UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

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

## Indore Pharma, Readymade Garments & Food Processing 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 pharma, readymade garments & food processing industry ***located at Indore, Madhya Pradesh, India***. The contents and views expressed in this document are those of the contributors and do not necessarily reflect the views of CII, BEE or UNIDO, its Secretariat, its Offices in India and elsewhere, or any of its Member States.

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

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

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Compendium of

# Energy Efficiency and Renewable Energy Technologies for Indore Mixed Cluster

September 2020

Developed under the assignment

## Scaling up and expanding of project activities in MSME Clusters

Prepared by

Confederation of Indian Industry
125 Years - Since 1895

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# Acknowledgement

# Acknowledgement

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

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**CII Team**

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# List of Abbreviations

| | |
|---|---|
| AC | Alternating Current |
| AHU | Air Handling Unit |
| AIDMA | All India Dal Mill Association |
| APFC | Automatic Power Factor Controller |
| BEE | Bureau of Energy Efficiency |
| BEP | Best Efficiency Point |
| BLDC | Brushless Direct Current |
| CAGR | Compound Annual Growth Rate |
| CII | Confederation of Indian Industry |
| CIP | Cleaning in Place |
| COP | Coefficient of Performance |
| DC | Direct Current |
| DG | Diesel Generator |
| DPIIT | Department for Promotion of Industry and Internal Trade |
| EC | Electronically Commutated |
| ECM | Energy Conservation Measure |
| EHP | Electric Heat Pump |
| FCU | Fan Coil Unit |
| FO | Furnace Oil |
| GDP | Gross Domestic Product |
| GEF | Global Environmental Facility |
| GHG | Green House Gas |
| HID | High-intensity discharge |
| HSD | High Speed Diesel |
| HVAC | Heating Ventilation and Air Conditioning |
| IAQ | Indoor Air Quality |
| IEC | Indirect Evaporative Cooling |
| IFC | Intelligent Flow Controller |
| IIUS | Industrial Infrastructure Up-gradation Scheme |
| IoT | Internet of Things |

| | |
|---|---|
| IRR | Internal Rate of Return |
| LED | Light Emitting Diode |
| LP | Low Pressure |
| LSP | Local Service Provider |
| MPPT | Maximum Power Point Tracker |
| MSME | Micro Small and Medium Enterprises |
| M&V | Monitoring & Verification |
| MPAMA | Madhya Pradesh Ayurvedic Manufacturing Association |
| MPLUN | Madhya Pradesh Laghu Udyog Nigam |
| MPPMO | Madhya Pradesh Pharmaceutical Manufacturers Organisation |
| MPSSDMA | Madhya Pradesh Small Scale Drugs Manufacturers Association |
| NG | Natural Gas |
| NPV | Net Present Value |
| OEM | Original Equipment Manufacturer |
| PF | Power Factor |
| PV | Photovoltaic |
| RE | Renewable Energy |
| SEC | Specific Energy Consumption |
| TOE | Tons of Oil Equivalent |
| UNIDO | United Nations Industrial Development Organisation |
| UOM | Unit of Measurement |
| VFD | Variable Frequency Drive |
| WHR | Waste Heat Recovery |

# Unit of Measurements

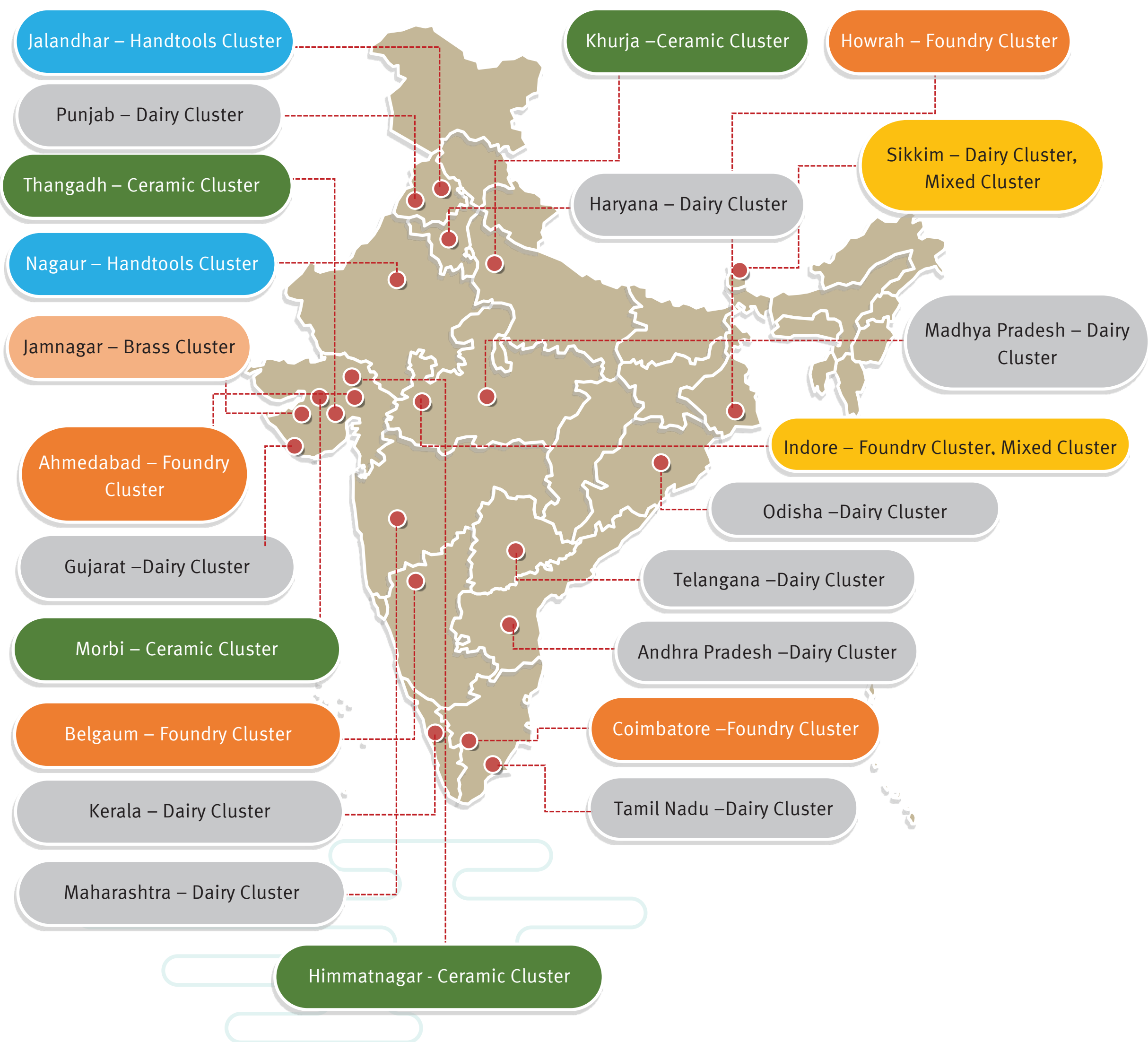
| | |
|---|---|
| CFM | Cubic feet per minute |
| gm | Grams |
| HP | Horse Power |
| kg | Kilogram |
| $kg/cm^2$ | kilo gram per area |
| kJ | Kilo Joule |
| kl | Kilo Litre |
| kl/hr | Kilo Litre per Hour |
| km | Kilometre |
| kVar | Reactive Power |
| kW | Kilo Watt |
| kWh | Kilo Watt Hour |
| kWp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


# 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 $CO_2$ emissions as on date.



The key components of the project include:

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

# About The Technology Compendium

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

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

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

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

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

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# Executive Summary

# Executive Summary

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

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

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

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

Chapter 1 of the compendium provides an overview of Indore industrial profile and brief about different clusters like Pharma, Food Processing & Readymade Garments

Chapter 2, Chapter 3, Chapter 4 focus on a brief overview of process, technology status in the cluster and energy saving opportunities for Food Processing, Pharma and Readymade Garment Clusters respectively.

Chapter 5 details all the general energy saving opportunities and best practices which are common and applicable to all the above mentioned sectors of this cluster.

Chapter 6 provides detailed case studies for some of the high impact and implementable energy efficient technologies in all the focussed sectors under separate sections of the chapter. In this chapter, **19** case studies have been included in areas such as:

- Biomass fired roaster systems & waste heat recovery systems for food processing industry.
- Indirect evaporative cooling systems for clean rooms, EC AHU technology and Active refrigerant agents for avoiding oil fouling in chillers for pharma industry.

- Condensate recovery systems, VFD for pumps and steam line leakage optimization for readymade garments industry.
- Compressor load optimization, automatic power factor correction, renewable energy and other utility energy enhancement systems for all the above-mentioned sectors in common.
- These technologies are described in detail, such as baseline scenario, proposed scenario, merits, demerits, etc., and wherever possible, a case reference from a similar industry that has implemented the technology has been included. In most of the case studies, typical energy saving data, GHG emission reduction, investments, payback period, Local service/ technology provider details etc., have been highlighted.

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

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# Indore Industrial Profile

# 1. Indore Industrial Profile

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

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

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

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

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

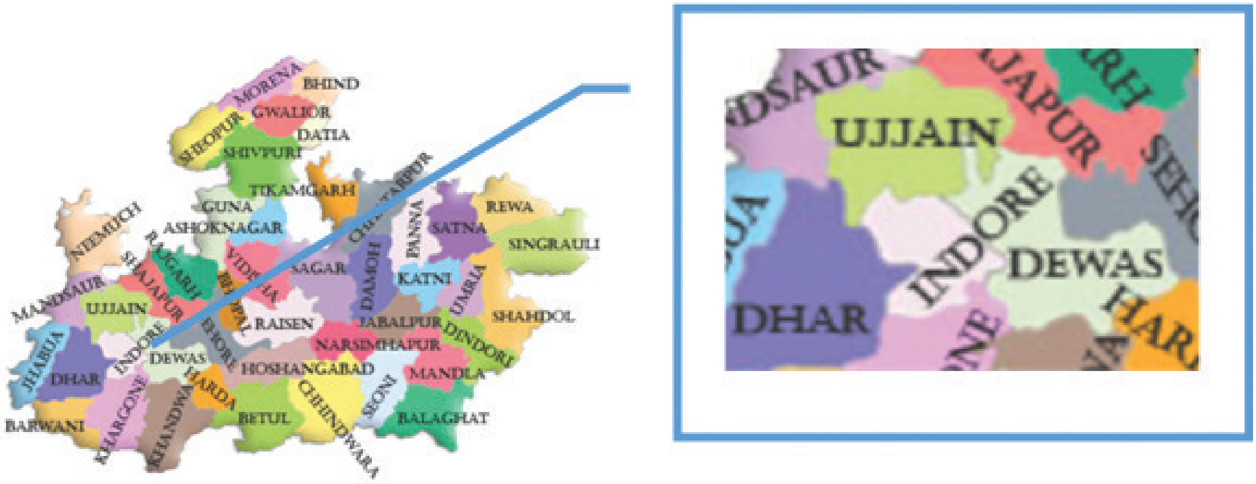


*Figure 1: MSME clusters in & around Indore*

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

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

## 1.1. Indore Food Processing Cluster

Apart from foundry, pharma & auto industries, there are about 200 food product manufacturing MSME units scattered across Indore and Ujjain. The major products processed in these food industries include poha (rice flakes) and various types of pulses – Pegion Pea, Red Lentil, Chick Peas, Arahar, Split Mung Bean, etc. New clusters like a Poha cluster in Ujjain, Dal mill & Namkeen clusters in Indore were formed recently.

### 1.1.1. Indore Dal Mill Cluster:

A dal mill procures dal from farmers and processes it for end consumers. Processing operations, such as dehusking, splitting, cleaning, sorting, and packing are carried out in a dal mill. Indore is an important dal mill cluster Madhya Pradesh. Dal is grown extensively around Indore due to favourable soil and weather conditions. Also there also is a high demand of Besan (Gram Flour) for making Namkeen (savoury snacks) by the local snack-manufacturing units. The cluster has about 100 dal mills. The estimated production of dal in the cluster is around 1,500 tons per day.

*Figure 2: Dal Mill*

#### Cluster Associations:

**The Association of Pulse Manufacturing Industries, Madhya Pradesh:** The Association of Pulse Manufacturing Industries, Madhya Pradesh has around 125 members. It is mainly involved in activities pertaining to addressing the common issues of its members and making representations to government bodies.

**All India Dal Mill Association (AIDMA):** This is the apex industry association for dal mills in the country. The association was incorporated with the objectives of providing support for its members on the promotion and development of its manufacturing activities, improving the overall market situation, and to keep it stable. It addresses national level issues pertaining to the industry with government ministries and other entities.

### 1.1.2. Ujjain Poha Cluster:

Around 50 units operate under Ujjain Poha cluster with an estimated turnover of around 100 crore. Raw material paddy is being transported from Chhattisgarh, Gujarat & from different parts of MP itself. Main market for the cluster is MP, Maharashtra, Bihar, Gujarat and Rajasthan.

*Figure 3: Poha Roaster*

## 1.1.3. Indore Namkeen Cluster:

Namkeen cluster was selected as the innovative cluster of Indore. Principal products manufactured in this cluster are Khaara, Farsan, Chevda, Sev, Chips, Bhajiya etc. Around 350 units are functional in this cluster with an estimated turnover of around of 420 crores.

**Cluster Association:** Indore Namkeen and Mithai Nirmata Sangh

*Figure 4: Namkeen Manufacturing*

**Cluster Association:**

Poha Permal Nirmatha Sangh

## 1.2. Indore Pharma Cluster

In 1958, the state government of Madhya Pradesh constructed multiple-shed complexes, enabling provision of basic infrastructure, which attracted pharmaceutical entrepreneurs to start business. The next decade (1960s) saw growth of Ayurvedic and Allopathic industries with the establishment of Laxmi Bai Nagar Industrial Area by the Industries Department of the Government of Madhya Pradesh. However, the real boom in the pharmaceutical industry was marked by the beginning of the active involvement of Madhya Pradesh Laghu Udyog Nigam (MPLUN).

The pharmaceutical sector is spread at Dewas, Ujjain, Dhar and Pithampur districts surrounding Indore. It is housing around 300 manufacturing units of the pharmaceutical sector and providing employment to around 20,000 personnel. Cipla, Novartis, Ranbaxy Limited, IPCA, and Lupin are the major anchor units of the sector in the state.

*Figure 5: Pharmaceutical Manufacturing*

The early nineties the saw establishment of a pharmaceutical industrial estate at Pithampur and that of Dawa Bazar, which covered 200 pharmaceuticals companies under one roof and helped wholesalers establish offices. Indore's Dawa Bazar is one of Asia's biggest pharmaceutical trade houses, where apart from wholesale and retail outlets of small manufacturers of the cluster, multinational and other big companies have marketing offices.

### Cluster Associations:

**Madhya Pradesh Pharmaceutical Manufacturers Organisation (MPPMO)** was formed and registered under Society Act during 1977 with the prime objective of regulatory affairs presentation with various government organisations like FDA, MPLUN, PCB, etc. Executive body meeting is held once a month to discuss general issues.

**Madhya Pradesh Small Scale Drugs Manufacturers Association (MPSSDMA):** This is another association of Pharmaceutical Manufacturers working for the development of the pharma companies.

**Madhya Pradesh Ayurvedic Manufacturing Association (MPAMA):** Ayurvedic medicine manufacturers do have their own association with the same objectives, and it works as the above two. Government of M.P. has identified an area of 167 acres near "Betma" at NH12, Indore–Ahmedabad Road. The area is to be developed as a "Herbal Park".

## 1.3. Indore Readymade Garments Cluster

During 1940-50, there were only two or three units, which moved up to six units in 1950-60, and during 1960-70, the total number of readymade garment units shot up to 150 units, due to a big change in fashions, as people tried out new designs encouraged by the movies of the time. Between the 70's and 80's, the number rose sharply to 500, and it went on increasing to 1,200 between the 80's and 90's, and up to 1,500 between 1990 and 2000, with an annual turnover of around INR 6,000 million. Most of the units were small units, with about 100,000 persons directly or indirectly engaged in the cluster.


*Figure 6: Readymade Garment Industry*

The readymade garments manufactured in Indore are well received in the overseas market. The products are exported through various marketing channels to the U.K., France, other EU countries, and the Middle East. Indore city has been a large centre of textile mills, and the Readymade Garments industry is an offshoot of these textile mills. The industry also owes its debut to the readymade garment industry in the nearby cities of Mumbai and Ahmedabad. At present, there are more than 2,200 units involved in the manufacturing of readymade garments.

The readymade garment industry of Indore can be categorized as under:

- Manufacturers who are exporters.
- Manufacturers in the domestic market.
- Fabricators.
- Machine embroidery groups.
- Skilled labour doing hand embroidery and other related works.

- Groups engaged in bleaching/dyeing/washing of the fabric garment.
- Groups comprising dealers, traders and manufacturers of fabric, buttons, labels, fittings, etc.
- Machine suppliers, tooling suppliers, manufacturers of packaging materials and other inputs.
- Groups comprising of dealers, traders, exporters, and marketing agents.

## Cluster Associations

**Indore Readymade Vastra Vyapar Sangh:** This association was formed in 1966. It plays an active role in the developmental work of its members and organizes many events from time to time. It also solves disputes between buyers and manufacturers of readymade garments. There are 600 members in this association.

**Readymade Garments Complex Association:** This association was formed recently and consists of all units which are located within the readymade garment complex. It is actively involved in all matters for the development of the readymade garment complex and problems faced by its members.

