated annual energy savings is 22,464 kWh equivalents to a monetary saving of INR 1.16 lakhs. The investment requirement is INR 0.10 lakhs with a simple payback period of 1 month.

Table 38: Cost benefit analysis for electric grinders

Cost Economics	UOM	Before Implementation	After Implementation
Operating Power	kW	4.2	0.6
Electricity consumption per annum(6,240 hr/year)	kWh/yr	26,208	3,744
Energy saving per annum	kWh/year	22,464	
Cost saving per year	INR Lakhs	1.16	
Investment cost	INR Lakhs	0.10	
Simple payback period	Month	1	
Emission factor	kg CO_2/kWh	0.82	
Annual reduction in CO_2 emissions	MT	18.42	
Annual Savings in TOE	TOE	1.93	
IRR	%	1,195	
NPV at 70% Debt	INR Lakhs	5.83	

4.17. Case Study 17: Energy Conservation by Modifying Compressed Air Line System

Present scenario

A metallic pipeline system was installed in Mahendra Pumps Private Limited (Unit 4), Coimbatore to cater compressed air to different user end points. Metallic pipe line with joints and welding at various points results in pressure drop and leakages.

Proposed System

Replace the metallic pipes in the compressed air system to MLC pipes to reduce pressure drop, leakages to conserve energy. This will minimize the pressure drop and leakages in the system. With reduction in pressure drop, the generation pressure can be reduced from the existing level and this results in power saving. 1 bar reduction in generation pressure results in 8% power saving.

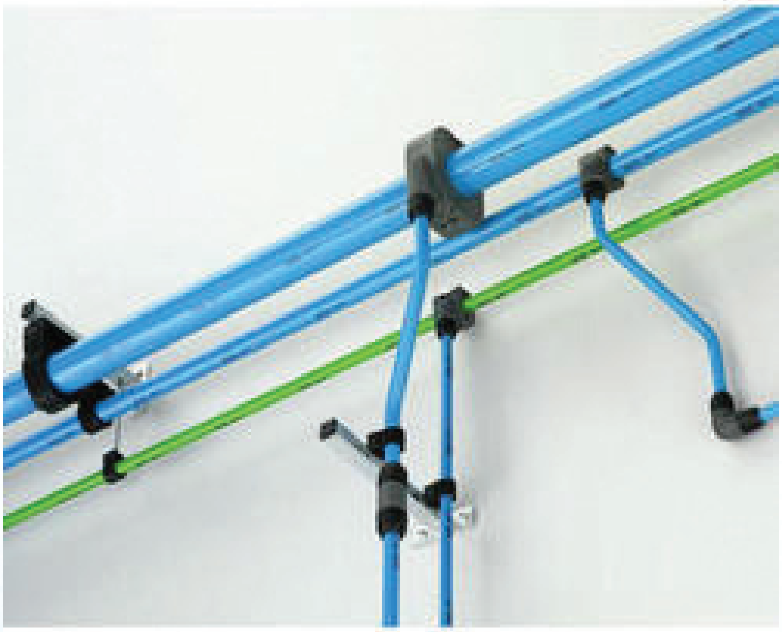

Figure 44: Compressed air line system

Benefits

- ❖ Reduced pressure drop
- ❖ Reduction in leakages
- ❖ Reduced energy consumption

Limitation

- ❖ Difficult for long pipelines
- ❖ Lesser strength

Cost Benefit Analysis

The estimated annual energy savings is 37,440 kWh, equivalent to a monetary saving of INR 2.84 lakhs. The investment requirement is INR 3.5 lakhs, with a simple payback period of 15 months.

Table 39: Cost benefit analysis for modifying compressed air line

Cost Economics	UOM	Before Implementation	After Implementation
Energy consumed per hour	kWh	37.5	30
Energy consumption per day	kWh/days	600 (16 hrs/day)	480 (16 hrs/day)
Electricity consumption per year (312 days)	kWh/year	187,200	149,760
Energy saving per annum	kWh/year	37,440	
Cost saving per year	INR	284,544 (INR 7.6/kWh)	
Investment cost	INR	350,000	
Simple payback period	Months	15	
Emission factor	kg CO_2/kWh	0.82	
Annual reduction in CO_2 emissions	MT	30.70	
Annual Savings in TOE	TOE	3.22	
IRR	%	106.18	
NPV at 70% Debt	INR Lakhs	12.79	

4.18. Case Study 18: Installing Timer for Sand Plant Process

Present scenario

Sand plant contains various auxiliary machines. These machines should be switched off along with the knock out system. But it was observed that the machines run continuously, resulting in idle running leading to high specific energy consumption. Relay timer is installed in the sand process to switch off the auxiliary machines three minutes after the knock out stops. This will avoid idle running and result in the energy savings in the sand plant.

