MANUAL ON ENERGY EFFICIENCY MEASURES IN BANGALORE MACHINE TOOL CLUSTER










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Bureau of Energy Efficiency

Ministry of Power, Government of India

Prepared By

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Petroleum Conservation Research Association, Bangalore

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CHAPTER - 1

1.0 ABOUT BEE SME PROGRAM

Worldwide the Micro, Small and Medium Enterprises (MSMEs) have been accepted as engines of economic growth to promote and accelerate equitable development. The major advantage of this sector is its enormous employment potential at significantly low capital involvement. This can be established from the simple fact that the MSMEs constitute over 90% of total enterprises in most economies and are credited with generating the highest rates of employment growth and account for a major share of industrial production and exports. In Indian context, MSMEs play a pivotal role in the overall industrial economy. In recent years the sector has consistently registered higher growth rate as compared to the overall industrial sector. With its agility and dynamism, the sector has shown admirable innovativeness and adaptability to survive the recent economic downturn and recession.

As per available statistics (the 4th Census of MSME Sector), this sector employs an estimated 59.7 million persons spread over 26.1 million enterprises. It is estimated that in terms of value, MSMEs have a 40% share in total industrial output at a huge volume of producing over 8,000 value-added products. At the same time, MSMEs contribute nearly 35% share in Direct Export and 45% share in the Overall Export from the country. SMEs exist in almost all-major sectors in the Indian industry such as Food Processing, Agricultural Inputs, Chemicals & Pharmaceuticals, Electrical & Electronics, Medical & Surgical Equipment, Textiles and Garments, Gems and Jewellery, Leather and Leather Goods, Meat Products, Bioengineering, Sports goods, tea, Plastics Products, Computer Software etc.

However, despite the significant contributions made towards various aspects of the nation's socio-economic scenario, this sector too faces several critical issues that require immediate attention. One such factor that falls in the ambit of this publication is the prevalence of age old technologies across the sectors and inherent inefficiencies associated with resource utilization, including, energy. The National Mission for Enhanced Energy Efficiency in Industry under the National Action Plan for Climate Change (released by Government of India on June 30, 2008) has emphasized the need for improving Energy Efficiency (EE) in the manufacturing sector. A number of sector-specific studies have also unanimously confirmed that energy intensity in the industry can be reduced with the widespread adoption of proven and commercially available technologies, which will improve EE and produce global benefits from reduced Green House Gasses (GHGs) emissions.

As a result of increasing awareness towards efficient usage of energy and other resources, there has been a visible reduction in energy intensity in comprehensive Indian industrial sector. However, focusing the observation on the MSME sector reveals that the energy intensity per unit of production is much higher than that of the organized large scale sector. Since energy cost is significant contributor to the overall production cost of SMEs due to high and rising energy costs in current scenarios, it is required to increase the Energy Efficiency (EE) levels in order to ensure the sustenance of SMEs. One of the ways to reduce the inefficiencies is by replacing the conventional/old/obsolete technology with feasible and adaptable energy efficient technologies. This would not only contribute towards reduction in production cost, but would also improve the quality and productivity of MSME products. However, while knowing the way out, there are still numerous barriers (as listed below) and market failures that have prevented widespread adoption of new energy efficient technologies.

Key barriers in promotion and adoption of EE technologies in Indian SME sector:

- Lack of awareness and capability on the part of SMEs to take up energy conservation activities
- Lack of scientific approach on monitoring and verification of performance assessment of installed equipments and utilities.
- Non availability of benchmark data for various equipments/process
- Low credibility of the service providers such as equipment suppliers and their technologies
- The SME owners are more concerned on production and quality rather than energy efficiency and conservation
- The key technical personnel employed in the SME units are based on their past experience in similar industries rather than technically qualified personnel and hence, they are not aware of the latest technologies or measures which improve energy efficiency

Lower priority to invest in improving efficiency than in expansion (this may be due to lack of knowledge on cost benefit)

Majority of SMEs are typically run by entrepreneurs and are leanly staffed with trained technical and managerial persons to deploy and capture energy efficiency practice to reduce manufacturing cost and increase competitive edge. Therefore, it will be useful to build energy efficiency awareness in the SMEs by funding/subsidizing need based studies in large number units in the SMEs and giving energy conservation recommendations including short-term energy conservation opportunities, retrofit/replacement options and technology up-gradation opportunities.

In this context, the Bureau of Energy Efficiency (BEE) has laid adequate emphasis on the SME sector as presented in the Working Group on Power for 11th Five-Year Plan (2007-2012)-Sub-Group 5. Consequently, the Bureau has initiated the Energy Efficiency Improvement program in 29 SME clusters in India.