# Indore Food Processing Cluster

# 2. Indore Food Processing Cluster

## 2.1. Process Description

### 2.1.1. Dal Mills

Since pulses are commonly consumed in de-husked and split form, the processing of pulses is a definite activity and assumes a lot of importance. The processing of pulses is undertaken at three levels i.e. Primary, Secondary and Tertiary.

- **Primary Processing:** Consists mainly of production of cleaned, graded and packaged pulses.
- **Secondary Processing:** Consists of de-husking, splitting, polishing, turmeric coating, powdered besan and packaged dal.
- **Tertiary Processing:** Consists mainly of preparation of roasted, fried dal and other associated dal products.

#### Conventional pulses milling process

- Wet Milling operations consist of cleaning of chaffs, dirt, etc. The steps in the process involve mainly Soaking, Mixing with red soil, Conditioning, De-husking and Splitting, Separation and Grading, Dehusked & Split Pulses, and Bagging.
- Dry Milling operations consist of Cleaning of Chaffs & dirt, Pitting, Pre-treatment with Oil, Conditioning, Dehusking and Splitting the mixture of husk, broken & Powder, Grading, Polishing, Grade I Pulses.

The description of various operations involved in the pulses processing are mentioned below.

#### Cleaning & Grading Cleaning

Helps in removing the husk, dust, etc. from the pulses and grading is done to segregate the grain legumes of desired shape and size on a rotating type of cleaner.

#### Pitting

An empty roller machine is used for cracking the husk layer and for scratching the clean pulses passing through it. This is done for loosening the husk from sticking to the cotyledons in order to facilitate subsequent oil penetration. Cracking and scratching of husk takes place mainly by friction between pulses as material is passed through narrowing clearance. During the operations, some of the pulses are de-husked and split and are separated by sieving.

*Figure 7: Sizing & Sorting Operations*

## Pre-treatment with oil

The scratched or pitted material is passed through a screw conveyor and mixing of some edible oil like linseed is done in it. Pulses coming out of the screw conveyor are kept out about 8 to 10 hours to diffuse oil.

## Conditioning Pulses

Pulses are conditioned by ultimate soaking / wetting, drying and temporary moisture of 3.5 per cent added after about 8 hours and grain is dried in sun again until all the pulses are sufficiently conditioned. The whole process of alternate wetting and drying is continued for 2 to 4 days. Pulses are finally dried to about 10 to 12 per cent moisture content prior to de-husking and splitting.

## De-husking & Splitting

For de-husking of conditioned pulses, carborundum coated emery rollers are used. In one pass 50 % of the pulses are de-husked. The de-husked split pulses are separated by sieving and husk is aspirated off. Un-split pulses and tail pulses are again de-husked and milled in a similar way. For complete de-husking and splitting, the whole process is repeated two to three times.

*Figure 8: Dehusking*

## Polishing

Polishing is completed by treating de-husked and split pulses with small quantity of oil.

## Weighing and Packaging

After polishing, the de-husked pulses are packed in bulk or retail packing, as desired. The packing material may be pre-printed or plain packs.

## 2.1.2. Poha

The various steps followed in making of poha are as follows:

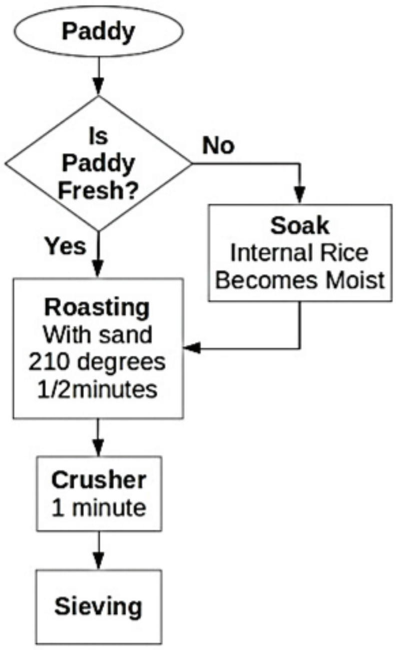


*Figure 9: Poha Manufacturing Process Flow Diagram*

- Paddy is cleaned and impurities are removed. Then it is soaked in hot water for 3 hours. If the paddy is straight from plant i.e. moist, one doesn't need to soak it in water.
- After drying it in shade overnight, paddy is put in to the hopper and transferred to roaster oven to remove moisture. Roaster can be of any type like depending upon the fuel availability.
- Roasted paddy comes out and some fraction of it gets popped. These flakes are then passed through sieves to remove unwanted material (husk)
- Husk obtained from sieve machine can be re-introduced in to fuel chamber of oven. Further the fly ash can be used as an additive in brick making.
- These filtered flakes are then passed through a roller to flatten. Starch helps in getting it flattened. The degree of flatness is adjusted by varying pressure applied by hand.
- Flakes thus obtained are of fairly even size but some would be whole, some broken in the process which are also separated. The flattened rice flakes are packed and stored for final dispatch.

*Figure 10: Poha packing section*

## 2.1.3. Namkeen

Namkeen manufacturing can be broadly explained in the below-mentioned steps.

### Laboratory:

First, the company receives raw material from the wholesaler and material is checked by the quality officer. If there is any problem in the material, it is rejected materials and sent back to supplier.

### Storage:

Raw material is not used all at once, so the extra material is kept in storage. Company has a large place for storing bulk material. Company's store room is behind the compass.

### Dough Making:

It is the first step is making a product; in this step, flour is tight according to production.

### Frying Process:

Second step of the production is frying. In this step, company fries all types of Fryums and namkeen in frying pan. The company has the latest machinery for this process.

### Oil Extractor:

After frying, excess oil in the namkeen is sent into the machinery. In this machine, extra oil is removed.

### Semi Automation Seasoning Process:

In this step, all namkeen and Fryums items are mixed with a seasoning. Seasoning can be sweet, spicy, salty, etc.

### Automatic Pouch Packing:

In this step, all products are packed properly. Gopal Namkeen has automated packaging according to weight in grams. A most important thing is packing the products into the correct bags.

### Box Packing:

Box packing is the last step of the entire process. In this process, all packed products are packed in big cartoons according to box size and sent to carriage.

# 2.2. Technology Status

There are about 200 food product manufacturing MSME units scattered across Indore and Ujjain. The major products processed in these food industries include poha (rice flakes) and various types of pulses – toor, masoor, chana, arahar, moong, etc., and the major energy consuming equipment are conventional motors, dryers and roasters. Due to their small sizes, lack of specialized manpower or knowledge about latest energy efficient technologies, these MSME units are operating with age-old technologies, which are inefficient and outdated. This results in consumption of more energy than required, increasing production costs and reducing their competitiveness in the market.

## 2.2.1. Dal Mills

Major processes/equipment used in dal mills are drying oven, milling machines, conveyor systems, air compressors & blower systems. Electricity and wood are the major sources of energy used in the cluster. Electricity is supplied by Madhya Pradesh Paschim Kshetra Vidyut Vitaran Company Limited (MPPKVVCL) and wood is procured from the local market. The power outage is minimal in the cluster, and hence, diesel consumption is insignificant. The cost of electricity per unit is INR 7.5, and wood cost is around INR 6-7 per kg.

The specific energy consumption (SEC) of the units varies considerably depending on the type of products being manufactured. The share of the energy cost in the final product accounts for about 6 – 8%. The overall energy consumption of the cluster is estimated to be about 4,241 tons of oil equivalent (TOE) per annum, which is equivalent to emissions of about 18, 368 tons of $CO_2$. The overall energy bill of the cluster is estimated at INR 210 million (approx).

Still, most of the units are using diesel operated ovens for drying, which can be upgraded to either wood-based or NG-based ovens for better techno-commercial benefits. There is also an option to go with VFD for air compressors as the loading was considerably low in some of the units.

## 2.2.2. Poha & Namkeen

Major energy sources used in poha and namkeen industries are grid electrical energy (30%) and thermal energy from wood or saw dust (70%). Thermal energy in the form of saw dust was being used to fire the roasters in poha units. It was observed that the roasters were operating very inefficiently due to several operating losses like supply of too much excess combustion air and non-availability of any waste heat recovery system in the flue gas path leading to high amount of dry flue gas loss. There was lack of combustion control mechanism in the roasters leading to over-heating of roaster internals; high surface temperature of roaster walls and inspection window remaining open all the time leading to high radiation and convection losses; improper combustion of fuel in the roaster leading to high amount of un-burnt in bottom ash and high CO in flue gas. Electrical energy is majorly used for powering up their conveyor system motors and general lighting. Some of the units have went for installing energy efficient motors above IE3 and achieved decently good results in energy savings. There exists a good scope for the industry to go with energy efficient motors.

Renewable energy quotient was also found very less in both dal and poha mills. Only limited number of plants have installed RE systems and other industries in Poha cluster were more interested to go with solar PV system installation.

# 2.3. Energy Efficiency Opportunities

## 2.3.1. Dal

**Ovens:** Some of the mills in the cluster use drying ovens. In general, the ovens are used in the rainy season for drying. The oven uses wood as the fuel. Insulation improvement, reduction in the heating volume, and, the proper use of air draft will result in fuel savings. Some units who were having a NG pipe line connection have shifted from wood fired oven systems to NG fired ovens

*Figure 11: Drying Oven*

**Use of cogged V-belts in Drives:** The driving motors are generally coupled with flat V-belts or flat belts in most machines. The transmission efficiency of flat V-belt is around 90%–92%. It is recommended to use a cogged V-belt instead of a flat V-belt. The transmission efficiency of a cogged V-belt is 3%–5% higher than a flat belt. Cogged V-belts use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and the power-transfer capability of belts. V-belt drives can have a peak efficiency of 95–98%. They play a dynamic role in allowing for heat dissipation and better contact with the pulley. There are several other potential benefits of using cog belts which include, (i) less slippage at high torque, (ii) low maintenance and re-tensioning, and (iii) suitable for wet or oily environment.

## 2.3.2. Poha

- Replacement of conveyor and elevator motors with energy efficient (EE) motors with gearbox.
- Replacement of press (poha) machine motors and flaker machine motors with EE motors
- Replacement of roaster motor with EE motor and gear controls.
- Rebuilding the roaster with fire bricks and providing thermal insulation of glass wool.
- Optimization of roaster excess air and fuel feed control using oxygen sensors and VFD on feeder motor.
- Providing cast door of MS sheet and insulating body for ash removal door on roaster.
- Conversion of saw dust as a fuel into gas based fuel system for roaster.
- Waste heat recovery from roaster flue gas.
- Installation of Solar Roof top system.

### 2.3.3. Namkeen

Installation of biomass gasifier based furnace for Namkeen making which has an advantage of clean energy utilization with an energy saving potential of around 35–50% compared to conventional fossil fuel based systems.

Installation of fryer machines with conveyor belts and bucket elevators will have precise process control and have a saving potential of around 20%.

Installation of efficient and uniform Namkeen mixing machine which will have a good potential for energy savings.

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# Indore Pharma Cluster

# 3. Indore Pharma Cluster

## 3.1. Process Description

Pharmaceutical processing is the process of drug manufacturing and can be broken down into a range of unit operations, such as blending, granulation, milling, coating, tablet pressing, filling and others. The Pharmaceutical manufacturing process has precise requirements and manufacturing guidelines in terms of quality. As a result, it is crucial that pharmaceutical manufacturing equipment complies with good manufacturing practices.

Pharmaceutical process development is the process from research and development, laboratory formulation to commercial production of pharmaceuticals.

While health is a crucially important social and economic asset, both infectious and non-communicable diseases pose a major threat to the well-being and prosperity of populations. In the pharmaceutical product development process quality is essential – cutting-edge research, excellent processes, quality products make pharmaceutical companies stand out. New diseases require new cures, increased competition requires faster, leaner processes in all aspects of the operations.

The pharmaceutical manufacturing process is typically made up of a combination of specific unit processes chosen according to the physical and chemical characteristics of the active pharmaceutical ingredient.

**Dry granulation:** Compaction of a low-density powder to a granule. The roller compaction process consists of a combination of screw feed, compaction and milling systems.

**Powder blending:** In the pharmaceutical industry, a wide range of excipients may be blended together to create the final blend used to manufacture the solid dosage form. The uniqueness of each individual drug formulation assures that no two blending processes can ever be identical.

**High shear and wet granulation:** Commonly used processes for densification, to improve flowability, content uniformity or wettability or to improve dispensing qualities.

**Fluid bed granulation:** Top spray, bottom spray and rotary (tangential spray) are commonly used in the food and pharmaceutical industries.

**Hot melt extrusion:** Utilized in pharmaceutical processing to enable delivery of drugs with poor solubility and bioavailability. Of particular interest is the use of HME to disperse active pharmaceutical ingredients (APIs) in a matrix at the molecular level, thus forming solid solutions.

**Drying:** Understanding and controlling moisture content of powders is critical to many pharmaceutical processes. Fluid bed or laminar flow drying conditions impact on both physical and chemical characteristics of powder and granules.

**Pharmaceutical milling:** The process of using rotary cutters in pharmaceutical equipment machinery to remove materials from a workpiece by feeding in at an angle with the axis of the tool.

**Compression of powder or granules into tablets:** An efficient process for producing a solid dose medication.

**Tablet coating equipment:** Options include batch process coating pan, off-press continuous coating or continuous processing.

**Pharmaceutical encapsulation:** The containment of a solid or liquid dose of a drug in a soft shell or hard pre-formed capsule.

**Micronization:** The process of reducing the particle sizes of pharmaceutical products, under very high pressures, sheer, turbulence, acceleration and impact, to make them more stable and clinically effective.

**Pharmaceutical processing equipment:** Pharmaceutical processing equipment includes a wide variety of equipment for specific unit processes, such as:

- Pharmaceutical Drying Equipment
- Pharmaceutical Extruders
- Pharmaceutical Mills
- Pharmaceutical Granulation Equipment
- Pharmaceutical Tablet Compression
- Pharmaceutical Feeders
- Pharmaceutical Filling Equipment
- Pharmaceutical Metal Detection
- Pharmaceutical Mixing Equipment
- Pharmaceutical Pneumatic Conveying Equipment

## 3.2. Technology Status

Pharmaceutical units in Indore can be divided into two groups:

- Allopathic Formulations.
- Ayurvedic Formulations.

At present about 350 pharmaceutical units in Indore are manufacturing different products like tablets, liquids, ointments, capsules eye drops, IV fluids etc. Majority of the units are using old/ traditional manufacturing technology due to non-availability of sufficient space for expansion.

The major energy forms used by pharmaceutical units in Indore Pharma cluster include electricity, LPG and HSD/LDO. Electricity from grid is used for different motive loads in the processing sections, chillers and air compressors. Thermal energy in the form of steam/ hot water is used for formulation process and drying. HSD/LDO and LPG is primarily used as the fuel in boiler for generating steam. Apart from steam generation, HSD is also used in the DG sets to cater the necessary power requirements during grid staggering.

Major energy consuming areas are HVAC systems, compressed air systems & boiler systems however almost all of the pharma units are using belt driven damper controlled AHU units. There is good scope to convert from belt driven to direct driven variable speed systems. Major portion of HVAC needs are catered by vapour compression system itself. There came an upgradation in chiller compression systems in most of the units but still there exists a scope of improvement for employing free cooling or indirect evaporative cooling systems.

Most of the compressors are running at partial loading conditions and some compressors are very old and having high specific energy consumption. Condensate recovery from boilers is also good opportunity many pharma units in the cluster can opt for.

It is observed that some units have installed solar thermal systems for process hot water generation. There is an opportunity still for many of the units for opting solar thermal energy.

## 3.3. Energy Saving Opportunities

A variety of opportunities exist in pharmaceutical laboratories, manufacturing facilities, and other buildings to reduce energy consumption while maintaining or enhancing productivity. Energy efficiency opportunities for the pharmaceutical industry are broadly categorized by various sections like HVAC Systems, Fume Hoods, Clean Rooms, Motor Systems, Compressed Air Systems, Pumps, Refrigeration Systems, Lighting, and Heat & Steam Distribution.

### HVAC Systems

The components of HVAC systems generally include dampers, supply and exhaust fans, filters, humidifiers, dehumidifiers, heating and cooling coils, ducts, and various sensors. Different spaces and building uses in manufacturing & laboratory facilities require different HVAC applications which also should comply with domestic and international standards.

**Energy efficient system design:** The greatest opportunities for energy efficiency exist at the design stage for HVAC systems in new industrial facilities. By sizing equipment properly and designing energy efficiency into a new facility, a pharmaceutical manufacturer can minimize the energy consumption and operational costs of its plant HVAC systems from the outset. This practice often saves money in the long run, as it is generally cheaper to install energy efficient HVAC equipment at building construction than it is to upgrade an existing building which can lead to further delays and production downtime.

**Energy monitoring and control systems:** An energy monitoring and control system supports the efficient operation of HVAC systems by monitoring, controlling, and tracking system energy consumption. Such systems continuously manage and optimize HVAC 24 system energy consumption while also providing building engineers and energy managers with a valuable diagnostic tool for tracking energy consumption and identifying potential HVAC system problems. Several industrial case studies indicate that the average payback period for HVAC control systems is about 1.3 years.