Proposed System

Mahendra Pumps foundry division is a medium scale foundry unit located near Civil Aerodrome, Coimbatore. Its average monthly production is around 225 MT of castings.

Plant has installed a timer to stop the auxiliary machines in the process after the knock out and thus to reduce the energy consumption in the sand plant, by avoiding idle running of these auxiliary equipment.

Figure 45: Timer for sand plant process

Benefits

- Reduction in energy consumption.
- Quick payback period.

Cost Benefit Analysis

The estimated annual energy savings is 36,000 kWh, equivalent to a monetary saving of INR 2.80 lakhs. The investment requirement is INR 0.02 lakhs with a simple payback period of less than 1 month.

Cost Economics

Table 40: Cost benefit analysis for timer in sand plant process

Cost Economics	UOM	Value
Energy saving per day	kWh/day	115
Energy saving per annum	kWh	36,000
Cost saving per year	INR Lakhs	2.80
Investment	INR Lakhs	0.02
Simple payback	Months	Immediate
Emission factor	kg CO_2/kWh	0.82
Annual reduction in CO_2 emissions	MT	29.52
Annual Savings in TOE	TOE	3.36
NPV at 70% Debt	INR Lakhs	14.18

4.19. Case Study 19: Reduce Energy Consumption by Modifying the Lining of Ladle

Present scenario

Maintaining the tapping temperature is a critical activity in any foundry. Minimizing or optimizing the tapping temperature mainly depends on ladle condition and heat retention capacity of the ladle. Improved heat retention capacity helps in reducing the tapping temperature, leading to energy conservation.

Proposed System

AKP Ferrocast Pvt. Ltd. is a foundry unit located in Belgaum region. Unit manufactures products like swing post, carriage and brackets, etc. Average production of the unit is in the range of 1,000 to 1,200 MT per month.

To improve heat retention capacity, ladle lining has to be modified to a castable material with higher refractory properties. The modified lining has a better lining life compared to traditional ones. Change the lining of the ladle in a foundry to castable material with higher refractory properties to minimize energy consumption.

Figure 46: Lining for ladle

Benefits

- Improved lining life
- Reduced radiation loss
- Reduced energy consumption and energy costs

Cost Benefit Analysis

The estimated annual energy savings is 117,000 kWh, equivalent to a monetary saving of INR 9 lakhs. The investment requirement is INR 6 lakhs, with a simple payback period of 9 months.

Table 41: Cost benefit analysis for modifying ladle lining

Cost Economics	UOM	Value
Reduction in tapping temperature	°C	15
Energy saving per MT of production	kWh/MT	15

Cost Economics	UOM	Value
Production per day	MT	25
Energy saving per day	kWh	375
Energy saving per year (312 days/year)	kWh	117,000
Annual cost saving (@ 7.75/kWh)	INR Lakhs	9.06
Investment cost	INR Lakhs	6.13
Simple Payback period	Months	9
Emission factor	kg CO_2/kWh	0.82
Annual reduction in CO_2 emissions	MT	95.94
Annual Savings in TOE	TOE	10.06
IRR	%	176
NPV at 70% Debt	INR Lakhs	43.10

4.20. Case Study 20: Installation of Rooftop Solar PV System

Baseline Scenario

The Machine Shop of IH Castings, a foundry unit based in Belgaum was depending on the grid electricity for its operations. Cost of grid power was INR 5.5/ kWh. The unit decided to install rooftop solar PV system considering the following:

- Need for reducing energy cost.
- Becoming green by utilizing the shadow-free roof area available in its facility.

Proposed System

Considering the availability of roof, a 30 kWp rooftop solar PV system has been installed in the facility of the unit. Horizontal global irradiation (Source: Meteonorm 7.2 (1998-2013)) for the location is given below.