1.1 PROJECT OBJECTIVES:

The BEE SME Program aims to improve EE (Energy Efficiency) in SME sector by technological interventions in the various clusters of India. The EE in SMEs is intended to be enhanced by helping these industries in the 29 energy intensive SME clusters of India by:

- Technology interventions
- Sustaining the steps for successful implementation of EE measures and projects in clusters, and
- Capacity building for improved financial planning for SME entrepreneurs.

The program also aims at creating a platform for dissemination of the best practices and the best available technologies available in the market for energy efficiency and conservation, to create awareness in the clusters, and to demonstration of the new technology interventions/ projects to stimulate adoption of similar technology/projects in the clusters.

The BEE SME program has been designed in such a way so as to address the specific needs of the industries in the SME sector for EE improvement and to overcome the common barriers in way of implementation of EE technologies in cluster through knowledge sharing, capacity building and development of innovative financing mechanisms. The major activities in the BEE SME program are:

- Energy use and technology studies
- Capacity building of stake holders in cluster for building EE projects
- Implementation of energy efficiency measures
- Facilitation of Innovative financing mechanisms for implementation of energy efficiency projects

The brief objective of each of these activities is presented below:

Energy use and technology studies

An in-depth assessment of the various production processes, energy consumption pattern, technology employed and possible energy conservation potential and operational practices in cluster by means of conducting detailed energy audits and technological gap assessment studies were conducted in the cluster. The energy audit study shall include analysis of the overall energy consumption pattern, study of production process, identification of energy intensive steps/sub-processes and associated technology gap assessment for the individual units. The study has also focused on identifying the best operating practices and the EE measures already implemented in the units.

Capacity building of stakeholders

The aim of this activity is capacity building of the enrolled LSPs to equip them with capacity to carry on the implementation of the EE technology projects in cluster on a sustainable basis. It would be ascertained that the needs of the LSPs is identified as a preparatory exercise to this activity, as in what they expect from the BEE Program in terms of technical and managerial capacity building.

Implementation of EE measures

To implement the EE and technology up-gradation projects in the clusters, technology specific Detailed Project Reports (DPRs) for five different technologies for three scales of operation will be prepared. The DPRs will primarily address the following:

- Comparison of existing technology with feasible and available EE technology
- Energy, economic, environmental & social benefits of proposed technology as compared to conventional technology
- Details of technology and service providers of proposed technology
- Availability of proposed technology in local market
- Action plan for implementation of identified energy conservation measures
- Detailed financial feasibility analysis of proposed technology

Facilitation of innovative financing mechanisms

The program aims to develop innovative and effective financing mechanisms for easy financing of EE measures in the SME units in the cluster. The easy financing involves following three aspects:

- Ease in financing procedure
- Availability of finance on comparatively easy terms and relaxed interest rates
- Compatibility and availing various other Central/ State Governments' incentive schemes like CLCSS, TUFF etc.

1.2 EXPECTED PROJECT OUTCOME

Expected project outcome of BEE SME program in clusters are:

Energy Use and Technology Analysis

The outcome of the activity includes identification of the EE measures, assessment of potential of renewable energy usage, fuel switching, feasibility analysis of various options, and cost benefit analysis of various energy conservation measures including evaluation of financial returns in form of payback period, IRR and cash flows. The cost liability of each measure, including the capital and operational cost will also be indicated.

The identified EE measures will be categorized as per the following types:

- Simple housekeeping measures/ low cost measures
- Capital intensive technologies requiring major investment.

The sources of technology for each of the suitable low cost and high cost measures, including international suppliers as well as local service providers (LSPs)/ technology suppliers, in required numbers shall be identified. It is envisaged to create a knowledge bank of detailed company profile and CVs of key personnel of these technology sources. The knowledge bank will also include the capability statements of each of these sources.

The EE measures identified in the energy use and technology audit study will be prioritized as per their energy saving potential and financial feasibility. Inventorization survey was done to establish details like the cluster location, details of units, production capacity, technologies employed, product range, energy conservation potential along with possible identified EE measures and respective technology suppliers.

The specific outcomes of this activity are as follows:

- Determination of energy usage and energy consumption pattern
- Identification of EE measures for the units in cluster
- Development and preparation of case studies for already implemented EE measures and best operating practices in the units
- Evaluation of technical & financial feasibility of EE measures in terms of payback period, IRR and cash flows.
- Enlisting of Local Service Providers(LSPs) for capacity building & training including creation of knowledge bank of such technology suppliers
- Capacity building modules for LSPs
- Development and preparation of cluster manuals consisting of cluster details and EE measures identified in cluster.

Implementation of EE measures

The aim of this activity is development and finalization of bankable DPRs for each of the EE projects, which would be presented before the SME units for facilitation of institutional financing for undertaking the EE projects in their respective units.