**Non-production hours set-back temperatures:** Setting back building temperatures (i.e., turning building temperatures down in winter or up in summer) during periods of non-use, such as weekends or non-production times, can lead to significant savings in HVAC energy consumption. Similarly, reducing ventilation in cleanrooms and laboratories during periods of non-use can also lead to energy savings. In recent studies of laboratories and cleanrooms in the pharmaceutical and similar industries, HVAC systems were found to account for up to two-thirds of facility energy consumption. Thus, scaling back HVAC energy consumption during periods of non-use can have a major impact.

**Duct leakage repair:** Duct leakage can waste significant amounts of energy in HVAC systems. Measures for reducing duct leakage include installing duct insulation and performing regular duct inspection and maintenance, including ongoing leak detection and repair. According to studies by Lawrence Berkeley National Laboratory, repairing duct leaks in industrial and commercial spaces could reduce HVAC energy consumption by up to 30%.

**Variable-air-volume (VAV) systems:** Variable-air-volume systems adjust the rate of air flow into a room or space based on the current air flow requirements of that room or space, and therefore work to optimize the air flow within HVAC ductwork. By optimizing air flow, the loads on building air handling units can be reduced, thereby leading to reduced electricity consumption. Adjustable speed drives (ASDs). Adjustable speed drives can be installed on variable volume air handlers, as well as recirculation fans, to match the flow and pressure requirements of air handling systems precisely. Energy consumed by fans can be lowered considerably since they are not constantly running at full speed. Adjustable speed drives can also be used on chiller pumps and water systems pumps to minimize power consumption based on system demand.

**Heat recovery systems:** Heat recovery systems reduce the energy required to heat or cool facility intake air by harnessing the thermal energy of the facility's exhaust air. Common heat recovery systems include heat recovery wheels, heat pipes, and run-around loops. For areas requiring 100% make-up air, studies have shown that heat recovery systems can reduce a facility's heating/cooling cost by about 3% for each degree (Fahrenheit) that the intake air is raised/lowered. The payback period is typically three years or less.

**HVAC chiller efficiency improvement:** The efficiency of chillers can be improved by reducing the temperature of the condenser water, thereby increasing the chilled water temperature differential. This can reduce pumping energy requirements. Another possible efficiency measure is the installation of separate high-temperature chillers for process cooling. Sizing chillers to better balance chiller load with demand is also an important energy efficiency strategy. Selection should be made in an effort to operate the chillers at as close to full load as possible, where they are most efficient. Larger chillers will run at full load and the smaller chiller will run to supply additionally cooling only on an as-needed basis, reducing energy needs.

**Fan modification:** Changing the size or shape of the sheaves of a fan can help to optimize fan efficiency and airflow, thereby reducing energy consumption.

**Building reflection:** Use of a reflective coating on the roof of buildings in sunny, hot climates can save on air conditioning costs inside. For colder climates, heat lost due to cool roofs (in winter, for example) also needs to be taken into account, and often negates savings. In addition to location and weather, other primary factors influence energy savings, such as roof insulation, air conditioning efficiency, and building age. Reflective roof materials are available in different forms and colours.

## Fume Hoods

Fume hoods are commonly installed in R&D laboratory facilities in the pharmaceutical industry. Fume hoods capture, contain, and exhaust hazardous gases generated by laboratory activities and industrial process and therefore protect workers from breathing harmful substances. The energy required to heat and cool make-up air for laboratory fume hoods can account for a significant fraction of laboratory HVAC energy consumption. Fume hoods are often operated at high air exchange rates in an effort to guarantee the safety of occupants in the facility. However, significant energy savings can often be realized by using low-flow fume hoods and variable flow exhaust systems.

**Improved storage/housekeeping:** Fume hoods are often used as temporary storage spaces for chemicals and instruments in laboratory environments. However, this practice can require that fume hood exhaust systems run continuously, leading to unnecessarily high energy consumption. Improved housekeeping and storage practices, whereby chemicals and instruments are always kept in their proper storage locations and unused fume hoods are kept closed, would help to reduce hood energy consumption.

**Restriction of sash openings:** The restriction of fume hood sash openings reduces the volumetric flow rate necessary to maintain a constant airflow velocity across the face of the hood. A reduced volumetric flow requirement can facilitate lower energy consumption in variable flow hoods. A fume hood's sash opening can be limited either by restricting the vertical sash movement or by using a horizontal sash to block the hood's entrance. Furthermore, sashes on unattended fume hoods should remain closed whenever possible.

**Promotion of a vortex in tops of fume hoods:** A "bi-stable" vortex can enhance a fume hood's containment performance while also reducing its direct and indirect energy consumption. The vortex is promoted and maintained within the hood via adjustable panels in the top of the hood. According to one manufacturer, the bi-stable vortex hood provides maximum containment but consumes only 40% of the energy required by conventional hoods. Additionally, the bi-stable vortex hood can lower necessary air exchange rates, leading to savings in facility HVAC energy consumption as well.

**Variable-air-volume (VAV) hoods:** Constant-air-volume (CAV) hoods, which maintain a constant volumetric exhaust rate regardless of hood face airflow requirements, have been the mainstay in many laboratories. Variable-air-volume hoods, which employ ASDs and direct digital control systems to adjust exhaust airflow based on face velocity requirements, can offer considerable energy savings compared to CAV hoods. Variable-air-volume hoods save energy by minimizing the volumetric flow rate of hood exhaust, which can lead to significant reductions in the amount of exhaust air that must be conditioned by a building's HVAC system.

## Clean Rooms

A cleanroom can be defined as an enclosed area in which ambient conditions—including airborne particles, temperature, noise, humidity, air pressure, air motion, vibration, and lighting—are strictly controlled. A significant portion of floor space in pharmaceutical and biotechnology facilities can be occupied by cleanrooms. In general, the largest consumers of energy in cleanrooms are the HVAC system (e.g., systems for chilled water, hot water, and steam) and process machinery. A recent study found that HVAC systems accounted for 36-67% of cleanroom energy consumption. Another recent study estimated the following energy distribution for cleanroom operation: 56% for cooling, 36% for heating, 5% for fans, and 3% for pumps.

**Reduced recirculation air change rates:** The rate of clean room air recirculation can sometimes be reduced while still meeting quality control and regulatory standards. A simulation study of a cleanroom can be done to explore the possibility of reducing the hourly air change rates of air recirculation units, which would lead to significant cost savings from reduced fan energy and resultant heat load.

**Improved air filtration quality and efficiency:** High Efficiency Particulate Air (HEPA) filters and Ultra Low Penetration Air (ULPA) filters are commonly used in the pharmaceutical industry to filter make-up and recirculated air. The adoption of alternative filter technologies might allow for lower energy consumption. Low pressure drop filters can also offer energy savings.

**Cooling towers:** In many instances, water cooling requirements can be met by cooling towers in lieu of water chillers. Water towers can cool water much more efficiently than chillers and can therefore reduce the overall energy consumption of cleanroom HVAC systems. Operating multiple cooling towers at reduced fan speed rather than operating fewer towers at full speed is a further option for lowering cooling water energy consumption

**Reduction of cleanroom exhaust:** The energy required to heat and cool cleanroom make-up air accounts for a significant fraction of cleanroom HVAC energy consumption. Measures to reduce cleanroom exhaust airflow volume can therefore lead to significant energy savings. Such measures include the use of efficient fume hood technologies as described in the previous section. Additionally, measures aimed at heat recovery in cleanroom exhaust systems might also be effective at reducing overall HVAC system energy consumption.

**Declassification:** Occasionally, a cleanroom is classified at a higher cleanliness level than is necessary for its current use, either due to conservative design or to a transition in its production characteristics over time. A simple efficiency measure that might be available for such cleanrooms is to declassify them from a higher class of cleanliness to a lower class of cleanliness, provided that the lower class still meets production requirements for contamination control and air change rates.

## Refrigeration

Refrigeration is another important process in the pharmaceutical industry and is used in many different applications. Energy savings in refrigeration systems can be found at the component, process, and systems levels. Energy efficiency measures include reducing condenser pressures, the correct selection and sequencing of compressors, optimizing insulation, and eliminating non-essential heat loads within the plant.

**Monitoring of refrigerant charge:** A low refrigerant charge can exist in many small direct expansion (DX) systems, and can also exist without obvious indicators on larger flooded or recirculation systems. Without proper monitoring to ensure that refrigerant is charged to the appropriate level, significant amounts of energy can be wasted in a refrigeration system. It is estimated for DX systems that one in six have a low refrigerant charge (or sometimes overcharge), which is sufficient to increase energy usage by 20%. Monitoring of refrigerant charge generally isn't necessary for large ammonia systems.

**Optimization of condenser and evaporator parameters:** An optimized refrigeration system works with minimized differences between condenser conditions and evaporator conditions. For the condenser, the goal is to obtain the lowest possible condensing temperature and pressure of the refrigerant. This reduces power input while increasing refrigeration output. For the evaporator, an increase in temperature and pressure increases the power input of the compressor, but can dramatically increase the refrigeration output of the system.

Increasing evaporator temperature by one degree can reduce the electricity consumption of the compressor by roughly 3%.

**Cooling line and jacket insulation:** It can often be cost effective to insulate cooling lines if the lines are un-insulated and there is a significant average temperature difference between the cooling lines and the surroundings (e.g., more than 15°F). If lines are already insulated, upgrading may not be cost effective. Interestingly, insulated jacket tanks use less refrigeration energy than tanks in an insulated enclosure (cold room) due to reduced losses.

**Absorption chillers:** Absorption chillers use heat to provide cooling, instead of mechanical energy. In absorption chillers, refrigerant vapour from the refrigeration system's evaporator is first absorbed by a solution contained in an absorber unit. Next, this solution is pumped from the absorber into a generator, which re-vaporizes the refrigerant using waste heat (e.g., from steam) as an energy source. Finally, the refrigerant-depleted solution returns to the absorber unit via a throttling device, completing the cycle. Absorption chillers have a lower coefficient of performance (COP) than mechanical chillers; however, absorption chillers can reduce operating costs since they use low-grade waste heat as an energy source. Low-pressure, steam-driven absorption chillers are available in capacities from 100 to 1,500 tons. Absorption cooling and refrigeration may be attractive in combination with cogeneration of heat and power.

## Heat and Steam Distribution

Boilers are the heart of a steam system, while the purpose of distribution systems is to get steam from the boiler to the process where it will be used. Boilers and steam distribution systems are major contributors to energy losses at many industrial facilities; they are therefore an area where substantial efficiency improvements are typically feasible. Many common energy efficiency measures for boilers and steam distribution are listed below.

**Boiler process control:** Flue gas monitors maintain optimum flame temperature and monitor carbon monoxide (CO), oxygen, and smoke. The oxygen content of the exhaust gas is a combination of excess air (which is deliberately introduced to improve safety or reduce emissions) and air infiltration (air leaking into the boiler). By combining an oxygen monitor with an intake airflow monitor, it is possible to detect even small leaks. A small 1% air infiltration will result in 20% higher oxygen readings. A higher CO or smoke content in the exhaust gas is a sign that there is insufficient air to complete fuel burning. Using a combination of CO and oxygen readings, it is possible to optimize the fuel/air mixture for high flame temperature (and thus the best energy efficiency) and lower air pollutant 54 emissions

**Reduction of excess air:** The more excess air is used to burn fuel, the more heat is wasted in heating this air rather than in producing steam. Air slightly in excess of the ideal stoichiometric fuel/air ratio is required for safety and to reduce emissions of nitrogen oxides (NOx), but approximately 15% excess air is adequate. The vast majority of boilers already operate at 15% excess air or lower, and thus this measure may not be widely applicable. However, if the boiler is using excess air, numerous case studies indicate that the payback period for this measure is less than a year. A rule of thumb often used is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F (22°C) reduction in stack gas temperature.

**Boiler insulation:** It is possible to use new materials, such as ceramic fibres, that both insulate better and have a lower heat capacity (and thus heating is more rapid). Savings of 6 - 26% can be achieved if improved insulation is combined with improved heater circuit controls. Due to the lower heat capacity of new materials, the output temperature of boilers can be more vulnerable to temperature fluctuations in the heating elements; improved control is therefore often required in tandem with new insulation to maintain the desired output temperature range.

**Boiler maintenance:** A simple maintenance program to ensure that all components of a boiler are operating at peak performance can result in substantial savings. In the absence of a good maintenance system, burners and condensate return systems can wear or get out of adjustment. These factors can end up costing a steam system up to 20-30% of initial efficiency over 2-3 years. On average, the energy savings associated with improved boiler maintenance are estimated at 10%. Improved maintenance may also reduce the emission of criteria air pollutants. Fouling on the fireside of boiler tubes or scaling on the waterside of boilers should also be controlled. Fouling and scaling are more of a problem with coal-fed boilers than natural gas or oil-fed boilers (boilers that burn solid fuels like coal should be checked more often as they have a higher fouling tendency than liquid fuel boilers do). Tests show that a soot layer of 0.03 inches (0.8 mm) reduces heat transfer by 9.5%, while a 0.18 inch (4.5 mm) soot layer reduces heat transfer by 69%. For scaling, 0.04 inches (1 mm) of build-up can increase fuel consumption by 2%

**Flue gas heat recovery:** Heat recovery from flue gas is the best opportunity for heat recovery in steam systems. Heat from flue gas can be used to preheat boiler feed water in an economizer. While this measure is fairly common in large boilers, there is often still room for more heat recovery. The limiting factor for flue gas heat recovery is that one must ensure that the economizer wall temperature does not drop below the dew point of acids contained in the flue gas (such as sulfuric acid in sulphur-containing fossil fuels). Traditionally, this has been done by keeping the flue gases exiting the economizer at a temperature significantly above the acid dew point. In fact, the economizer wall temperature is much more dependent on feed water temperature than on flue gas temperature because of the high heat transfer coefficient of water. As a result, it makes more sense to preheat feed water to close to the acid dew point before it enters the economizer. This allows the economizer to be designed so that exiting flue gas is just barely above the acid dew point. One percent of fuel use is saved for every 45°F (25°C) reduction in exhaust gas temperature.

**Condensate return:** Reusing hot condensate in boilers saves energy, reduces the need for treated boiler feed water, and reclaims water at up to 100°C (212°F) of sensible heat. Typically, fresh feed water must be treated to remove solids that might accumulate in the boiler; however, returning condensate to a boiler can substantially reduce the amount of purchased chemical required to accomplish this treatment. The fact that this measure can save substantial energy costs and purchased chemicals costs.

**Blowdown steam recovery:** When water is blown from a high-pressure boiler tank, the pressure reduction often produces substantial amounts of steam. This steam is low grade, but can be used for space heating and feed water preheating. The recovery of blowdown steam can save 1.3% of boiler fuel use in small boilers.

**Boiler replacement:** Replacing inefficient coal-fired boilers with gas-fired/ dual fired boilers increases energy efficiency and reduces emissions.

**Distribution system insulation:** Using more insulating material or using the best insulation material for the application can save energy in steam systems. Crucial factors in choosing insulating material include low thermal conductivity, dimensional stability under temperature change, resistance to water absorption, and resistance to combustion. Other characteristics of insulating material may also be important depending on the application. These characteristics include tolerance of large temperature variations, tolerance of system vibrations, and adequate compressive strength where insulation is load bearing. It is often found that after heat distribution systems have undergone some form of repair, the insulation is not replaced. In addition, some types of insulation can become brittle or rot over time. As a result, a regular inspection and maintenance system for insulation can save energy. Exact energy savings and payback periods are unknown and vary based on the existing practices.

**Steam trap maintenance:** A simple program of checking steam traps to ensure that they are operating properly can save significant amounts of energy for very little money. When steam traps are not regularly monitored, up to 15-20% of traps can be malfunctioning. Energy savings for a regular system of steam trap checks and follow-up maintenance is conservatively estimated at 10%. In addition to energy and cost savings, proper functioning of steam traps will reduce the risk of corrosion in the steam distribution system.

**Flash steam recovery:** When a steam trap purges condensate from a pressurized steam distribution system to ambient pressure, flash steam is produced. As with flash steam produced by boiler blowdown, this steam can be used for space heating or feed water preheating. The potential for this measure is extremely site dependent, as it is unlikely that a producer would build an entirely new system of pipes to transport this low grade steam to places where it can be used. If, on the other hand, the areas where low-grade heat is useful were already very close to the steam traps, this measure would be easy to implement and could save considerable energy.

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# Indore Readymade Garments Cluster

# 4. Indore Readymade Garments Cluster

## 4.1. Process Description

Garment production is an organized activity consisting of sequential processes such as laying, marking, cutting, stitching, checking, finishing, pressing and packaging. This is a process of converting raw materials into finished products. It will be difficult to maintain the industry if production is not, up to the mark if the preproduction phase of preparation of material is not properly carried out.

### Steps Involved in Manufacturing

#### Receiving Fabrics

Garment factories receive fabric from overseas textile manufacturers in large bolts with cardboard or plastic centre tubes or in piles or bags. The fabric typically arrives in steel commercial shipping containers and is unloaded with a forklift. Garment factories often have a warehouse or dedicated area to store fabric between arrival and manufacturing.

#### Fabric Relaxing

"Relaxing" refers to the process that allows the material to relax and contract prior to being manufactured. This step is necessary because the material is continually under tension throughout the various stages of the textile manufacturing process, including weaving, dyeing, and other finishing processes. The relaxing process allows fabrics to shrink so that further shrinkage during customer use is minimized.

Garment manufacturers perform the relaxing process either manually or mechanically. Manual fabric relaxing typically entails loading the bolt of fabric on a spinner and manually feeding the material through a piece of equipment that relieves tension in the fabric as it is pulled through. Mechanical fabric relaxing performs this same process in an automated manner.