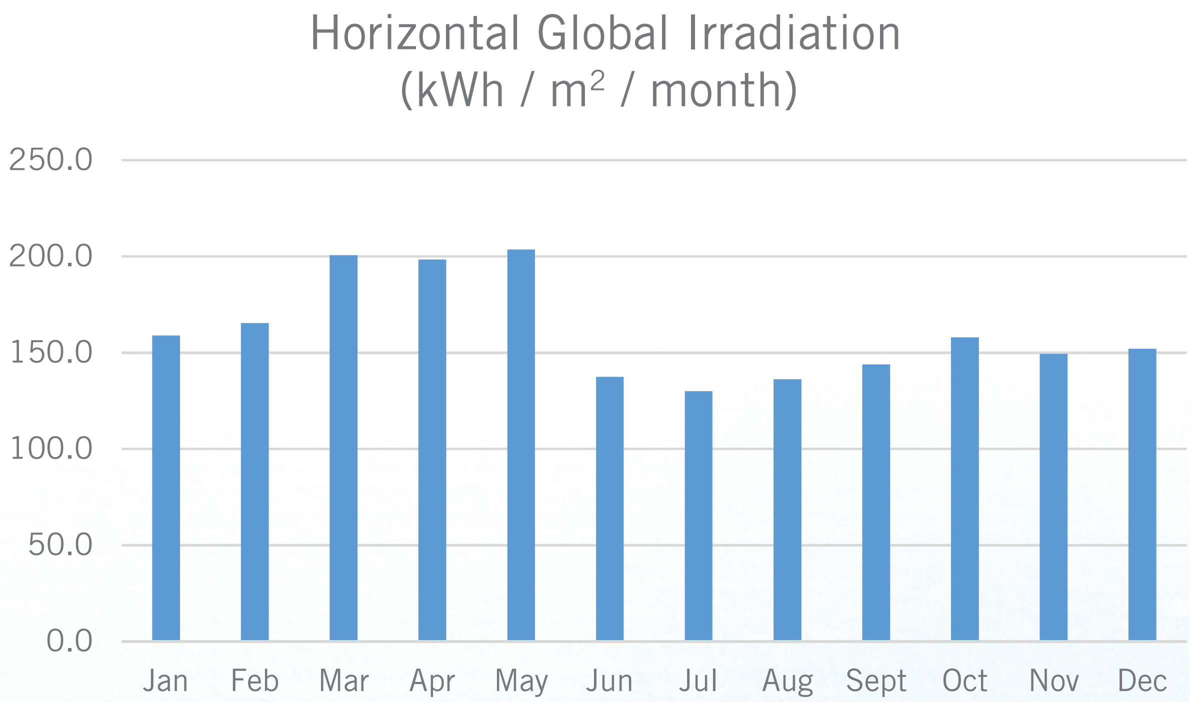

Figure 47: Horizontal global irradiation for plant location in Belgaum

Solar Photovoltaic (PV) modules installed on the roof absorb sunlight and convert light energy from the sun to DC current. This DC current is then converted to AC current with the help of a 30 kWp grid-tied inverter, and the power is fed to the loads.

Figure 48: Rooftop solar PV system

The installed system is capable of generating 120 units of electricity per day. The project has been completed in a period of 45 days. The system is grid connected and excess generation (if any) is fed back to the grid under net-metering scheme of the State of Karnataka.

Merits

- ❖ Solar power is pollution-free and environment friendly.
- ❖ Reduced dependence on foreign oil and fossil fuels.
- ❖ Cost of electricity generation from rooftop solar is becoming cheaper than grid electricity.
- ❖ Commercial and industrial customers paying higher tariff to grid can expect payback in just 3-4 years.
- ❖ Excess power can be sold back to the power company if grid connected.

Limitations

- ❖ Initial investment is high.

Cost Benefit Analysis

Cost benefit analysis for solar-wind hybrid system is provided below. The installed system is capable of generating 36,000 units per annum, thereby saving a minimum of INR 2.16 lakhs per annum.

Table 42: Cost benefit analysis of rooftop solar PV system

Implementation Details	UOM	
Installed capacity of rooftop solar PV system	kWp	30
Electricity tariff	INR / kWh	6
Average annual energy generation on conservative basis	kWh	36,000
Annual cost savings	INR (lakhs)	2.16
Investment	INR (lakhs)	13.5
Accelerated depreciation	%	40%
Simple payback period	Years	4
Emission factor	kg CO_2/kWh	0.82
Annual CO_2 emission reduction	MT	29.5
Annual savings in TOE	TOE	3.10
IRR	%	25.11
NPV	Lakhs	5

Technology Supplier Details

1. Orb Energy

Mr Prabhakar A
Manager - Projects (PV)
M: +91 9480153394
E: a.prabhakar@orbenergy.com

4.21. Case Study 21: Installation of Solar-Wind Hybrid System

Baseline Scenario

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

Sidvin Plastech, Shamirpet has installed solar wind hybrid for power generation. Renewable energy is deemed to be the best substitute for conventional fossil fuel. Implementation of renewable energy poses various challenges, such as high capital cost and inconsistency in power output, of which the latter can be solved by the installation of a 'Solar-Wind Hybrid System'. The unit has enough rooftop area which can be utilized to install a solar-wind hybrid system that can harness solar energy and wind energy for generating electricity.