The activity will ensure that there is close match between the proposed EE projects and the specific expertise of the Local Service Providers (LSPs). These DPRs will be prepared for EE, renewable energy, fuel switching and other possible proposed measures during course of previous activities. Each DPR will include the technology assessment, financial assessment, economic assessment and sustainability assessment of the EE project for which it has been developed. The technology assessment will include the details of the design of equipment/ technology along with the calculation of energy savings. The design details of the technology for EE project will include detailed engineering drawing for the most commonly prevalent operational scale, required civil and structural work, system modification and included instrumentation and various line diagrams. The LSPs will be required to report the progress of the implementation of each such project to BEE PMC. Such implementation activities can be undertaken by the LSPs either solely or as a group of several LSPs.

Capacity Building of LSP's and Bankers

The outcome of this activity would be training and capacity building of LSPs so as to equip them with necessary capacity to undertake the implementation of proposed EE projects as per the DPRs. Various training programs, training modules and literature are proposed to be used for the said activity. However, first it is important to ascertain the needs of the LSPs engaged, as in what they expect from the program in terms of technical and managerial capacity building. Another outcome of this activity will be enhanced capacity of banking officers in the lead banks in the cluster for technological and financial feasibility analysis of EE projects that are proposed by the SME units in the cluster. This activity is intended to help bankers in understanding the importance of financing energy efficiency projects, type and size of projects and ways and means to tap huge potential in this area. Different financing models would be explained through the case studies to expose the bankers on the financial viability of energy efficiency projects and how it would expand their own business in today's competitive environment.

Concluding workshop

The outcome of this activity will be the assessment of the impact of the project as well as development of a roadmap for future activities. The workshop will be conducted for the representatives of the local industrial units, industry associations, LSPs and other stakeholders so that the experiences gained during the course of project activities including implementation activities of EE project can be shared. All the stakeholders in the project will share their experience relating to projects undertaken by them as per their respective roles. Effort from industrial units as well as LSPs to quantify energy savings thus achieved would be encouraged. This would lead to development of a roadmap for implementing similar programs in other clusters with greater efficiency and reach.

1.3 PROJECT DURATION

The mentioned activity of the project (in paragraph – 2/chapter – 1) was initialized in August 2009. The expected successful completion of the project is December 2010.

1.4 IDENTIFIED CLUSTERS UNDER THE PROGRAM & TARGET CLUSTER FOR IMPLEMENTATION

29 most energy intensive MSME clusters across different end use sectors have been identified to implement the BEE SME program for EE improvement. The details of industrial sectors and identified clusters are provided in Table 1 below:

Table 1.1: List of clusters identified for BEE SME Program

S. No.	Cluster Name	Location
1.	Oil Milling	Alwar; Rajasthan
2.	Machine Tools	Bangalore; Karnataka
3.	Ice Making	Bhimavaram; Andhra Pradesh
4.	Brass	Bhubaneswar; Orissa
5.	Sea food processing	Kochi, Kerala
6.	Refractories	East &West Godavari, Andhra Pradesh
7.	Rice Milling	Ganjam, Orissa
8.	Dairy	Gujarat
9.	Galvanizing	Howrah, West Bengal
10.	Brass& Aluminium	Jagadhari, Haryana
11.	Limestone	Jodhpur, Rajasthan
12.	Tea processing	Jorhat, Assam
13.	Foundry	Batala, Jalandhar & Ludhiana, Punjab
14.	Paper	Muzaffarnagar, Uttar Pradesh
15.	Sponge iron	Orissa
16.	Chemicals& Dyes	Vapi, Gujarat
17.	Brick	Varanasi, Uttar Pradesh
18.	Rice Milling	Vellore, Tamil Nadu
19.	Chemical	Ahmedabad, Gujarat
20.	Brass	Jamnagar, Gujarat

S. No.	Cluster Name	Location
21.	Textile	Pali, Rajasthan
22.	Textile	Surat, Gujarat
23.	Tiles	Morbi, Gujarat
24.	Textile	Solapur, Maharashtra
25.	Rice Milling	Warangal, Andhra Pradesh
26.	Coir	Alleppey, Kerala
27.	Textile	Tirupur, Tamil Nadu
28.	Roof Tiles	Mangalore, Karnataka
29.	Glass	Firozabad, Uttar Pradesh

As a part of BEE SME program, one of cluster identified was the Bangalore Machine Tool cluster. It was proposed to carry out energy use and technology audit studies in 30 units in the Bangalore Machine Tool cluster covering all types and sizes of the industries to understand/give valuable insight into the process of developing energy efficiency solutions relevant to the SME industries in the Bangalore Machine Tool cluster.