Many garment manufacturers will also integrate quality assurance into this process to ensure that quality of fabric meets customer standards. This step is performed by manually spot-checking each bolt of fabric using a backlit surface to identify manufacturing defects such as colour inconsistency or flaws in the material. Fabrics that fail to meet customer standards are returned to the textile manufacturer.

#### Spreading, Form Layout, and Cutting

After the fabric has been relaxed, it is transferred to the spreading and cutting area of the garment manufacturing facility. The fabric is first to cut into uniform plies and then spread either manually or using a computer-controlled system in preparation for the cutting process.

The fabric is spread to:

- ❖ Allow operators to identify fabric defects;

- Control the tension and slack of the fabric during cutting; and
- Ensure each ply is accurately aligned on top of the others.
- The number of plies in each spread is dependent on the fabric type, spreading method, cutting equipment, and size of the garment order.
- Next, garment forms—or patterns—are laid out on top of the spread, either manually or programmed into an automated cutting system. Lastly, the fabric is cut to the shape of the garment forms using either manually operated cutting equipment or a computerized cutting system.

## Laying

Laying of paper pattern helps one to plan the placement of the pattern pieces in a tentative manner. Large pieces are laid first and then the smaller ones are fitted.

It is very economical in laying the pattern and cutting. Even a small amount of material saved in a single layer will help to bring about a large saving of money as hundreds of layers of fabric will be laid and cut simultaneously.

When laying, the length of the garment should be parallel to the selvedge of the material. The pattern is placed in the correct grain. Fabrics drape and fall better on the lengthwise grain and also last longer. Parts that have to be placed on the fold should be exactly on the edge of the fold. All laying is done on the wrong side of the material.

When laying the paper pattern, the design of the fabric is considered. Care is taken to see that the design runs in the same direction throughout the garment. All checks and strips have to match the seams both lengthwise and across.

## Marking

This can be a manual or a computerized technique. The marker planner uses full-size patterns and arranges them in an economical manner on marker paper. This is a specially printed paper having symbols on it which enable the marker planner to visually control the positioning of components according to specified grain lines.

Markers produced on paper are fixed to fabric with pins, staples or on an adhesive paper which is heat sealed to the top layer of the fabric. Marker planning provides details of the spreads. In the cutting room, the fabric is laid manually or a spreading machine is used to arrange fabric inlays 100 (layers) and markers for the production, any in orders planned. Here planning is done also for fusible, linings, trims, pocketing etc.

The supervisors of marker planner plan and allocates the cut orders to various operations to be carried out in the cutting room.

## Cutting

This is the major operation of the cutting room when they spread and cut into garments. Of all the operations in the cutting room, this is the most decisive, because once the fabric has been cut, very little can be done to rectify serious defects.

A first planning consideration is whether the totals arrived at in the cutting room are the same as those required to maintain full production in the sewing room and subsequently the planned delivery schedule. Any cloth problems created in the cutting room can affect the output in the sewing room. Assuming all components of fabric, design, and trims are acceptable and correctly planned and cut, the next stage is to extend the cutting room programme to the sewing room. All cutting operations are carried out by straight knife cutting machines.

## Embroidery and Screen Printing

Embroidery and screen printing are two processes that occur only if directly specified by the customer; therefore, these processes are commonly subcontracted to off-site facilities. Embroidery is performed using automated equipment, often with many machines concurrently embroidering the same pattern on multiple garments. Each production line may include between 10 and 20 embroidery stations. Customers may request embroidery to put logos or other embellishments on garments.

Screen printing is the process of applying paint-based graphics to fabric using presses and textile dryers. Specifically, screen printing involves sweeping a rubber blade across a porous screen, transferring ink through a stencil and onto the fabric. The screen printed pieces of fabric are then dried to set the ink. This process may have varying levels of automation or may largely be completed at manually operated stations. Like embroidery, screen printing is wholly determined by the customer and may be requested to put logos or other graphics on garments or to print brand and size information in place of affixing tags.

## Sewing

Stitching or sewing is done after the cut pieces are bundled according to size, colour and quantities determined by the sewing room.

Garments are sewn in an assembly line, with the garment becoming complete as it progresses down the sewing line. Sewing machine operators receive a bundle of cut fabric and repeatedly sew the same portion of the garment, passing that completed portion to the next operator. For example, the first operator may sew the collar to the body of the garment and the next operator may sew a sleeve to the body. Quality assurance is performed at the end of the sewing line to ensure that the garment has been properly assembled and that no manufacturing defects exist. When needed, the garment will be reworked or mended at designated sewing stations. This labour-intensive process progressively transforms pieces of fabric into designer garments. The central process in the manufacture of clothing is the joining together of components. Stitching is done as per the specification is given by the buyer.

High power single needle or computerized sewing machines are used to complete the sewing operation. Fusing machines for fusing collar components, button, and buttonhole, sewing machines for sewing button and buttonholes are specifically employed.

## Checking

It is realistic to assume that however well checking or quality control procedures operate within a factory there will always be a certain percentage of garments rejected for some reason or other. The best way to carry out quality checks are given below:

- Establish a standard as a criterion for measuring quality achievement.
- Production results can be measured and compared to the planned quality standard.
- Corrective measures to be carried out if there are any deviations in the plans.
- Ideally, any system should detect possible deviations before they occur through forecasting. Work produced with minus defects will produce quality products, enhance economy and productivity.

## Spot Cleaning and Laundry

In addition to identifying manufacturing defects, employees tasked with performing quality assurance are also looking for cosmetic flaws, stains, or other spots on the garment that may have occurred during the cutting and sewing processes. Spots are often marked with a sticker and taken to a spot-cleaning area where the garment is cleaned using steam, hot water, or chemical stain removers.

Some customers request that a garment be fully laundered after it is sewn and assembled; therefore, garment factories often have on-site laundry or have subcontract agreements with off-site laundry operations. Commercial laundry facilities are equipped with at least three types of machines: washers, spinners, and dryers. Some facilities also have the capability to perform special treatments, such as stone- or acid-washing.

Laundering is done by highly sophisticated washing machines if any articles are soiled during the manufacturing process. However, this step is required only if the garments are soiled.

## Fusing and Pressing

Fusing and pressing are two processes which have the greatest influence on the finished look of a garment. Fusing creates the foundation and pressing put the final seal of quality on the garment.

After a garment is fully sewn and assembled, it is transferred to the ironing section of the facility for final pressing. Each ironing station consists of an iron and an ironing platform. The irons are similar looking to residential models but have steam supplied by an on-site boiler. Workers control the steam with foot pedals and the steam is delivered via overhead hoses directly to the iron. In most facilities, the ironing platforms are equipped with a ventilation system that draws steam through the ironing table and exhausts it outside the factory.

## The basic components of pressing are:

Steam and heat are necessary to relax the fabric and make it pliable enough to be moulded by manipulation.

**Pressure:** When the cloth has been relaxed by steam, the pressure is applied which sets the fibres into their new positions.

**Drying:** After the application of steam and pressure, the component or garment must be dried and cooled so that cloth can revert to its normal condition. This is done by a vacuum action which removes surplus water from the fabric and at the same time cools it. For some pressure operations hot air or infrared heating is used instead of vacuum for drying.

## Packaging and Shipping

In the last steps of making a product retail-ready, garments are folded, tagged, sized, and packaged according to customer specifications. Also, garments may be placed in protective plastic bags, either manually or using an automated system, to ensure that the material stays clean and pressed during shipping. Lastly, garments are placed in cardboard boxes and shipped to client distribution centres to eventually be sold in retail stores.

Most garments are packed in plastic bags, either at the end of production or when they enter the finished goods store. Products like shirts and underwear's are usually bagged and boxed directly after final inspection and enter the stores in prepacked form. For these and similar types of products, many automatic machines are used.

Other hanging garments such as jackets, dresses & skirts are usually bagged by manual machines, semi-automatic machines, and fully automatic machines. Some of these automatic machines bag, seal, and transport in trolley; some 500 garments per hour.

When the boxed or hanging garment has to be transported in bulk the garment or boxes are packed into cartons which can be sealed by adhesive paper or plastic Manual and automatic machines are available for both.

## 4.2. Technology Status

Ready to wear apparel or garment manufacturing involves many processing steps, beginning with the idea or design concept and ending with a finished product. Apparel manufacturing process involves Product Design, Fabric Selection and Inspection, Patternmaking, Grading, Marking, Spreading, Cutting, Bundling, Sewing, Pressing or Folding, Finishing and Detailing, Dyeing and Washing, QC, etc.

For these processes, the major share of energy consumed is electrical and a little portion will be of thermal. In Indore Readymade Garment cluster, there are more than 150 units, out of which only very few are integrated. Most of these units use electrical energy from grid as their major source of energy. Solar energy quotient is also very less in this cluster.

## 4.3. Energy Efficiency Opportunities

Readymade garment industry uses both electrical & thermal energy for its various processes like sewing, dyeing, washing & pressing etc. There is a good scope for improvement in energy consumption of ready garment manufacturing by employing various energy conservation measures as below:

**Use of counter-flow currents for washing:** In this system, as the fabric runs through the washing compartments from entry to exit, clean water is passed through the plant from the back to the front. This means that the cleanest fabric comes into contact with the cleanest washing liquor. By applying this counter-flow principle, it is possible to save both water and energy. This process was developed to reduce water consumption for washing and is composed of washing equipment, a washing and dehydration mechanism, filter equipment, sensors and pumps. Washing water is supplied from a direction in the reverse of fabric flow, and the sensor detects water impurity to adjust automatically the feed rate of the water. For example, during dyeing with the cold-pad-batch dyeing method, a padder with nip-controlled rollers is used to apply dyestuffs to the fabric in a defined manner. After a dwelling time (which varies depending on the dyestuff) the excess dyestuff needs to be washed out. Here, a distinction is made between the following processes:

- Rinsing out dyestuff from the fabric surface.
- Soaping (the dyes are moved from the core of the fibres to the surface).
- Neutralization.
- Washing out of the salts produced during neutralization.

This process normally requires 20 litres of water and 1.6 kg of steam per kg of fabric. However, the counter-flow principle can be applied sequentially to each individual processes, resulting in water and energy savings. The water used to wash out the salts in the back compartment is directed around the soaping compartments and is then used again when the surface dyestuffs are rinsed out. As the level of soil is low in the back part of the washing process, this liquor can be used effectively to wash in the front part. In addition, less heating of the water is required for the soaping process, which saves energy in the form of steam.

**Installing covers on nips and tanks in continuous washing machines:** The losses at nips in continuous washing machines are considerable and even in some cases they can exceed 40% of total energy demand of washing machines. Hence, it is important to cover them as well as the hot tanks. Any fitted covers should be easily removable to allow quick access. This simple retrofit measure can result in significant energy savings.

**Installing automatic valves in continuous washing machines:** Automatic stop valves which link the main drive systems of machines to water flows can save considerable amounts of energy and water by shutting off water flow as soon as a stoppage occurs. A series of shorter stoppages typically accounts for up to 20% of machine working time. Often both the water flow and the heating are left on throughout these short interruptions, which in total will result in significant energy and water wastage. The payback period for installing automatic stop valves on continuous washing machines could be as low as one month.

**Installing heat recovery equipment in continuous washing machines:** Installing heat recovery equipment on a continuous washer is usually a simple but very effective measure since water inflow and effluent outflow are matched and this eliminates the need for holding tanks. The effluent from these machines can become contaminated with fibrous material, so it is important to install a heat exchanger capable of handling such loads. One option is a self-cleaning, rotating element exchanger which has an efficiency of about 70%. Another measure is to install a simple plate heat exchanger with a pre-filter, which may have a higher initial cost, but which also has an efficiency that could be higher than 90%.

**Introducing point-of-use water heating in continuous washing machines:** Point-of-use gas-fired water heaters can be used to enable processes to be run independently of plant central boiler systems. This means that boiler and distribution losses associated with centralized systems (which can be as much as 50% of the fuel input) can be eliminated. Point-of use heating also offers greater flexibility since it allows operation outside of main boiler operating hours. This measure, however, requires significant changes to the washing machine and may have a high capital cost.

**Flash Steam and Condensate recovery from Jet Dyeing Machine:** When steam transfers its heat in a manufacturing process, heat exchanger, or heating coil, it reverts to a liquid phase called condensate. An attractive method of improving Boiler's energy performance is to increase the condensate return to the boiler. Recovery of condensate and using it as Boiler Feed Water has many benefits, such as: less make-up water requirement; saving in fuel by way of less sensible heat requirement; less boiler blow down; saving of chemicals and treatment costs.

The typical consumption of a 250 Kg capacity Jet Dyeing Machine is 150 Kg Steam per hour. Typically, 97% condensate is recoverable in a non-direct injection type system and heat content in the condensate and also in Flash Steam is typically 10% each. A typical condensate recovery system with Flash Steam Recovery system would cost approx INR 5.0 Lakh (INR 3.5 Lakh towards condensate pump and 1.5 Lakh towards flash Steam recovery system) with a payback period of less than 2 years.

**Fabric Moisture indicator and Automatic over drying controller for Stenters:** Over Drying is a common problem. Fabrics have natural moisture levels and drying below these levels would mean over drying. The typical natural moisture levels at 20°C and 65% RH is given below:

*Table 1: Natural Moisture levels*

| Fiber | Moisture Regain Value |
|---|---|
| Cotton | 7 |
| Wool | 16-18 |
| Viscose | 12.5 |
| Polyester | 0.4 |
| Acrylic | 1.5 |
| Polypropylene | 0 |

Hence installing automatic controller for Stenters will have a good scope for energy savings.

**Install Heat Recovery from Stenter exhaust:** The exhaust from Stenters in case of Heat Setting is at a temperature of 140°C and that in case of resin finish is 120°C. This provides enough opportunity to recover waste heat and use it for heating incoming air to the Stenter or heat process water required in the unit. There two options in heat recovery from exhaust gases:

Air to air heat in this the heat of exhaust gases is used to heat the fresh air. It reduces process heat demand by 12 to 15% and in case of dry heat setting it is even 30%.

Air to wate r— water can be heated up to 90 degree centigrade and can be used directly to process/boiler feed.

**Stopping Air Circulation Fans during idling of stenter:** Generally stenter remains idle for at least one hour every day due to various reasons in most of the plants. This stoppage is for durations ranging from 5 to 15 minutes. As per normal practice, the fans remain operating at high speed even when the stenter is idling to seemingly avoid overheating and yellowing of fabric. It is suggested that the fans be brought to slow speed when stenter is idling by providing interlocking.

**Prevent air intake in the steamer:** In the steaming process, constant and reproducible conditions must be achieved in the steamer atmosphere. A disruptive factor can be the intake of air in the steamer, for example via the entrance and exit splits. This air reduces the temperature in the steamer and makes the atmosphere unstable. In some processes, oxygen disrupts the chemical reactions important for fixating dyes. As a result of these disruptions, more steam than necessary is added to establish the desired conditions as yet. Keeping the splits in the steamer as small as possible can reduce the steam consumption. Modern Steamers come with air curtain to stop ingress of air.

- Ensure proper steam conditioning in the steamers.
- The proper steam conditioning is important. Most processes use saturated steam. Make sure the steam is not overly heated. This has a detrimental effect on the temperature and moisture content of the fabric. Sub-optimal steam conditions will generally result increased steam consumption.
- Reuse of Steam in Loop Steamer and heat recovery system.

# General Energy Saving Opportunities

# 5. General Energy Saving Opportunities – Applicable to all Sectors

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

## Motors and Motor Systems

Motors and drives are used throughout the pharmaceutical industry to operate HVAC systems, to drive laboratory or bulk manufacturing equipment (including mixers, pumps, centrifuges, and dryers), and for transport and equipment operation in the formulation and packaging stages. The energy efficiency measures described in the following section apply to any system that uses motors. Where appropriate. When considering energy efficiency improvements to a facility's motor systems, it is important to take a "systems approach." A systems approach strives to optimize the energy efficiency of entire motor systems (i.e., motors, drives, driven equipment such as pumps, fans, and compressors, and controls), not just the energy efficiency of motors as individual components. A systems approach analyses both the energy supply and energy demand sides of motor systems as well as how these sides interact to optimize total system performance, which includes not only energy use but also system uptime and productivity. A systems approach typically involves the following steps. First, all applications of motors in a facility should be located and identified. Second, the conditions and specifications of each motor should be documented to provide a current systems inventory. Third, the needs and the actual use of the motor systems should be assessed to determine whether or not motors are properly sized and also how well each motor meets the needs of its driven equipment. Fourth, information on potential repairs and upgrades to the motor systems should be collected, including the economic costs and benefits of implementing repairs and upgrades to enable the energy efficiency improvement decision-making process.

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

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

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

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

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

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

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

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

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

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

## Compressed Air Systems

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

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

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

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

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

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

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

- Pressure gauges on each receiver or main branch line and differential gauges across dryers, filters, etc.
- Temperature gauges across the compressor and its cooling system to detect fouling and blockages.
- Flow meters to measure the quantity of air used.
- Dew point temperature gauges to monitor the effectiveness of air dryers.
- Kilowatt-hour meters and hours run meters on the compressor drive.
- Checking of compressed air distribution systems after equipment has been reconfigured to be sure that no air is flowing to unused equipment or to obsolete parts of the compressed air distribution system.
- Checking for flow restrictions of any type in a system, such as an obstruction or roughness, which can unnecessarily raise system operating pressures. As a rule of thumb, every 2 psi pressure rise resulting from resistance to flow can increase compressor energy use by 1%. The highest pressure drops are usually found at the points of use, including undersized or leaking hoses, tubes, disconnects, filters, regulators, valves, nozzles and lubricators (demand side), as well as air/lubricant separators, after-coolers, moisture separators, dryers and filters.