Horizontal global irradiation for the location is given below.

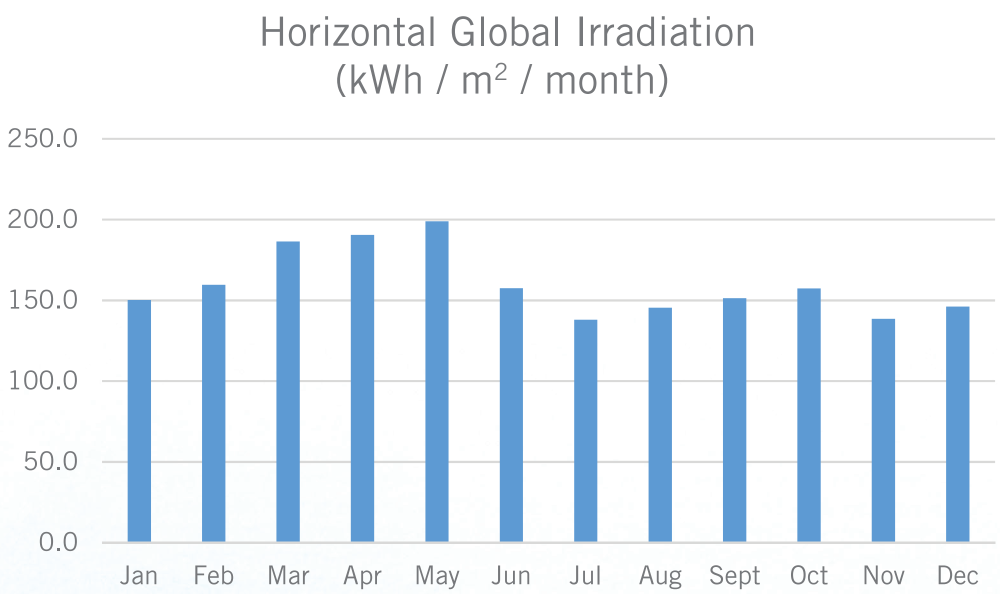

Figure 49: Horizontal global irradiation for plant location in Hyderabad

Average wind speed data (Source: NASA wind speed data and Meteonorm Solar Radiation data) for the location is given below:

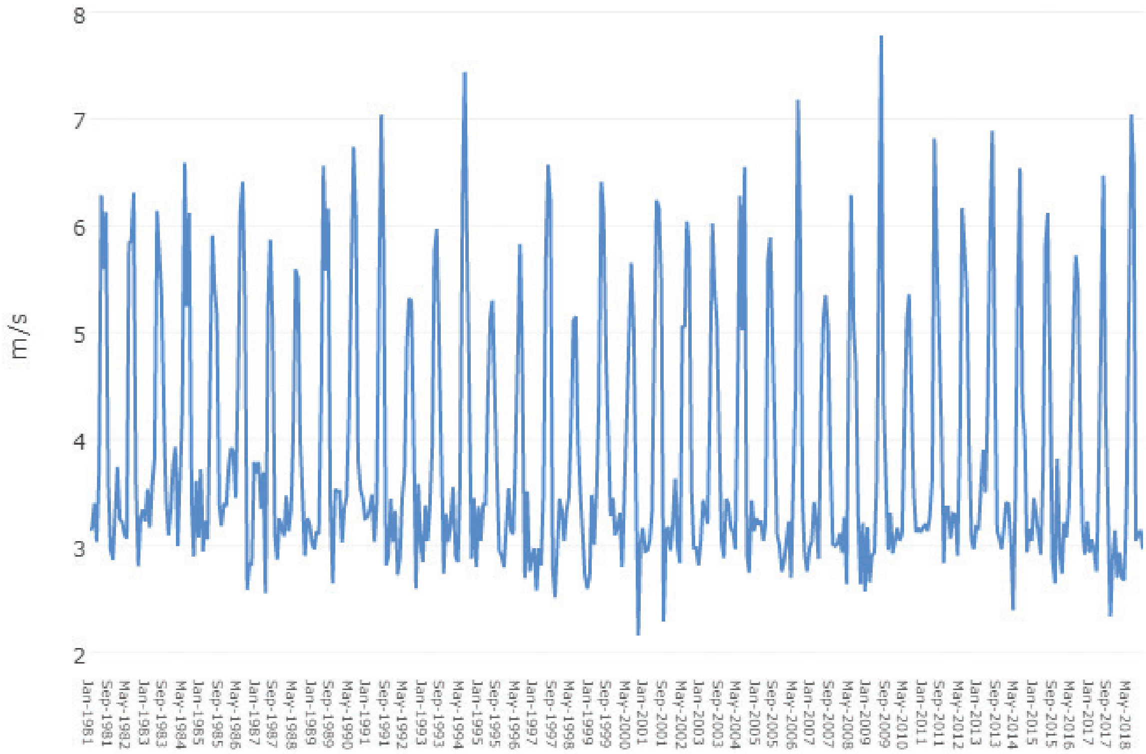

Figure 50: Wind speed at 10 m height in Hyderabad

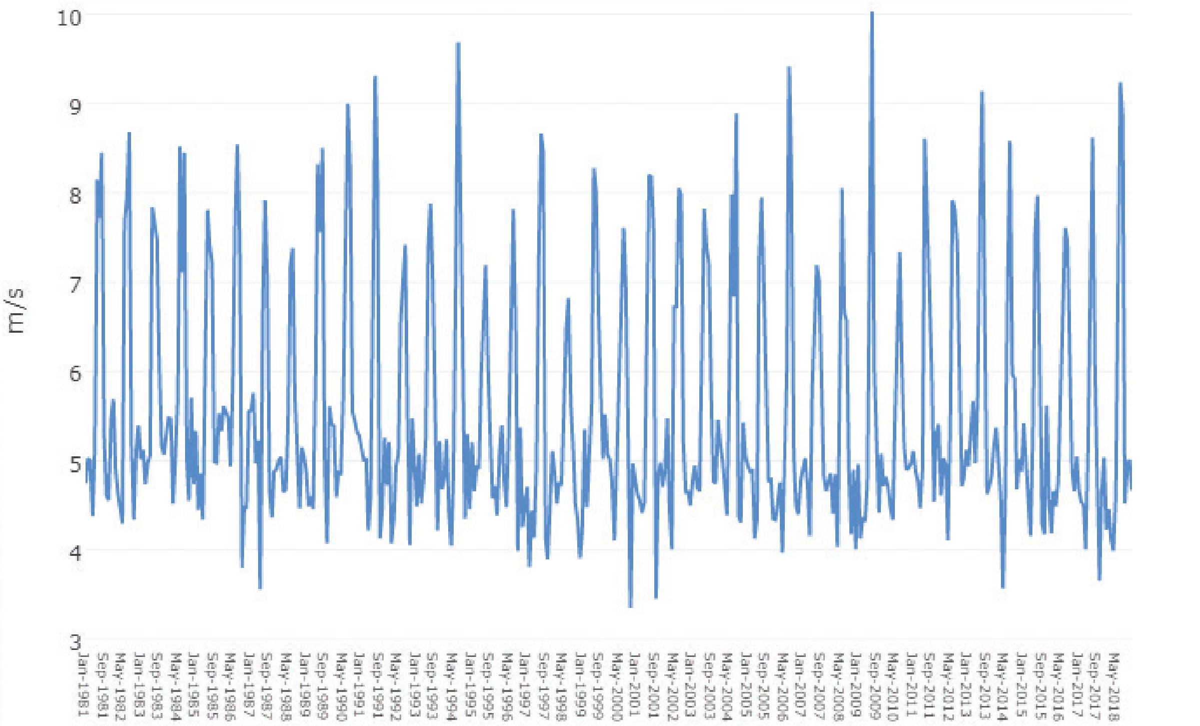

Figure 51: Wind speed at 50 m height in Hyderabad

Proposed System

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

- ❖ Daytime energy from sun and wind.
- ❖ 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 52: 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.