CHAPTER2

2.0 Bangalore Machine Tool Cluster Scenario

2.1 OVERVIEW OF BANGALORE MACHINE TOOL CLUSTER

The Machine Tools Cluster of Bangalore is located in the Bangalore district. Bangalore, also known as Bengaluru is the capital of the Indian state of Karnataka, located on the Deccan Plateau in the south-eastern part of Karnataka. Bangalore was inducted in the list of Global cities and ranked as a "Beta World City" alongside Geneva, Copenhagen, Boston, Cairo, Riyadh, Berlin, to name a few, in the studies performed by the Globalization and World Cities Study Group and Network in 2008.

Table 2.1 Bangalore at a Glance

Geographical Location	**$12^{\circ}58'0''$N $77^{\circ}34'0''$E**
Geographical Area	**741 km^2**
Average Annual Rainfall	**859 mm**
Temperature (2004)	**23. $^{\circ}$C**
Population	**5,438,065 (2009)**
Literacy (2001)	**85.74%**

Today as a large city and growing metropolis, Bangalore is home to many of the most well-recognized colleges and research institutions in India. Numerous public sector heavy industries, software companies, aerospace, telecommunications, and defence organisations are located in the city. Bangalore is known as the Silicon Valley of India because of its position as the nation's leading IT exporter. A demographically diverse city, Bangalore is a major economic and cultural hub and the fastest growing major metropolis in India

2.1.1 Cluster Background:

Bangalore is the "HUB" for machine tools in India. The cluster accounts for 60% of the value of production of machine tools in the country. Bangalore is predominantly a metal cutting cluster. The structure of machine tool industry in Bangalore has at its apex 6 large machine tool manufacturers, about 100 small and medium machine tool manufacturers, their suppliers and vendors in large numbers.

The units of Bangalore machine tool cluster located in Peenya Industrial estate, Abbigere Industrial estate and Bommasandra Industrial estate are manufacturing components, machine accessories and special purpose machines catering to different sectors of economy such as automobile industry, aerospace industry, and CNC Machine industry across the globe. Heat treatment units are also located in the cluster catering to the needs of the machine tool units. What is apparently seen as a unique feature of the cluster is the other industrial unit does not replicate the products manufactured for machines by an industrial unit. Though there are a large number of units located in the cluster, many of them are of insignificant magnitude in size and operation. It was observed from the data collected from various sources that the total number of units in the cluster is around 100 falling in the purview of the above-mentioned classification. The study was conducted in 30 units to identify the energy efficient technologies that result eventually in saving of energy.

All units studied are registered as small scale industries under the Government of Karnataka and many of them have entrepreneurship memorandum number issued by department of MSME. Most of the industries identified for this project are registered with Karnataka Small Scala Industries Association, Bangalore Machine Tool Manufacturer Association and Peenya Industrial Association. Geographical distribution of units in Bangalore machine tool cluster are as shown in the figure 2.1

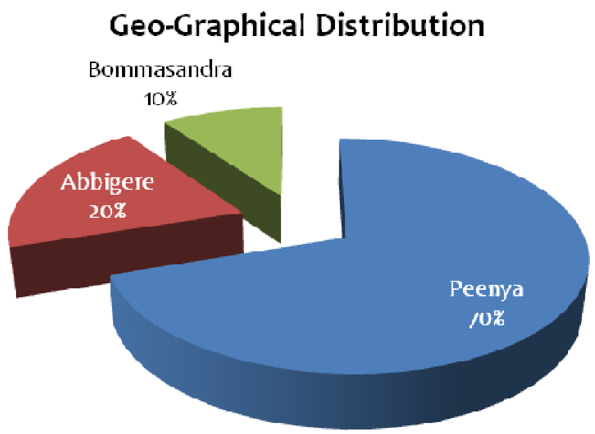


Figure 2.1: Geographical distribution of Machine tool units in Bangalore cluster

The above associations are providing the member industries abreast of the latest developments with necessary technical know-how. Also, they support them in capacity building, training and skill updation. Indian Machine Tool Manufacturers Association is located in Bangalore and is catering to the requirements of medium and large-scale industries. However, there is not much of awareness among the industries about energy efficient measures as energy constitutes a small part of the overall expenditure. Raw material for these industries is Steel and Cast Iron.

2.1.2 Product manufactured

In SME cluster of Machine Tools at Bangalore, there are varieties of products manufactured that include spindles, centre grinding machines, ID grinding machines, Self centering Steady Rests, Bar feeding attachments, Rotary tables, Index tables, Special purpose machines, Co-ordinate Measuring machines, aerospace fixtures, CNC Machine enclosures, Sound proofs, armature rewinding machines etc. There are supporting industries like heat treatment are also located in the cluster. These products/ machines are usually utilized in automobile industry, aerospace industry, CNC Machine industry across the globe. These are products custom made to suit the requirements of ISRO,HAL, BEML,MICO,BHEL, Kirloskar Electric, Bayforge Ltd etc.