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

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

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

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

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

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

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

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

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

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

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

## Pumps

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

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

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

- ❖ Replacement of worn impellers, especially in caustic or semi-solid applications.
- ❖ Bearing inspection and repair.

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

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

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

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

## Lighting

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

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

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

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

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

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

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

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

### Blowers:

- Provide a proper enclosure for air drying of processed components (reduction in blowing time and required motor capacity).
- Provide proper drain time to minimise water blown off from the components during blowing operation.
- Collect the blown off water and reuse in process baths.

### Cooling Towers:

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

# Case Studies

# 6. Case Studies

## 6.1. Food Processing

### Case Study 1: Switching from sawdust-based roaster to biomass blend-based Multi fuel roaster system

**Plant: Shivay Industries, Ujjain**

*Figure 12: Auto Fuel feeding System*

**Implementation Details:** This unit is manufacturing flattened rice flakes (Poha) using paddy as a raw material. They are mainly using sawdust for heat generation for roasting the poha. The main problem faced by the industry was high amount of black smoke formation and more than permissible solid particulate emissions from the roaster's chimney. That is why, they planned to switch to automatic fuel feeding with a cleaner biomass fuel to get compliant with the CPCB norms and energy savings too as the specific energy consumption was low in case of biomass. M/S Shivay Industries approached Steamax with the intent of up-gradation/modification of air pollution control devices, auto-fuel feeding with a shift to cleaner biomass fuel and improving existing manufacturing process.

Detailed analysis of the roasting process was done and designed a new heating system for the poha manufacturing units, "Multifuel Poha Roaster Heater". After successful trials of the prototypes, the unit was commissioned on 19th September 2019.

**Merits:**

- ❖ Reduction in fuel consumption and hence the process cost.
- ❖ Improved quality due to improvement in system efficiency & uniform heat distribution.
- ❖ Reduced manpower requirement due to auto-fuel feeding system of the roaster.
- ❖ Reduction in heater breakdown incidences.
- ❖ Significant reduction of ash disposal cost.

**Limitations:**

- ❖ Initial capital investment.

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Daily fuel consumption (kg) | 1,000 | 500 |
| 2 | Fuel used | Sawdust | Biomass |
| 3 | GCV ( kcal/kg) | | > 4200* |
| 4 | Fuel cost (INR/kg) | 6 | 11.5 |
| 5 | Monthly fuel bill | 1,50,000 | 1,44,000 |
| 6 | Black smoke | Yes | No |

**GCV from supplier technical sheet*

## Technology Supplier Details:

Steamax India
901, Vishwadeep tower, Janakpuri District Centre,
Jankapuri, New Delhi, Delhi-110058 (India)
Phone: 9810272614
Email: info@steamaxindia.com

## Local Cluster Supplier / Service Provider:

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

# 6.2. Pharma

## Case Study 1: Replacing conventional belt driven blower drives with EC drives

### Plant: Renowned Pharma plant.

**Implementation Details:** The leading pharmaceutical industry in India has done a retrofit on one of their exhaust system to showcase energy conservation opportunity by implementing Electronically Commutated (EC) Technology in place of conventional AC blower system. Pictures of system with before and after installation of EC blowers are shown below.


*Figure 13: Pictures of Before & After Implementation of EC System*

Designed parameters and power consumption of before and after implementation were taken down and are tabulated below.

*Table 2: Design Parameters of proposed system*

| Design Parameters of Selected System | | Motor Rating in kW | | Power Consumption in kW | |
|---|---|---|---|---|---|
| Design Flow (CFM) | Static Pressure (mm) | Existing | Proposed | Before | Proposed |
| 11,685 | 150 | 15 | 14.8 | 13.2 | 8.0 |

As seen from the table above design parameters of proposed system was 11,685 CFM with 150 mm of static pressure, at these parameters it was proposed that the system will consume around 8 kW of power.

*Table 3: Performance comparison before & after implementation*

| Parameter | Before | After | |
|---|---|---|---|
| Design | | | |
| kW | 15 | 14.8 | |
| HP | 20 | 20 | |
| AMP | 28 | 24 - 18.4 | |
| RPM | 1450 | 4,100 | |
| Voltage | 415 | 380-480 | |
| HTZ | 50 | 50 | |
| Actual | | | |
| kWh | 13.22 | 6.25 | 53% Savings |
| kvah | 13.29 | 6.26 | |
| Amps | 19.05 | 8.86 | |
| PF | 0.99 | 0.99 | |

As seen from the above picture consumption of conventional system was 13.2 kW and that of EC blower was around 6.25 kW. Total power saving of 7 kW was achieved by installation of EC blower; in terms of percentage it is around 53% of power consumption of conventional system with same air flow and static pressure. Unit was able to save nearly **60,200** units of electrical energy. Annual reduction in $CO_2$ emission is **49.36 MT**. at 0.82 emission factor.

**Merits:**

- Reduced transmission losses.
- Reduced maintenance of belts ,gear boxes etc.
- Highly efficient motoring with inbuilt intelligent protection & control.

**Limitations:**

- Initial capital investment nearly twice of a belt driven model.
- Available only for lower flowrates.

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 4.21 Lakh | 4.20 Lakh | 12 Months |

## Technology Supplier Details:

AAD TECH INDIA PRIVATE LIMITED
21, Papa Industrial Estate, 40 Suren Road,
Andheri East, Mumbai, Maharashtra 400093
Phone: 9876724003
Email: manpreet@aadtech.in

## Alternate Technology Supplier Details:

Ebm-papst India Pvt. Ltd.
26/3, G.N.T. Road Erukkencherry
600 118 Chennai
Phone: +91 44 26720103
Email: sales@in.ebmpapst.com

# Case Study 2: Installing air pre cooling system for existing air conditioning system

## Plant: Lupin Pharma, Pune

**Implementation Details:** Lupin's facility in Pune, India, is a state-of-the art facility for tablet manufacturing. The tablet manufacturing process requires strict temperature control and very low relative humidity (RH), which is why pharmaceutical companies generally use air conditioning systems to maintain the temperature and dehumidifiers for RH control. The facility has clean rooms on the ground and first floors for various processes. These clean rooms are cooled by 12 dedicated AHUs (air handling units) with a capacity of 15,000 CFM each. These AHUs are stacked together on a common service area on the second floor and are connected to a chilled water system.

For maintaining a healthy indoor air quality (IAQ) inside the rooms, each AHU is designed to have a specific provision for 4-5% fresh air intake and the rest 95% is re-circulated from within the room. Since the fresh ambient air is generally of higher temperatures than the recirculated air, cooling this fresh air places a significant load on the chilled water system.

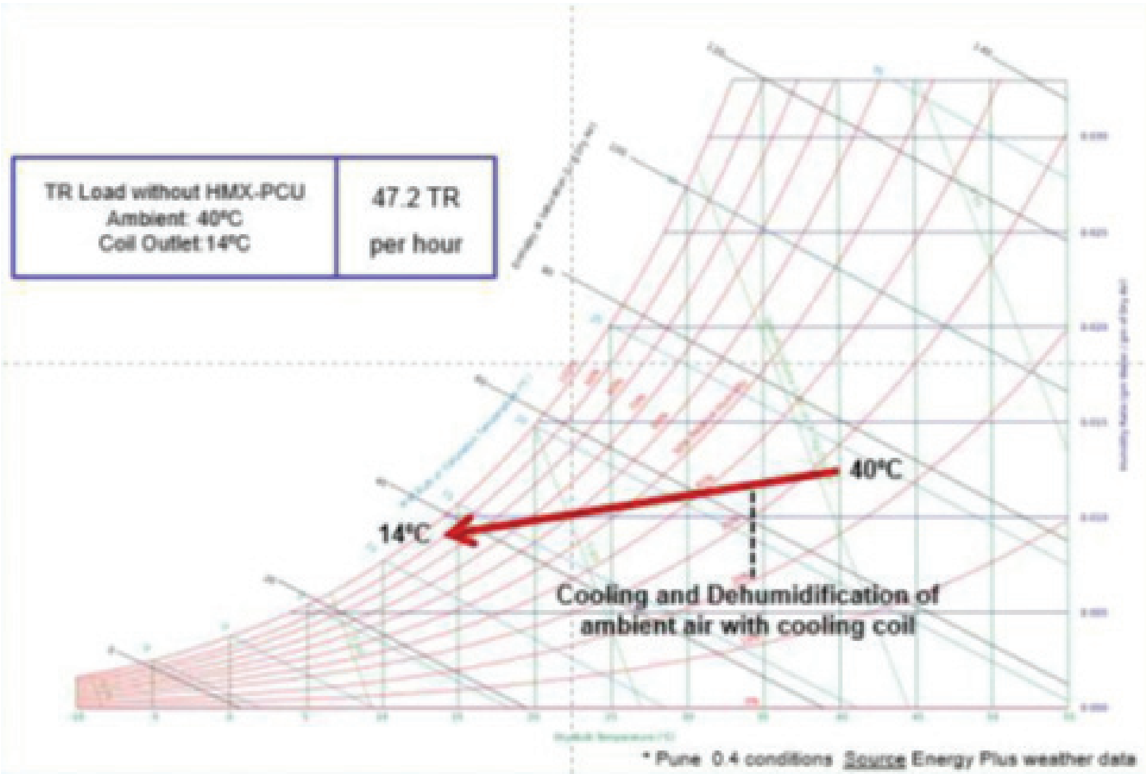



*Figure 14: Characteristics with cooling coil*

To ensure that the requirement of 4-5% fresh air in each room is met while simultaneously reducing the TR load, one common unit of HMX-PCU was installed in the AHU bay. The 8,000 CFM HMX-PCU is an indirect evaporative cooling (IEC) module which sensibly pre-cools the fresh air before it enters the AHUs, thereby reducing the overall load on the chilled water system.

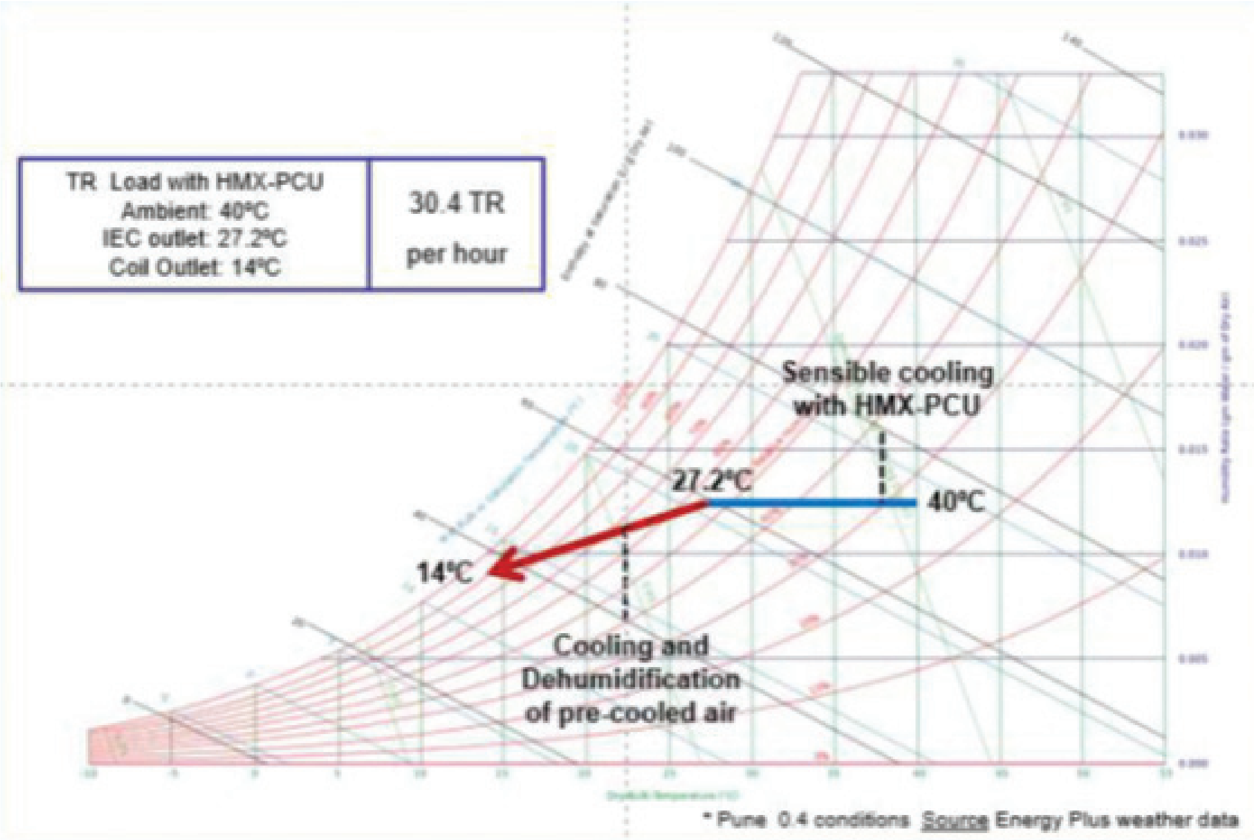
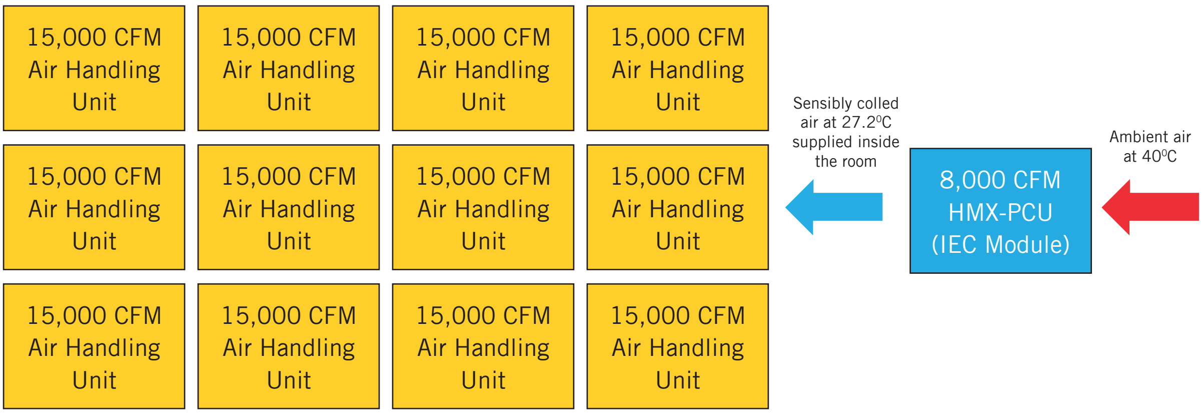



*Figure 15: Characteristics with HMX Pre Cooling*




Schematic of Lupin, Pune, Service Floor

*Figure 16: Schematic of the refrigeration system*

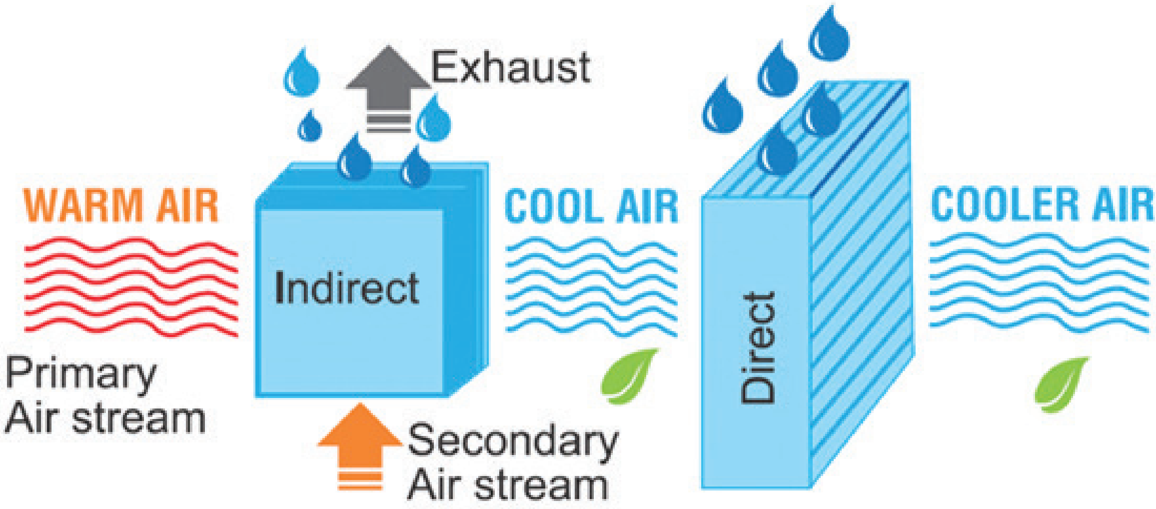



*Figure 17: Indirect Evaporative Cooling Working Principle*

**Merits:**

- ❖ Low cost cooling solution.
- ❖ Reduces load on existing vapour compression cooling system.
- ❖ Environmental friendly refrigerant (water).

**Limitations:**

- ❖ Little more maintenance.
- ❖ Less effective at humid climatic conditions.