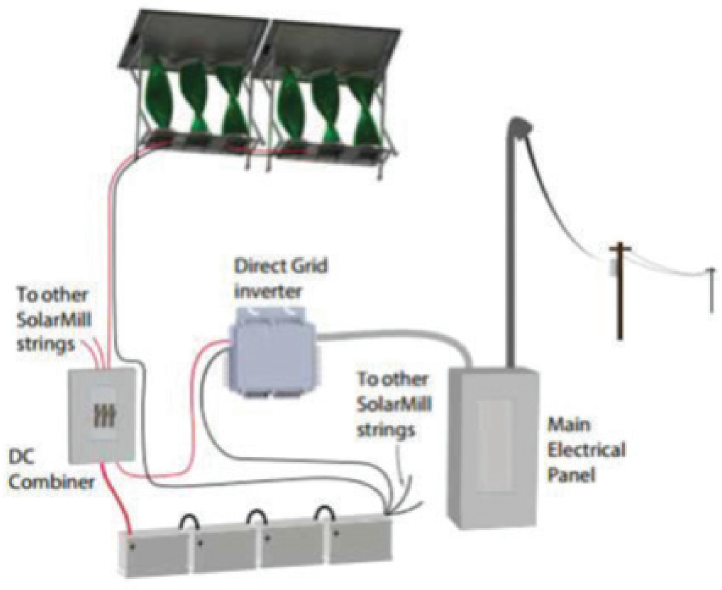

Figure 53: Solar-wind hybrid system connected to supply

The increase of renewable power per square foot of roof is obtained by combining two power sources. For a rooftop installation, combining solar and wind power is a complementary combination. For example, many locations are less windy in the middle of the day when the sun is at its peak, and the wind picks up after dusk. Other advantages are solar module providing protection for the wind portions of the mechanism from direct rain and hail, and assisting with the direction of air into the turbines.

Since this compact installation is designed for rooftops and urban atmosphere, savonous type of wind turbine is chosen for its low running speed and relative insensitivity to turbulence. Power generation begins at a wind speed of 5 kmph. Independent MPPT for both wind and solar is calibrated. Maximum power point tracking (MPPT) is an algorithm included in charge controllers used for extracting maximum available power.

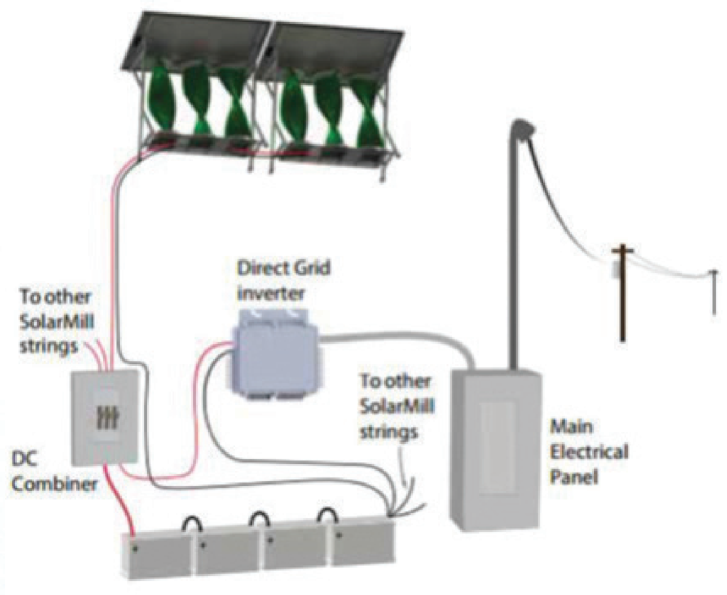

Figure 54: Solar-wind hybrid system connected to loads

The power from both wind and solar generation is routed into a common 48V DC bus which has built-in charge control for a lead acid battery bank.

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.

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 starts at 2-5 m/s and mechanical braking occurs beyond 18 m/s.

Limitations

- High initial investment.

Cost Benefit Analysis

Cost benefit analysis for solar-wind hybrid system is provided below.

Table 43: Cost benefit analysis of solar-wind hybrid system

Implementation Details	UOM	
Installed capacity of solar-wind hybrid system	kWp	50
Average generation per day per kWp	kWh	6.0
Area required	m^2	60
Annual operating days	Days	365
Electricity tariff	INR / kWh	6.5
Average annual energy savings on conservative basis	kWh	1,09,500
Annual cost savings	INR (lakhs)	7.11
Investment	INR (lakhs)	50
Simple payback period	Years	7
Emission factor	kg CO_2/kWh	0.82
Annual CO_2 emission reduction	MT	89.8
Annual savings in TOE	TOE	8.77
IRR	%	20.88
NPV	Lakhs	13.15

5. Conclusion

The Belgaum Foundry sector is keen on adopting various emerging technologies to reduce the overall energy consumption and increase productivity. The main objective of foundry units is to provide quality castings to consumers also remain competitive in the market.