2.1.3 Classification of Units

Type of Product

Major products being manufactured in the cluster are classified in to four major categories including heat treatment, which is a supporting activity of the cluster. The other product categories are components (which are generally used in aerospace, automobile, electrical & electronic and other machineries), Accessories (which are used in conventional and CNC machine tools) CNC Machines and Special Purpose Machines. The percentage of the units in each of the categories is indicated in the figure 2.2.

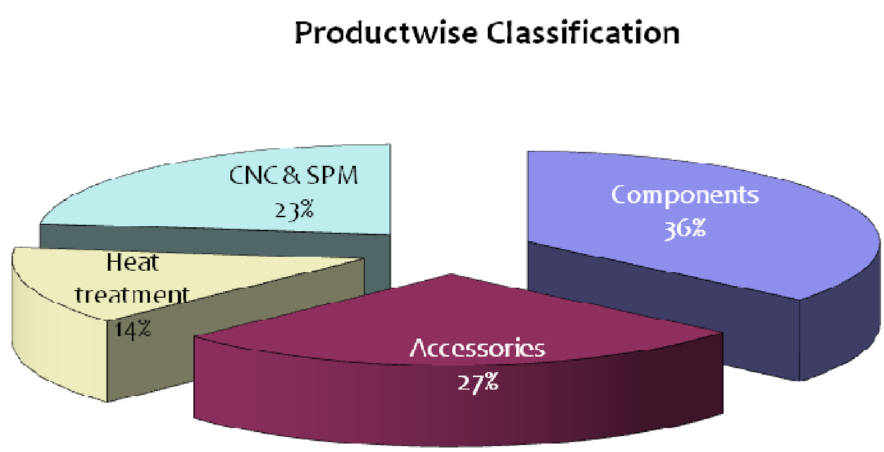


Figure 2.2: *Product wise classification of Machine tool units*

Production capacity

Production capacity of machine tool units in Bangalore cluster depends on the type of product being produced in unit. Production capacity of machine tool units in Bangalore cluster is in the range of 1500 kg per Annum –1050000 kg per Annum. The following figure shows the classification of machine tool units in Bangalore cluster based on production capacity. The production capacity as the weight of the metal removed in case of components, accessories and SPM making industries. In case of Heat treatment, weight of the material treated has been considered as the production capacity. The above methodology is adopted as major energy is spent towards removing the metal, as per the specifications of the product, while carrying out jobs such as milling, turning, grinding and drilling. In case of heat treatment units, major energy is spent in the heat treatment furnaces. Hence, the weight of material processed is taken as production capacity.

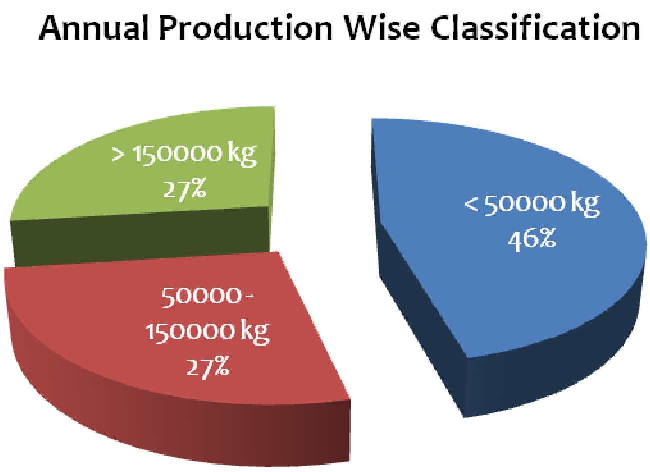


Figure 2.3: Annual Production Wise classification of Machine tools units

Energy consumption pattern

In Bangalore machine tool unit cluster, the amount of electrical energy consumed varies from 6000 kWh to 1600000 kWh per annum. Energy consumption is the lowest in case of SPM making units, medium in case of component/ accesaries making units, and the maximum in heat treatment units. The following figure shows the classification of percentage of machine tool units in Bangalore cluster based on consumption of electrical energy per annum.