The HMX-PCU has proved to be an eco-friendly way to reduce tonnage load on the air-conditioning system. In the peak summer, HMX-PCU can save up to 15% of the operational cost required for running in the entire air- conditioning system.

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 2.50 Lakh | 5.00 Lakh | 24 Months |

## Technology Supplier Details:

HMX (A Business Unit of A.T.E. Enterprises Private Limited)
A 422, 1st Main, 1st Stage, Peenya Industrial Area,
Tumakuru Road, Bengaluru, Karnataka 560058
Phone: +91-91583 08880
Email: r_h_matta@hmx.co.in

## Alternate Technology Supplier Details:

Renotech Air Engineering
Gat No. 310, Alandi-Vadgaon Rd. Alandi, Khed, Pune 412 105
Phone: 9881608066
Email: sales@renotech.in

## Local Technology Supplier / Service Provider:

Selectra
Kasliwal Compound, Near Astha Cinema 10 Sanjay Nagar
Phone: 09827223272
Vijay Nagar, Indore - 452010

# Case Study 3: Active refrigerant agent addition in lube oil for chillers

## Plant: Zydus Cadila Health Care Limited, Ankleshwar

**Implementation Details:** Plant is having a 310 TR, R134a refrigerant based Trane water cooled chiller for catering their cooling requirements in the plant. Average energy consumption per tons of refrigeration was found around 0.501. It's also observed frequent fouling of heat exchanger tubes due to oil. Generally during the piston stroke in the cylinder of a compressor, the refrigerant gets a small amount of oil from the compressor, which over time, adheres to the inner pipe of the evaporator. That adhesion oil acts as an insulator reducing the heat transfer capacity of the evaporator. Typically an AC's efficiency deterioration will be more than 30% for 20 years old system.

To avoid these effects due to oil fouling plant has used active refrigerant agent which is an intermetallic compound technology which, when introduced into the refrigerant oil, forms a permanent bond to metal surfaces which removes oil fouling, changes the thermal nature of the metal and lowers the boiling point of the refrigerant gas, resulting in a more efficient operating system with substantial energy cost savings.

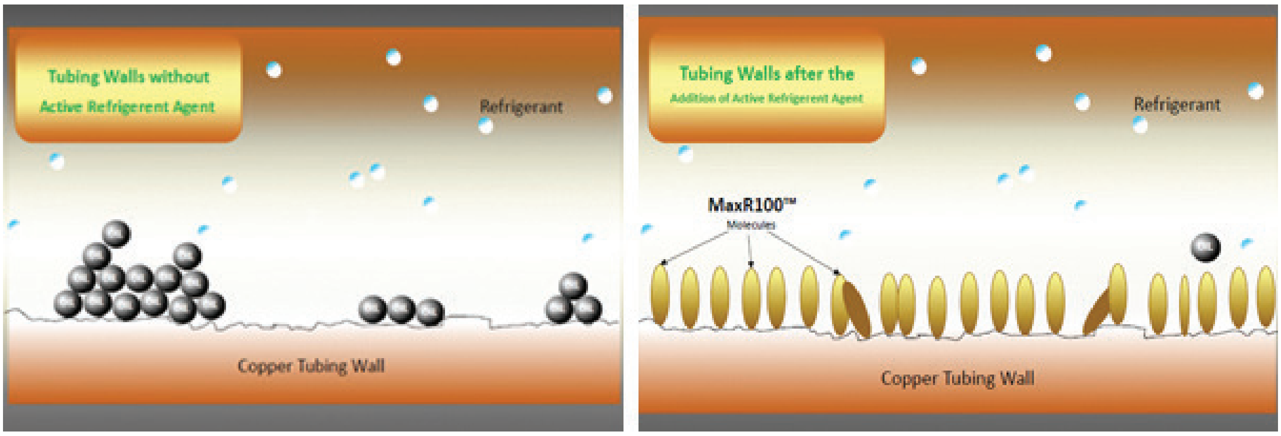



*Figure 18: Copper Tubes Before & After Active Refrigerant Agent Addition*

**Merits:**

- ❖ Increases effective heat transfer
- ❖ Substantial Energy savings
- ❖ Reduces maintenance

**Limitations:**

- ❖ Initial high cost
- ❖ Works only with open & semi hermetically open type compressors

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Total Running Hours | 99.05 | 89.95 |
| 2 | Total Energy Consumption in KWH | 14,935 | 13,828 |
| 3 | Average Energy Consumption / Hour in KWH | 150.79 | 153.74 |
| 4 | Average Load in KW / Hour | 150 | 164.2 |
| 5 | Average Energy Consumption / KW | 1.005 | 0.93628 |
| 6 | Average Phase Voltage (VLL) | 428.2 | 428 |
| 7 | Average Phase to Neutral Voltage ( VLN) in Volts | 247.2 | 247.2 |
| 8 | Average Current in Amps | 209.6 | 277.8 |
| 9 | Average RH IN % | 58.76 | 32.77 |
| 10 | Set Point in °C | 7 | 7 |
| 11 | Average Chillers inlet Temperature in °C | 10.35 | 12.63 |
| 12 | Average Chillers Outlet Temperature in °C | 7.23 | 8.92 |
| 13 | Average Condenser Inlet Temperature in °C | 32.17 | 27.05 |
| 14 | Average Condenser Outlet Temperature in °C | 36.33 | 32.78 |
| 15 | Average Ambient Temperature in °C | 33.84 | 28.89 |
| 16 | Average RT produced in Refrigeration Tons | 300.6 | 346.2 |
| 17 | Average Energy Consumption / RT | 0.501630073 | 0.444068516 |
| 18 | Annual kWh Savings | 1,37,500 | |
| 19 | Annual Energy Savings in TOE/Yr | 11.8 | |
| 20 | Annual Reduction in $CO_2$ at 0.82 Emission Factor | 112 MT | |

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 11 Lakh | 7.5 Lakh | 8 Months |

## Technology Supplier Details:

Amnyk India

40, Bank Street, Khatau Building, Ground Floor, Mumbai, Maharashtra 400001

Phone: 9246340166

Email: bs@amnyk.com

# 6.3. Readymade Garments

## Case Study 1: Condensate Recovery in Boiler

### Plant: Super Fashion, Faridabad

**Implementation Details:** Presently the boiler was generating steam at a pressure 7 kg/cm$^2$, at corresponding temperature of 180°C. Boiler generations was measured about 65% of the rated 400 kg/hr. About 25% of the steam is considered to be utilized directly during process from which condensate cannot be recovered, but remaining of steam after utilization in the process indirectly used, which is drained a large amount of heat loss. The Consultant suggested to recover condensate and feedback to boiler. The unit has implemented this measure and installed new condensate recovery system for both boilers.

*Figure 19: Condensate Recovery System*

**Merits:**

- ❖ Condensate is an excellent source of feed water as it is relatively pure (compared to most water supplies) being condensed water vapour.
- ❖ Boiler water cycles of concentration can be increased and blow down amounts can be reduced with its use.
- ❖ Improves energy efficiency.
- ❖ Reduces water treatment chemical cost.
- ❖ Reduces make-up water costs.

**Limitations:**

- ❖ Requires regular maintenance.
- ❖ Estimation of proper back pressure.
- ❖ Inventory of electronic spare parts to be maintained.

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Ambient Temperature °C | 30 | 30 |
| 2 | Final Temperature of Feed Water °C | 30 | 70 |
| 3 | Gain in Temperature °C | 40 | |
| 4 | Feed water Flow rate (kg/hr) | 261.3 | 261.3 |
| 5 | Heat Gain by feed Water (kCal/hr) | 10,452 | |
| 6 | Calorific Value of Diesel (kCal/kg) | 11,840 | |
| 7 | Efficiency of Boiler % | 81 | |
| 8 | Annual operating Hours (Hours/Annum) | - | 3,000 |
| 9 | Diesel Saving (Liters/hr) | 1.32 | |
| 10 | Annual Diesel Saving (Litres/Annum) | 3,956 | |
| 11 | Annual Energy Savings in TOE | 0.71 | |
| 12 | Annual reduction in $CO_2$ | 6.86 MT | |
| 13 | at 0.82 emission factor | | |

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 1.92 Lakh | 2.76 Lakh | 17 Months |

## Technology Supplier Details:

Nitesh ENTERPRISES

PLOT NO. 13 NEW DLF INDUSTRIAL AREA, FARIDABAD 121004

Phone No. 9891668835

## Local Technology Supplier / Service Provider:

Basu Technologies

Phone: 0731 - 2446554

Email: sales@basutechnology.com

# Case Study 2: VFD for RO Plant Pumps

### Plant: Shahi Dyeing Private Limited, Faridabad

**Implementation Details:** There are two RO plants installed in plant. Discharge valve for new RO system was throttled which is the most in efficient way of control and hence power loss observed in throttling.

In RO water supply pump, for plant has one bypass line through which excess water returns back to sump. The actual water requirement for New RO plant is 18 CMH and for process it is 12 CMH. The Consultant suggested plant team to install VFD on both above mentioned RO water pumps used for RO Plant and for Process.

Plant has installed one VFD on new RO plant high pressure pump. Another RO system is not in use, so VFD was not installed on that system. Detailed measurement was carried out during M&V. Power consumption of high pressure pump after installation of VFD was measured as 12.50 kW. Installation of VFD on high pressure pump has reduced energy cost for processing.

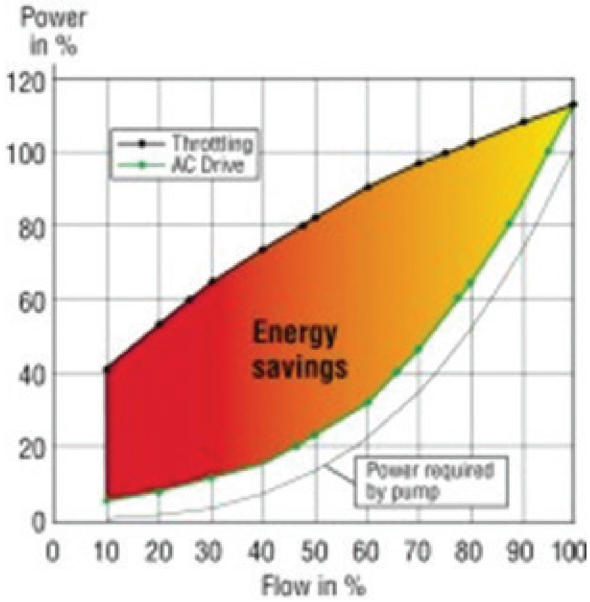



*Figure 20: Pump power consumption variation with flow control by throttling & by AC drive*

*Figure 21: VFD implementation*

**Merits:**

- ❖ Smooth starting of pump.
- ❖ Energy efficient flow control.
- ❖ Reduction in starting power demand.

**Limitations:**

- ❖ Injection of a little harmonics in to the system which can be easily mitigated through existing capacitor banks & cable reactance.
- ❖ Initial high capital investment.

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Pump Design Flow ($m^3$/hr) | 18 | 30 |
| 2 | No of Pump | 1 | 1 |
| 3 | Pump Design Pressure (kg/$cm^2$) | 14.4 | 15.9 |
| 4 | Connected Load (kW) | 18.5 | 12.5 |
| 5 | Operational hours/Day (hours/Day) | 24 | 24 |
| 6 | Annual operating days (Days/Annum) | 300.0 | 300.0 |
| 7 | Annual Energy Consumption (kWh/Annum) | 1,33,200 | 90,000 |
| 8 | Annual Energy Saving (kWh/Annum) | 43200 | |
| 9 | Annual Energy Savings (TOE) | 3.71 | |
| 10 | Annual reduction in $CO_2$ at 0.82 emission factor | 35.42 MT | |

## Cost Benefits:

**Annual Savings**

**3.70 Lakh**

**Investment**

**0.73 Lakh**

**Simple Payback Period**

**2 Months**

## Technology Supplier Details:

Nanotek Controls

Address : 3729/25, Dua Compound

33 FL Road, Sanjay Colony, Sector -23 , Faridabad

Mobile no – 09313046720

E-mail ID :- nanotekcontrols@gmail.com

## Alternate Technology Supplier Details:

YASKAWA India Pvt Ltd.,
The Parinee Cresenzo, 8th Floor, Tower - B, (Opp. MAC),
G - Block, Bandra Kurla Complex, Mumbai - 400 051, India
Phone: 22 4880 0774
Email: sales@yaskawa.in

## Local Technology Supplier / Service Provider:

Synergy Distributors
MSB-508,,New Siyaganj, Maal Godam Road,
Block-B, New Siyaganj, Indore.452007
Phone: 94259 00080

# Case Study 3: Optimization of Leakages in steam line

## Plant: Colorline, Faridabad

**Implementation Details:** During the field study it was observed that there are more than 50 leakage points starting from the boiler itself to the machines. The diameter of leak points ranged from few mm to more than 6 mm leading to steam losses. The total steam losses were estimated as 10%. It was recommended to replace the steam pipes and steam valves to optimize the leakages and avoid the steam losses.

The unit has implemented this ECM. During the M&V visit detailed measurements were done. The unit has reduced steam leakages. As per plant team, continuous monitoring of steam leakage was done and efforts were made to reduce the leakages, which contributed to the reduction in steam loss of 873 tons/annum.

*Table 4: Leakage Estimation*

| Orifice Dia in mm | Steam flow kg/h, when steam pressure (in kg/cm$^2$) is | | | | | |
|---|---|---|---|---|---|---|
| | 7 | 9 | 10.5 | 14 | 17.6 | 21 |
| 0.79 | 1.23 | 1.5 | 1.77 | 2.31 | 2.86 | 3.36 |
| 1.59 | 4.9 | 5.99 | 7.08 | 9.21 | 11.39 | 13.52 |
| 2.38 | 11.07 | 13.48 | 15.93 | 20.74 | 25.59 | 30.4 |
| 3.18 | 19.69 | 24 | 28.31 | 36.89 | 45.37 | 53.99 |
| 3.97 | 30.81 | 37.52 | 44.19 | 57.62 | 70.78 | 84.39 |
| 4.76 | 44..33 | 53.99 | 63.52 | 83.03 | 102.54 | 121.6 |
| 5.56 | 60.34 | 73.5 | 86.66 | 112.98 | 139.29 | 165.61 |
| 6.35 | 78.49 | 96.19 | 113.43 | 147.46 | 181.94 | 216.42 |
| 7.14 | 99.82 | 121.6 | 143.38 | 186.93 | 230.04 | 213.59 |
| 7.94 | 123.41 | 150.18 | 176.95 | 230.49 | 284.48 | 338.02 |
| 8.73 | 149.27 | 181.49 | 214.16 | 279.04 | 343.92 | 408.8 |
| 9.53 | 177.4 | 215.97 | 254.54 | 332.12 | 409.26 | 486.84 |
| 10.32 | 208.26 | 253.63 | 299 | 389.75 | 480.49 | 571.23 |
| 11.11 | 241.38 | 294.01 | 346.64 | 451.91 | 557.17 | 662.43 |
| 11.91 | 277.22 | 337.57 | 397.91 | 519.06 | 639.75 | 760.44 |
| 12.7 | 315.34 | 384.3 | 452.81 | 590.29 | 727.77 | 865.25 |

Merits:

- Considerable amount of fuel savings.
- Safety due to leakage arrest.

| S.No | ECM – Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Leakage Points | 2 | 2 |
| 2 | Diameter of Leak point per hole | 6 | 1.5 |
| 3 | Steam Loss per hole | 931 | 58 |
| 4 | Reduction in Steam loss (Tons/Annum) | 873 | |
| 5 | Reduction in heat loss (kCal/Annum) | 34,04,70,000 | |
| 6 | GCV of Wood (kCal/kg) | 2,800 | |
| 7 | GCV of Coal (kCal/kg) | 3,600 | |
| 8 | Effective Fuel saving (MT/Annum) | 99.90 | |
| 9 | Annual Energy Savings (Mkcal/yr) | 340 | |
| 10 | Annual Energy Savings (TOE/Yr) | 34 | |
| 11 | Annual reduction in $CO_2$ at 0.82 emission factor (MT) | 324 | |

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 9.0 Lakh | 6.5 Lakh | 9 Months |

## Local Technology Supplier Details:

Unimod Systems

M9, Rukmani plaza, 14 Palasia, AB Road, INDORE

Phone: 0731 2545596, 2546314

Email: info@unimodsystems.com

# 6.4. General

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

### Plant: Melting Centre Pvt Ltd, Kolhapur

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

*Figure 22: Energy Efficient Pump*

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

**Merits:**

- Higher efficiencies.
- Robust design & less maintenance.

**Limitations:**

- Initial high capital cost.

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Cost of Electricity(INR/kWh) | 7.83 | 7.83 |
| 2 | Power Consumption kW | 3.34 | 1.97 |
| 3 | Annual Operating hours | 7,200.00 | 7,200.00 |
| 4 | Annual savings (kW hr/yr) | 9,864.00 | |
| 5 | Annual savings (TOE/Yr) | 0.84 | |

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 6 | Annual reduction in $CO_2$ at 0.82 emission factor | 8 MT | |

## Cost Benefits:

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

## Technology Supplier Details:

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

Phone: 9552202099

## Local Technology Supplier Details:

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

Phone: 07272-227397

## Applicable Sectors:

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

# Case Study 2: Replacing old inefficient lighting with energy efficient lighting system

## Plant: OK Auto Components, Faridabad

**Implementation Details:** Plant is having T-8, T- 12 and T-5 fixtures with magnetic ballast installed for catering lighting requirement. These lights have low efficacy. It was recommended to replace 36 Watt FTL and 40 Watt FTL with LEDs Tube lights of lesser wattage thereby reducing approximately 40% of electricity consumption.