In a typical foundry, furnace, sand handling and moulding sections consume the major share of energy. Overall, energy and specific energy consumption indicators vary significantly from foundry to foundry, due to the variation in the type of castings being made, level of technology adopted, vintage of these units, and capacity utilization.

This compendium highlights energy efficiency improvement opportunities in major areas like furnaces, sand handling systems, and other areas like compressors, motors, cooling towers, pumps, 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 : Low Investment

- Optimization of Air compressor VFD performance through PID loop optimization
- Installation of FRP blades for cooling tower fans
- Installation of electric grinders in place of pneumatic grinders to save energy in a foundry unit
- Installing timer for sand plant process in a foundry

Type B : Medium Investment

- Installation of LID Mechanism for Induction Furnace
- Automation of heat treatment process
- Replacement of existing raw water pump with energy efficient pump
- Replacement of Existing motors with energy efficient (IE3) motors
- Replace LDO firing circuit by biomass gasifier-based producer gas firing circuit
- Improve power factor by Installing KVAR compensator
- Installation of VFD for compressor
- Installation of Energy Management System
- Reduce energy consumption by modifying the lining of ladle in a foundry

Type C : High Investment

- Replacement of SCR based Induction furnace with IGBT Induction Furnace
- Replacement of cupola furnace with EE Induction Furnace
- Replacement of normal cupola furnace with divided blast furnace
- Replacement of all old reciprocating air compressors with new energy efficient screw air compressor
- Replacement of conventional sand plant with energy efficient sand plant
- Energy conservation by modifying compressed air line system in a foundry
- Installation of Rooftop Solar PV System
- Installation of Solar-Wind Hybrid System

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. The foundries 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 attractiveness of the project can also be assessed from the unit abatement cost (UAC). The UAC is defined as the cost/ investment of reducing one unit of energy or pollution. The options having lower UAC are attractive to reduce a unit of energy consumption as lower investments are required to achieve energy savings.

The Begaum Foundry Industry 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 foundries in Belgaum cluster to implement the Renewable Energy & Energy Efficiency projects, and support their journey towards achieving world class standards.

6. List of Technology Suppliers

Table 44: Technology-wise list of suppliers

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	56 A/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.	1 No, Taratala Rd, Taratala, Kolkata, West Bengal 700088	Mr S F Rodrigues Manager 9163700116 s.f.rodrigues@megatherm.com
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.	No 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

Sl No	Name	Address	Contact details
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	No 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.	No 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
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.	No 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 Chennai TN 600062	Mr Sujit Kar General Manager (Foundry - India) 9836190098 sujit.kar@calderys.com

Sl No	Name	Address	Contact details
8	CarprefIndia Private Limited	Plot # 3&4, S.S. Nagar Extension, Anna Main Road, Thirumullaivoyal Chennai Chennai TN 600062	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 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 9822112162 rbkkelsons@gmail.com
Technology : Automation Process Control Sensors (Temperature / Carbon / Silicon Analysis)			
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, 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

Sl No	Name	Address	Contact details
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, Sonini 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)	No 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)	No 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 (Flow Sensor, Dew Point Sensor, Leak Detector, Smart Monitor Software)			
1	Systel Energy Solutions (INDIA) Pvt. Ltd.	No 12, Venkata Lakshmi Nagar, Chellandy Amman Nagar, Singanallur, Tamil Nadu 641005	Ms. Sasi Kala Sales Coordinator 90477 78715 support@systel.asia
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	No 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

Sl No	Name	Address	Contact details
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
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

Sl No	Name	Address	Contact details
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.	Mr Sameer Kanabargi 9448480724 phoenix_bgm@hotmail.com
Technology : Solar PV			
1	Orb Energy	No 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

Sl No	Name	Address	Contact details
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. N-46, House No. 4-9-10,, HMT Nagar, Nacharam, Hyderabad, Telangana 500076	Mr Devaraj South Head – BD ✆ 8870014206 ✉ suseendhar@fourthpartner.co
	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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