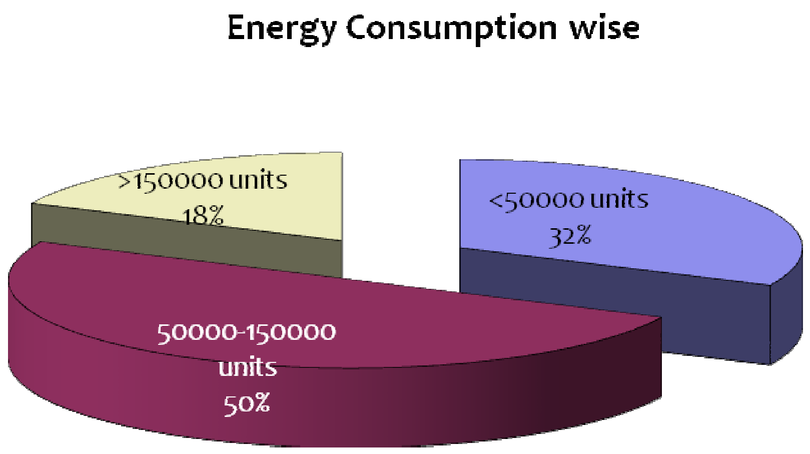


Figure 2.4: Energy Consumption Wise classification of Machine tools units

Turn over

These industries are classified based on their turnover into small and medium enterprises. Small industries have a turn over of less than 5 crores and medium industries have a turnover of 5 crores and above. Turn over of the machine tool units surveyed in this cluster range from Rs. 75 lakhs to Rs. 8 crores. The following figure shows the classification of machine tool units in Bangalore cluster based on turn over.

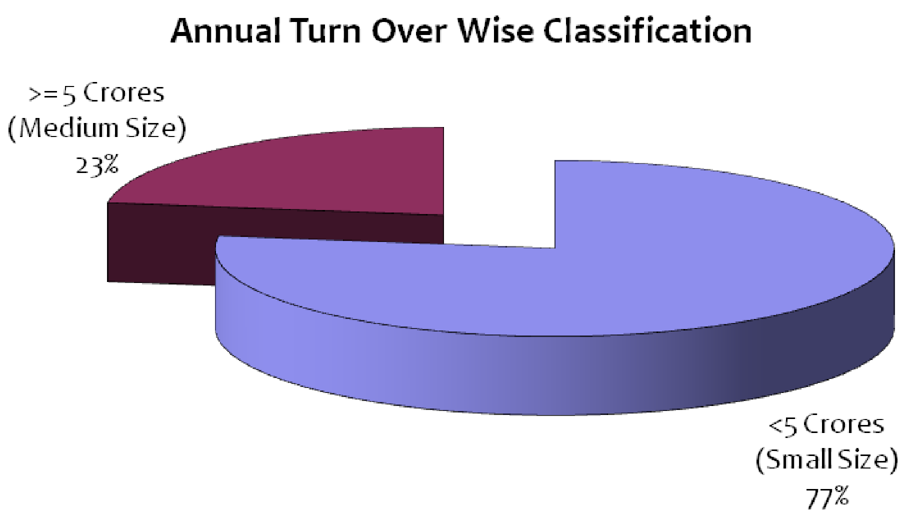


Figure 2.5: Annual Turn Over Wise Classification of Machine Tool Units

2.1.4 Installed Production Capacity

These industries do not have a standard design or nameplate capacities per say. This is due to the nature of industry, which makes different types of products in large numbers catering to variety of industries cutting across all sectors. The production capacity is considered as the weight of the metal removed in case of components, accessories and

SPM making industries. In case of Heat treatment, weight of the material treated has been considered as the production capacity. The above methodology is adopted as major energy is spent towards removing the metal, as per the specifications of the product, while carrying out jobs such as milling, turning, grinding and drilling. In case of heat treatment units, major energy is spent in the heat treatment furnaces. Hence, the weight of material processed is taken as production capacity.

2.1.5 Raw Material used

Raw Material for these industries is Steel, Cast Iron and Pig Iron. Requirement of raw material is chosen as per the requirements of the end products of the customer. In the category of component industry, the raw material is supplied by the client along with the drawing to complete finishing and machining jobs. Most of the industries make use of steel as raw material.

2.2 ENERGY SITUATION IN THE CLUSTER

2.2.1 Energy Type & Prices

The machine tool industries in this cluster use electricity from grid to meet their electrical energy requirement. Some of the industrial units having the backup power generator (Diesel Based) to meet the demand in case of grip power supply failure or scheduled power cut from the grid. The main and primary energy for machine tool industries is the electricity for operation of production and utility services. In manufacturing of some category of products, heat treatment process required to achieve the desired material properties. In heat treatment units of the clusters, which are very few in numbers (only 14 %) are using electricity as the main source of energy even in the process of heat treatment, which is usually outsourced. The percentage segregation of used energy in the cluster is given in figure 2.6, which reveals that the 95.9% of energy used in the cluster is drawn from the Bangalore Electricity Supply Company Limited (BESCOM) grid whereas only 4.1% of total energy required is being generated by thermal energy (High Speed Diesel) using DG sets. Electrical Tariff is given in **annexure – 4**.