The unit has implemented this ECM. During the M&V visit, it was found that plant team has installed LED lights of 18 Watts, 16 Watts, 25 Watts and 60 Watts to replace existing luminaries. Installation of high efficacy lamps has reduced energy cost and also improved lux level in the plant.

| BULB \ BRIGHTNESS | 450 lumens | 800 lumens | 1100 lumens | 1600 lumens | 2600 lumens | 5800 lumens |
|---|---|---|---|---|---|---|
| LED | 6W | 9-10W | 13W | 16-18W | 24W | 45W |
| | | | | | special high voltage lamps | |
| CFL | 8-9W | 13-14W | 18-19W | 23W | 40W | 85W |
| Regular Incandescent | 40W | 60W | 75W | 100W | 150W | 300W |
| Halogen | 29W | 43W | 53W | 72W | 150W | 300W |

*Figure 23: Efficacy Comparison of Different Lighting Systems*

**Merits:**

- ❖ High lumens per watt.
- ❖ Directional lighting.
- ❖ Rugged & have longer lifetimes.
- ❖ Excellent colour rendering index.
- ❖ Controllable Brightness & colour features.

**Limitations:**

- Temperature dependence.
- Voltage sensitivity.
- High initial investment.

| S.No | ECM – Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Installed Capacity kW | 2.3 | 1.31 |
| 2 | Working Hours per day (Hr/ Day) | 12 | 12 |
| 3 | Working Days per year (Days/ Annum) | 300 | 300 |
| 4 | Annual consumption (kWh/yr) | 8,280 | 4,716 |
| 5 | Average Unit Cost (INR/kWh) | 6.53 | 7.5 |
| 6 | Annual savings (kWh/ Annum) | 3564 | |
| 7 | Annual reduction in $CO_2$ | 2.92 MT | |
| 8 | at 0.82 emission factor | | |

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 0.27 Lakh | 0.56 Lakh | 25 Months |

## Technology Supplier Details:

Rajan Associates
3C/132, NIT Faridabad
Phone No-0129 4028654

## Local Technology Supplier Details:

1.Ganit Star Engineering

45/2, Nayta Mundla, Agrawal Parisar, Nemawar Road Palda, Opposite Badi Lakhani Factory, Opposite Badi Lakhani Factory, Palda,

Indore-452020, Madhya Pradesh, India

Phone: 8048111146

2.Wipro Enterprises (P) Ltd.

United Compund, A.B Road,

Dewas Naka, Indore,

Madhya Pradesh - 452010

Tel: +91 98279 99668

## Applicable Sectors:

Foundry, Autocomponents, Pharma, Readymade Garments & Food processing

# Case Study 3: Replacement of all old reciprocating air compressors with new energy efficient screw air compressor

## Plant: Aum Prasad Casting (P) Ltd, Pune

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

**Merits:**

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

**Limitations:**

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

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

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

## Cost Benefits:

**Annual Savings**

6.41 Lakh

**Investment**

7.28 Lakh

**Simple Payback Period**

14 Months

## Technology Supplier Details:

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

## Local Technology Supplier Details:

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

## Applicable Sectors:

Foundry, Autocomponents, Pharma & Food processing

# Case Study 4: Voltage Optimization at Incomer

## Plant: OK Auto Components, Faridabad

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

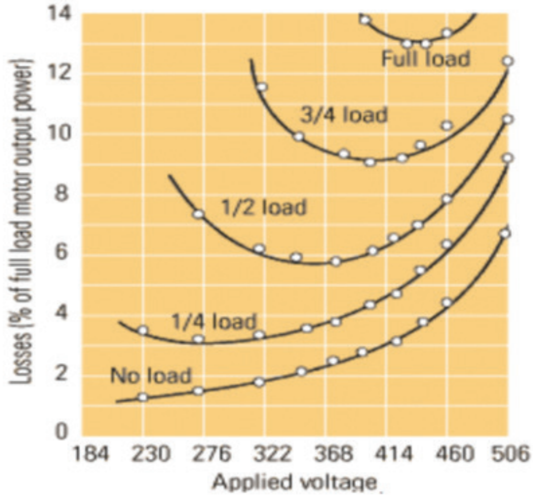



*Figure 24: Motor Losses with variation in applied voltage*

**Merits:**

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

**Limitations:**

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

| S.No | Implementation Details | Before Implementation | After Implementation |
|---|---|---|---|
| 1 | Average Three phase voltage (V) | 451.0 | 405.0 |
| 2 | Reduction in Three phase voltage (%) | 10.2 | |
| 3 | Reduction in Energy Consumption (%) | | 0.19 |
| 4 | Annual energy consumption - Three Phase (kWh/yr) | 4,55294 | 3,67,155 |
| 5 | Annual Saving (kWh/Annum) | | 88,139 |
| 6 | Net Saving from Voltage Regulation (5 Months) | | 36,725 |
| 7 | Unit Cost (INR/kWh) | 6.53 | 7.5 |
| 8 | Annual energy savings (TOE/Yr) | 7.57 | |
| 9 | Annual reduction in $CO_2$ at 0.82 emission factor | 72 MT | |

## Cost Benefits:

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

## Technology Supplier Details:

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

## Local Technology Supplier Details:

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

## Applicable Sectors:

Foundry, Autocomponents,Readymade Garments, Pharma & Food processing

# Case Study 5: Installation of solar roof top PV system

## Plant: Amul Fed Dairy, Gandhinagar

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

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

*Figure 25: Solar PV Installation*

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

Latitude : 23.25  Longitude : 72.65

Annual Average : 5.75 kWh/m$^2$/day

Monthly Average

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

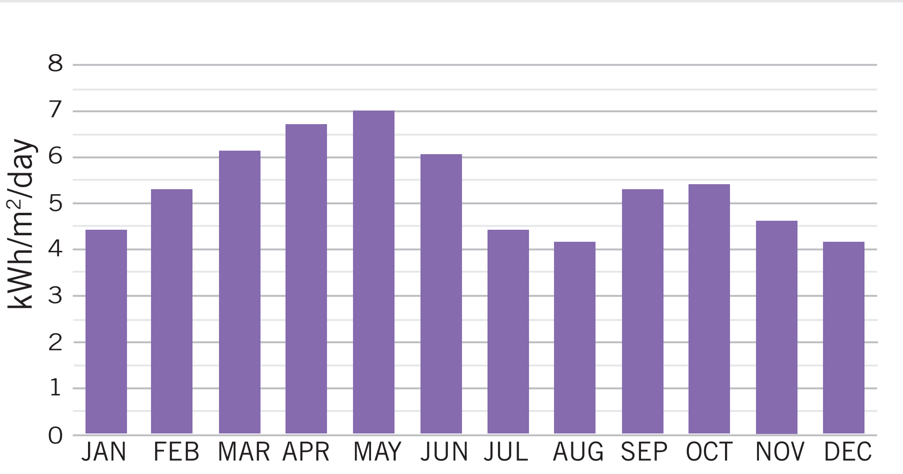



*Figure 26: Annual Solar Irradiance of the site*

**Merits:**

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

**Limitations:**

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

*Table 5: Project Details*

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

## Cost Benefits:

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

## Technology Supplier Details:

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

## Local Technology Supplier Details:

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

## Applicable Sectors:

Foundry, Autocomponents,Readymade Garments, Pharma & Food processing

# Case Study 6: Installation of Solar-Wind Hybrid System

## Plant: Manufacturing Facility

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

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

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

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

*Figure 27: Solar Wind Hybrid System*

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

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

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

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

### Merits

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

- ❖ A compact hybrid solar mill to meet a portion of the plant's load after detailed study with vendors.
- ❖ Power generation stats at 2-5 m/s and mechanical braking occur beyond 18 m/s.

### Limitations

- ❖ Initial higher investment.

Latitude : 23.05 Longitude : 72.55

Annual Average : 5.82 kWh/m2/day

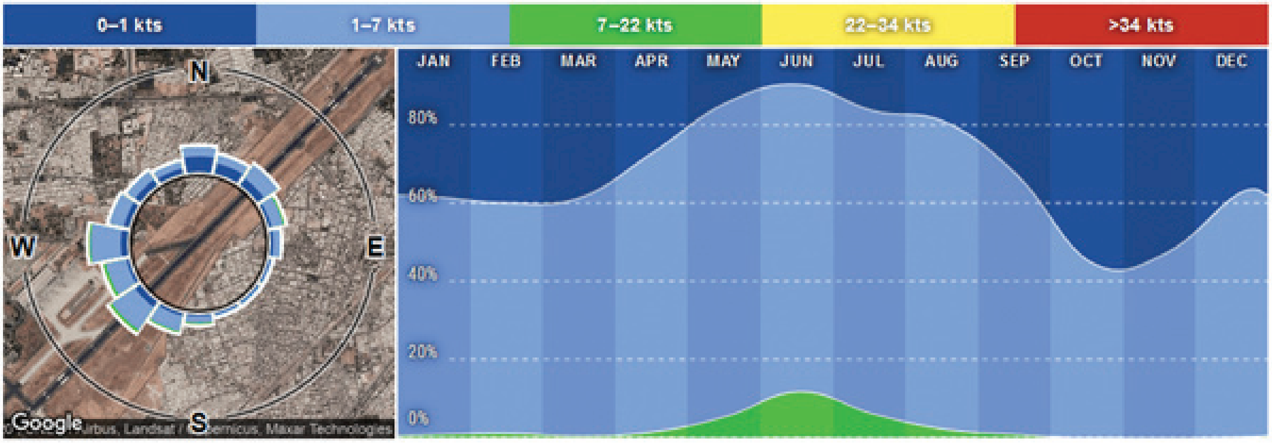



*Figure 28: Average winds in and around Ahmedabad area*

Latitude : 23.05 Longitude : 72.55

Annual Average : 5.82 kWh/$m^2$/day

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

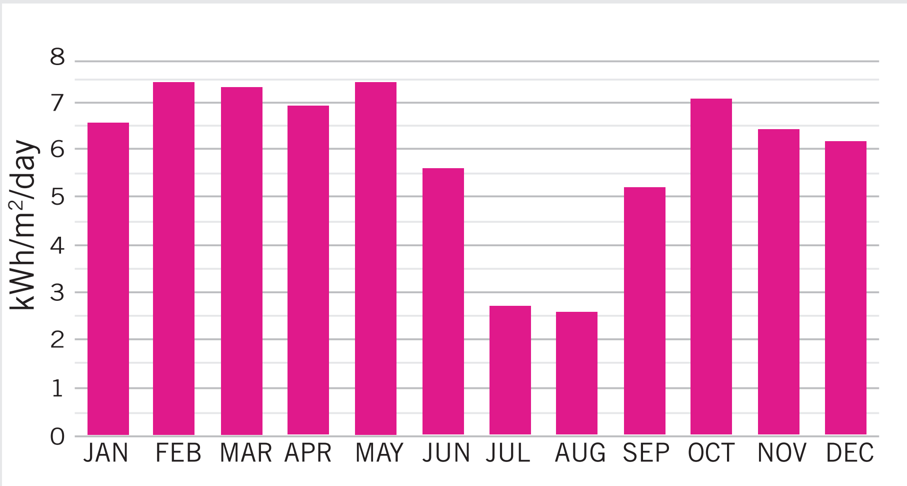



*Figure 29: Average direct solar irradiance of site*

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

## Cost Benefits:

| Annual Savings | Investment | Simple Payback Period |
|---|---|---|
| 7.11 Lakh | 50.0 Lakh | 84 Months |

## Technology Supplier Details:

Windstream Technologies

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

Email: bhaskars@windstream-inc.com

Phone: +91 99599 18782

## Applicable Sectors:

Foundry, Autocomponents,Readymade Garments, Pharma & Food processing

# Case Study 7: Installation of Duplex Hybrid Solar Panel System

## Plant: Oyo Town House 045, Hyderabad

**Implementation Details:** Oyo Town House at Hyderabad had a hot water consumption of 2 KL – 3KL per day. They required 5 kW of power for running the complete facility. Challenge with normal PV system was the space, which was just 500 s. ft. and unable to meet the requirement of both electric power and hot water.

Then the facility opted for new duplex hybrid solar panel technology which has the merits mentioned below.

**Merits:**

- Hot water and electricity from a single panel.
- Most efficient solar panel in India (35% 40%).
- Same electric output (300W) as an ordinaryelectric panel.
- Same hot water output (100-120 litres per day) as an ordinary hot water panel.
- Single compact system that meets total energy requirements at the same cost.
- Maximizes the savings per sq. ft. of roof top space.
- More energy per sq. ft. – nearly 11.5 units a day.
- Quick break-even less than 4 years.

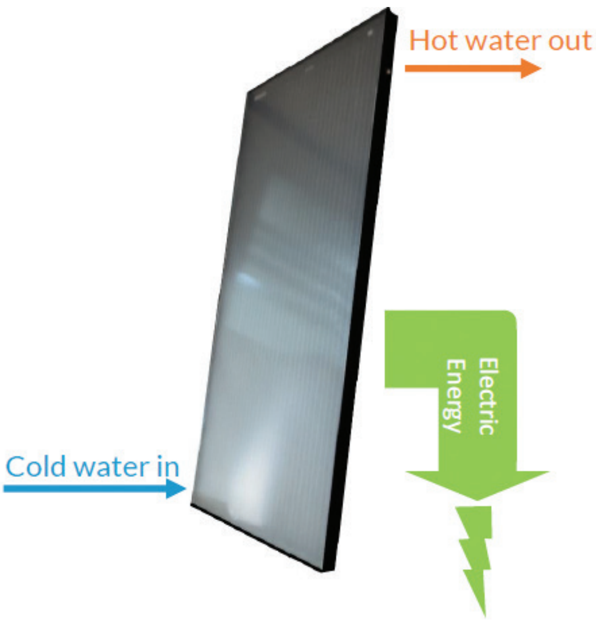



*Figure 30: Hybrid Solar Panel System*

**Limitation:**

- Hot water requirement should also be there for realizing the optimum benefits of the system

This proposed 'Duplex' system only take up 450 sq. ft. of space. This system can deliver 4.5 kW and up to 1,500 LPD of hot water simultaneously from a single system. Conventional standalone systems would have taken up 1,000 sq.ft.

*Table 6: Design Details of the System*

| | Heat pump | FPC panels | Birds Eye Energy 'Duplex' solar panels |
|---|---|---|---|
| Design life of the system | 10 years | 7-0 years | 25 years |
| Warranty | 2 years | 3 years | 20 years |
| No. of replacements in 25 years | 2 | 2 | 0 |
| Frequency of maintenance (de-scaling) | 8 times per year | Once per year | Once per 3 years |
| Other possible failures | Gas leak, Compressor failure | None | None |
| Refrigerant needed | Yes | No | No |
| Customer can repair the system | No | Yes | Yes |
| Remote monitoring & diagnostic | No | No | Yes |

Solar energy systems produce the least energy during June, July & August due to frequent rains and cloudy weather. This innovative solar energy system was still able to almost meet the target temperature during these months (set point is usually 50 - 55 °C).

*Table 7: Output Details*

| Month | Electricity output | |
|---|---|---|
| | Average daily generation kWhr | Monthly generation (kWhr) |
| 1st June to 30th June | 15.9 | 477 |
| 1st July to 31st July | 14.1 | 437 |
| 1st Aug to 31st Aug | 14.6 | 453 |

*Table 8: Water Consumption Details*

| Duration | No. of days | Total hot water supplied (L) | Avg temp of hot water (deg C) |
|---|---|---|---|
| 17th June to 29th June | 13 | 11, 733 | 55 |
| 13th July to 31st July | 19 | 23,923 | 48 |
| 3rd Aug to 31st Aug | 29 | 35,853 | 48 |

*Table 9: Savings Calculations*

| Electricity output | | | Hot water output | | |
|---|---|---|---|---|---|
| Month | Average daily generation (kWhr) | Monthly generation (kWhr) | Average daily savings (kWhr) | Monthly savings (kWhr) | Monthly savings (@ ₹9 / unit) |
| June | 15.9 | 477 | 34 | 1,020 | ₹ 13,473 |
| July | 14.1 | 437 | 35 | 1,085 | ₹ 13,698 |
| August | 14.6 | 453 | 31 | 961 | ₹ 12,726 |

## Cost Benefits:

**Annual Savings**
2.30 Lakh

**Investment**
6.92 Lakh

**Simple Payback Period**
36 Months

## Technology Supplier Details:

Birds Eye Energy Technologies
Bank of Baroda Lane, Rd no. 10 Banjara Hills, Hyderabad, Telangana 500034
Phone: +91 - 9100 625112
Email: sales@birdseyeenergy.in

## Applicable Sectors:

Pharma, Autocomponents, Ready made Garments

# Case Study 8: Improve power factor by Installing KVAR compensator and APFC

## Plant: Reputed foundry unit in Kolhapur

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

**Effects of Lower power factor:**

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


*Figure 31: KVAR Compensator*

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

From a technical point of view this is the best solution, as the reactive energy is produced at the point where it is consumed. Heat distribution losses ($I^2R$) 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:**

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

**Limitations:**

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

## Cost Benefits:

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

## Alternate Technology Supplier Details:

Inphase power technologies

No 59, Kachohalli, Machohalli Industrial Area

Magadi Main Road, Chikka Gollarahatti, Bangalore-560091

Phone: +91-7760693303

Email: sales@inphase.in

## Local Technology Supplier Details:

Bharmal Traders

20, Udhyog Puri, Nemawar Road, Indore, MP

Phone: 9827023499

Email: sales@bharmaltraders.com

## Applicable Sectors:

Foundry, Pharma, Autocomponents, Ready made Garments, Food processing

# Case Study 9: Replacement of aluminium blades of cooling tower fan by FRP blade

## Plant: Caspro Metal Industries Pvt Ltd, Kolhapur

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

**Merits:**

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

**Limitations:**

- A Little high on cost.

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

*Figure 32: FRP Cooling Tower Fan*

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

## Cost Benefits:

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

## Alternate Technology Supplier Details:

Encon Engineers
2B/17, SHIVKRIPA, N.C. KELKAR ROAD, DADAR (WEST), MUMBAI-400 028 (INDIA)
Phone : 022 2430 6578
Email : encon@encongroup.in

## Local Technology Supplier Details:

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

## Applicable Sectors:

Foundry, Pharma, Autocomponents

# Case Study 10: Replacement of Existing Motors with Energy Efficient (IE3) Motors

## Plant: A foundry unit in Kolhapur

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

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

*Table 10: Classification of Motors as per IEC*

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

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

### EESL's National Motor Replacement Program

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

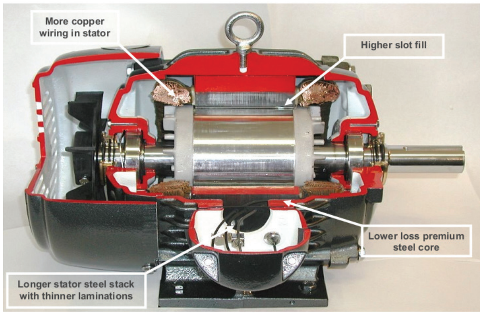



*Figure 33: Energy Efficiency Induction Motor Construction*

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

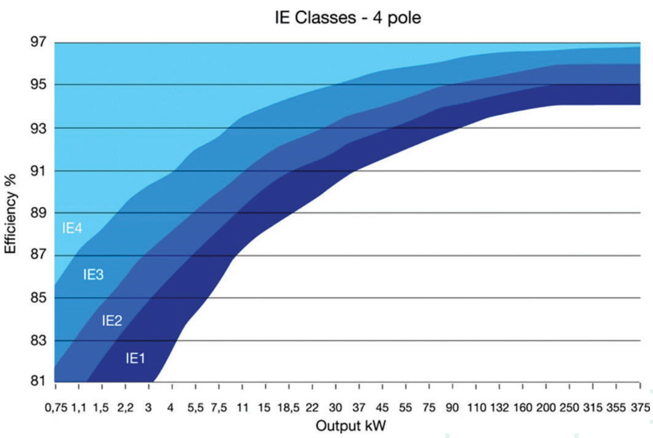



*Figure 34: Efficiency Variation Graph for Various kW Ratings of EE Motors*

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

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

**Benefits**

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

**Limitations:**

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

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

## Expected Cost Benefits:

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

## Alternate Technology Supplier Details:

EESL
Mr Gopinath
Engineer, EESL
8095037607

## Applicable Sectors:

Foundry, Pharma, Autocomponents, Foodprocessing, Readymade Garments

# Case Study 11: Installation of Light Pipe to Harness Daylight

## Plant: Indian Railways Production Unit

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

*Table 11: Facilities Artificial Lighting Details*

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

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

**Light pipes:**

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

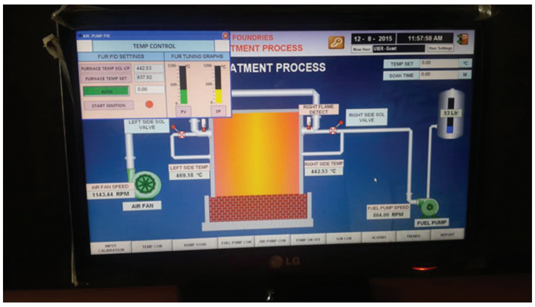


*Figure 35: Light Pipe Components*

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

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

### Benefits

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

### Limitations:

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

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

*Figure 36: Light Pipe Installation*

## Expected Cost Benefits:

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

## Technology Supplier Details:

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

## Applicable Sectors:

Foundry, Autocomponents, Foodprocessing.

# 7. Conclusion

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

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

## Type A: Small Investment

- Replacing old in efficient lighting with energy efficient lighting system.
- Replacement of Existing Motors with Energy Efficient (IE3) Motors.
- Replacement of aluminium blades of cooling tower fan by FRP blade.
- Replacement of existing raw water pump with energy efficient pump.
- Improve power factor by Installing KVAR compensator and APFC.
- Condensate Recovery in Boiler.

## Type B: Medium Investment

- Installation of Duplex Hybrid Solar Panel System.
- Installing air pre-cooling system for existing air conditioning system.
- Installation of solar roof top PV system.
- VFD for RO Plant Pumps.
- Replacing conventional belt driven blower drives with EC drives.
- Replacement of all old reciprocating air compressors with new energy efficient screw air compressor.
- Voltage Optimization at Incomer.
- Installation of Solar-Wind Hybrid System.
- Optimization of Leakages in steam line.
- Switching from sawdust-based roaster to biomass blend -based Multi fuel roaster system.
- Installation of Light Pipe to Harness Daylight.

## Type C: High Investment

- Active refrigerant agent addition in lube oil for chillers.

*Table 12: Summary of Energy Conservation Measures*

| S.No. | Technologies | Ease of Implementation | | | Priority of Activity | | |
|---|---|---|---|---|---|---|---|
| | | Easy | Moderate | Difficult | Short | Medium | Long |
| 1 | Switching from sawdust-based roaster to biomass blend -based Multi fuel roaster system | | | * | | * | |
| 2 | Replacing conventional belt driven blower drives with EC drives | * | | | * | | |
| 3 | Installing air pre cooling system for existing air conditioning system | | * | | | * | |
| 4 | Active refrigerant agent addition in lube oil for chillers | * | | | * | | |
| 5 | Condensate Recovery in Boiler | | * | | | * | |
| 6 | VFD for RO Plant Pumps | * | | | * | | |
| 7 | Optimization of Leakages in steam line | * | | | * | | |
| 8 | Replacement of existing raw water pump with energy efficient pump | * | | | * | | |
| 9 | Replacing old in efficient lighting with energy efficient lighting system | * | | | | * | |
| 10 | Replacement of all old reciprocating air compressors with new energy efficient screw air compressor | | * | | | * | |
| 11 | Voltage Optimization at Incomer | * | | | | * | |
| 12 | Installation of solar rooftop PV system | | | * | | | * |
| 13 | Installation of Solar -Wind Hybrid System | | * | | | | * |
| 14 | Installation of Duplex Hybrid Solar Panel System | | | * | | | * |
| 15 | Improve power factor by Installing KVAR compensator and APFC | * | | | | * | |
| 16 | Replacement of aluminium blades of cooling tower fan by frp blade | * | | | * | | |
| 17 | Replacement of Existing Motors with Energy Efficient (IE3) Motors | | * | | | * | |
| 18 | Installation of Light Pipe to Harness Daylight | | * | | | * | |

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

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

*Table 13: Technology supplier details*

| Sl No | Name | Address | Contact details |
|---|---|---|---|
| **Technology : Indirect Evaporative Cooling** | | | |
| 1 | HMX (ATE Group) | Ahmedabad | Mr Rishabh Matta<br>Assistant Manager - Sales<br>9158308880<br>r_h_matta@hmx.co.in |
| 2 | Renotech Air Engineering | Pune | Mr Shamkant Mirashi<br>Technical Consultant<br>8788825644<br>sales@renotech.in |
| **Technology : EC Fans** | | | |
| 1 | AAD Tech India Pvt ltd | Delhi | Mr Manpreet Singh<br>GM - Projects<br>9876724003<br>Manpreet@aadtech.in |
| **Technology: Active Refrigerant Agent** | | | |
| 1 | Amnyk India | Hyderabad | Mr Sureshwar<br>DGM Marketing<br>9246340166<br>bs@amnyk.com |
| **Technology: Biomass Based Roaster System** | | | |
| 1 | Steamax India | New Delhi | Mr Sarvesh Yadav<br>Proprietor<br>9810272614<br>info@steamaxindia.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<br>Manager - Marketing<br>9346280052<br>latesh.k@in.atlascopco.com |

| Sl No | Name | Address | Contact details |
|---|---|---|---|
| 2 | Vertex Pneumatics Pvt. Ltd. (Dealers of Atlas Copco) | 3,16th cross, lakkasandra, Gopalappa Layout, Opp. Chowdeshwari temple, Bengaluru, Karnataka 560030 | Mr B S Shrikanth Swamy<br>Sales Engineer<br>9686656101<br>sales@vertexpneumatics.com<br>service@vertexpneumatics.com |
| 3 | Prakash Sales Agencies (Authorised Dealers of ELGI) | 39, Corporation Complex, Goaves, Belgaum, Karnataka 590011 | Mr Amit Sathaye<br>9449053626<br>psa_bgm@dataone.in<br>psabgm@gmail.com |
| 4 | Beko Compressed Air Technologies Pvt Ltd | Plot No.43, CIEEP, Gandhi Nagar, Balanagar, Hyderabad, Telangana 500037 | Mr Madhusudan Masur<br>Executive Director<br>040-23081106<br>Madhusudan.Masur@bekoindia.com |
| **Technology : Compressed Air Solutions (1. FLOW SENSOR , 2. DEWPOINT SENSOR , 3. LEAK DETECTOR, 4. SMART MONITORING SOFTWARE)** | | | |
| 1 | Systel Energy Solutions (INDIA) Pvt. Ltd. | 12, Venkata Lakshmi Nagar, Chellandy Amman Nagar, Singanallur, Tamil Nadu 641005 | Ms. Sasi Kala<br>Sales Coordinator<br>90477 78715<br>support@systel.asia |
| 2 | Beko Compressed Air Technologies Pvt Ltd | Plot No.43, CIEEP, Gandhi Nagar, Balanagar, Hyderabad, Telangana 500037 | Mr Madhusudan Masur<br>Executive Director<br>040-23081106<br>Madhusudan.Masur@bekoindia.com |
| **Technology : Aluminium Piping for compressed air** | | | |
| 1 | Godrej & Boyce Mfg Co. Ltd. | | Mr Kiron Pande<br>Asst VP<br>kcp@godrej.com |
| 2 | Pneumsys Advance Energy Solutions | 1-143, Street No 6, Srinivasa Colony, Boduppal, Hyderabad, Telangana 500092 | Mr Girish K<br>Project Sales Manager (South)<br>tsmsouth@pneumsysenergy.com |
| 3 | Legris Parker | Victoria Ranigunj, Bolaram Nagar, Rani Gunj, Secunderabad, Telangana 500003 | Mr Joy Dewan<br>National Manager Transair<br>joy.dewan@parker.com |
| **Technology : VFD** | | | |
| 1 | Apex Industries (Dealers of 'CG Power' drives) | | Mr Deelip Mulay<br>Chief Executive<br>9850060698<br>8855003009<br>apexindustries92@gmail.com<br>dilipmulay@gmail.com |

| Sl No | Name | Address | Contact details |
|---|---|---|---|
| 2 | Siemens Ltd | Siemens Limited<br>Birla Aurora, Level 21,<br>Plot No. 1080,<br>Dr. Annie Besant Road, Worli,<br>Mumbai – 400030<br>India | Mr Prathish T M<br>Manager (Drives & Automation)<br>7259400100<br>prathish.t_m@siemens.com |
| **Technology : Blowers** | | | |
| 1 | Techflow Enterprises Pvt. Ltd. | Plot 803/B, Near Canal,<br>Kubadthal Village, Via Kunjad-Kathlal Highway, Ahmedabad,<br>Gujarat 382430 | Mr Rashmin Patel<br>Manager - Sales<br>8238044155<br>rashmin.patel@techflow.net |
| **Technology : PID Loop Optimisation** | | | |
| 1 | AKXA Tech | Plot# 122 1&2 Shinoli (BK),<br>Taluk: Chandgad, Kolhapur,<br>416508 | Mr Raghuraj Rao<br>9243209569<br>9731043921<br>raghuraj.rao@akxatech.com |
| **Technology : Energy Efficient Pumps** | | | |
| 1 | Grundfos | Grundfos Pumps India Pvt<br>823/4, first floor, Chaitra complex,<br>13th Cross, Near JSS Circle,<br>Jayanagar 7th block west,<br>Bangalore- 560 070. | Mr Mehul Rana<br>Manager Sales<br>9725045271<br>mehul@Grundfos.com |
| 2 | Shakti Pumps | Shakti Pumps (India) Limited,<br>Plot No. 401, 402, & 413,<br>Industrial Area<br>Sector - 3, Pithampur,<br>Dist. Dhar - 454774 (M.P.) India | Mr Tarun Songaria<br>Deputy Manager - Industrial Sales<br>7389911004<br>tarun.songaria@shaktipumps.in |
| **Technology : Cooling Tower** | | | |
| 1 | Flow Tech Air Pvt Ltd | B-105, Mehrauli - Badarpur Rd,<br>Block B, Vishwakarma Colony,<br>Pul Pehlad Pur, New Delhi,<br>Haryana 110044 | Mr Ritwick Das<br>Vice President - Sales & Marketing<br>7838978768<br>ritwickdas@flowtechair.com |
| **Technology : FRP Blades** | | | |
| 1 | Encon Group | 2 / 3, Ashirwad, N. C.<br>Kelkar Road, Dadar West,<br>Mumbai-400028, Maharashtra,<br>India | Mr Rai<br>Manager - Marketing<br>9324294400<br>akrai@encongroup.in |
| **Technology : Energy Efficienct Motors** | | | |
| 1 | Siemens Limited | Siemens Limited<br>Birla Aurora, Level 21,<br>Plot No. 1080,<br>Dr. Annie Besant Road, Worli,<br>Mumbai – 400030<br>India | Mr Siddu Mareguddi<br>Territory Manager<br>8105592066<br>siddu.mareguddi@siemens.com |

| Sl No | Name | Address | Contact details |
|---|---|---|---|
| 2 | Energy Efficiency Services Limited | Energy Efficiency Services Limited<br>NFL Building, 5th & 6th Floor, Core – III, SCOPE Complex, Lodhi Road, New Delhi – 110003 | Mr Gopinath B V<br>Engineer (Tech)<br>9482376407<br>gopinath@eesl.co.in |
| **Technology : PF Improvement** | | | |
| 1 | P2Power | A-95, Block A, Sector 80, Noida, Uttar Pradesh 201305 | Mr Shwetank Jain<br>Founder<br>9910911774<br>shwetank.jain@p2power.com |
| **Technology : KVAR Compensator** | | | |
| 1 | Athena Cleantech | | Mr Sanjeev Reddy<br>Regional Sales Head South<br>9440259863<br>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<br>9448480724<br>phoenix_bgm@hotmail.com |
| **Technology : Solar PV** | | | |
| 1 | Orb Energy: | 95, Digital Park Rd, 2nd Stage, Yeswanthpur, Bengaluru, Karnataka 560022 | Mr Prabhakar A<br>Manager - Projects (PV)<br>9480153394<br>a.prabhakar@orbenergy.com |
| 2 | Thermax Ltd | | Mr Akshay Sonkusare<br>Sales Engineer<br>9711120055<br>Akshay.Sonkusare@thermaxglobal.com |
| 3 | Sunshot Technologies | A-302, GO Square, Wakad Rd, Kaspate Wasti, Wakad, Pimpri-Chinchwad, Maharashtra 411057 | Mr Niraj Jain<br>Marketing Head<br>7021153736<br>niraj.jain@sunshot.in |
| 4 | Sunedison Infrastructure Limited | 11th floor, Bascon Futura SV IT Park,<br>Venkatnarayana Road,<br>T.Nagar, Chennai-600017. | Mr Vikram Dileepan<br>Director<br>aseen.p@sunedisoninfra.com |
| 5 | Fourth Partner Energy | Fourth Partner House, Plot No. N46, House No. 4-9-10,, HMT Nagar, Nacharam, Hyderabad, Telangana 500076 | Mr Devaraj<br>South Head – BD<br>8870014206<br>suseendhar@fourthpartner.co |
| **Technology: Solar Duplex** | | | |
| 1 | Birds Eye Energy Technologies Pvt. Ltd | Hyderabad | Mr Harshavardhan<br>Co-founder<br>9830936464<br>harsha@birdseyeenergy.in |

| Sl No | Name | Address | Contact details |
|---|---|---|---|
| | | **Technology: Light Pipe** | |
| 1 | E-View Global | Mumbai | Mr Rajiv Gupta<br>Director<br>9769421112<br>rajiv@eviewglobal.com |
| | | **Technology: Hydroxy Fuel Generator** | |
| 1 | Kankyo Group of Companies | Chennai | Mr Devanand<br>Chairman & Maniging Director<br>9962500069<br>dev@kankyo.global |
| | | **Technology : Wind - Solar Hybrid** | |
| 1 | EnergyHive | Energyhive Renewables LLP<br>5/82, Blue Beach Road,<br>Neelankarai, Chennai 600041<br>Tamilnadu, India | Mr Venugopal<br>Director<br>9884370945<br>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<br>Senior VP - Manufacturing<br>7036297093<br>vtimmaraju@windstream-inc.com |

For more details, please contact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