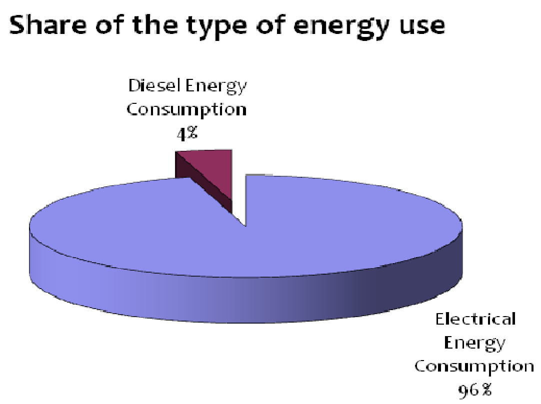


Figure 2.6: Share of Energy Type used in the Machine Tool Units

2.2.2 Energy consumption in a typical industry

Electricity from the BESCOM grid is the primary source of electrical energy, constituting 96% of the energy requirement of the cluster. The cluster in general does not use any thermal energy except for diesel, which is used for generating the power through D.G. sets as back up power. Total energy cost constitutes 5 - 8% of the total production cost. The share of thermal energy (HSD) in the total energy consumption is estimated to be 4%. The major units having the LT connection from the BESCOM at 440 volt supply whereas some of the units have taken HT connection at 11 kV. The average electrical energy cost is Rs.4.57/- per unit (kWh). As the machine tolls units has been classified into four segments depending on the product type such as components, accessaries, SPMs and heat treatment. The typical energy consumption pattern of these four types of units is given in table 2.2. Electrical tariff is given in annexure-4.

Table 2.2 Energy Consumption Pattern of Typical Units

Type of units	Electrical Energy, kWh/Year	Diesel, Lt/Year	Total Energy, GJ/Year
Components	77891	1757	343
Accessories	114863	786	442
Machines	34704	648	148
Heat Treatment	1141109	0.1	4109

The electrical energy and diesel energy consumption of the Bangalore Machine Tools cluster is given in table 2.3.

Table 2.3 Energy Consumption Pattern of Machine Tools Cluster

Parameters	Unit	Components	Accessories	Machines	Heat Treatment	Total Cluster
Annual Electrical Energy Consumption	kWh/year	28,04,067	31,01,301	7,98,201	1,59,75,531	2,26,79,100
Annual Electrical Energy Consumption	GJ/Year	10,096	11,167	2,874	57,522	81,659
Diesel consumption for Electricity generation	Lt/Year	6,32,52	21,214	14,909	1.10	99,376
Annual Diesel consumption	GJ/Year	2,251	755	531	0.04	3,537
Total energy consumption	GJ/Year	12,347	11,922	3,405	57,522	85,196
% of total energy consumption	%	14.5	14.0	4.0	67.50	100

The annual electrical energy consumption and fuels in Bangalore Machine Tools cluster is estimated to be around 2,26,79,100 kWh and 99,376 litres respectively. Total energy consumption in the cluster is around 85,196 GJ.

Total annual energy consumption in Bangalore Machine tool cluster is around 85,196 GJ. The percentage share of energy consumption in the classified units of the Bangalore Machine tools cluster is given in figure 2.7.

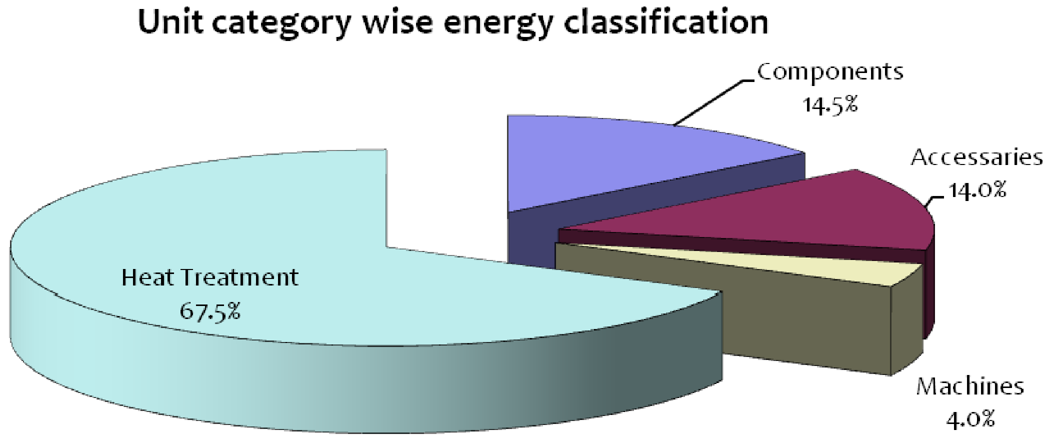


Figure 2.7: Share of various types of units in annual energy consumption

2.2.3 Specific energy consumption in Bangalore Machine Tool cluster:

The specific energy consumption depends on the final product being manufactured by the machine tool units, therefore SEC has been classified according to the types of products produced in the cluster. Details of the SEC depending on the type of products is shown in the following table

Table 2.4 Energy Consumption Pattern of Machine Tools Cluster

Type of units	Specific Energy Consumption, GJ/Tonne	Specific Energy Consumption, kWh/Tonne
Components	24.8	6472
Accessories	19.7	5118
Machines	2.2	600
Heat Treatment	64.2	15057
Average	27.7	6811.8

2.3 MANUFACTURING PROCESS/TECHNOLOGY OVERVIEW

2.3.1 Process Flow Diagram

Typically, process for machine tool units in Bangalore is not the same for all industries involving various activities, as the end products of the industry are different for each industrial unit. Therefore, there is some variation in the flow of activities depending on the customized requirement of the products. However, these activities could be grouped together as shown below, though not in the same order as mentioned.

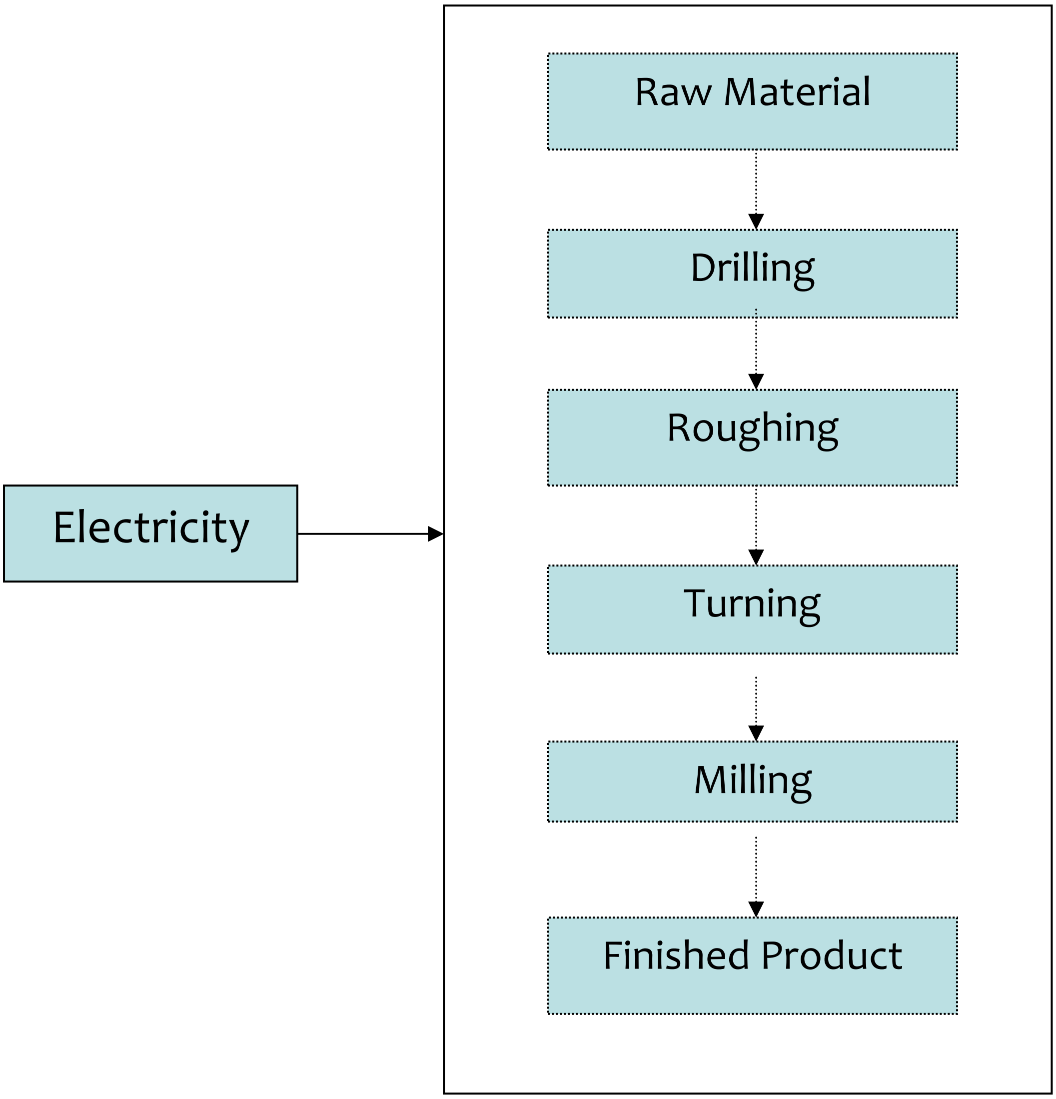


Figure 2.8: General Process Flow Diagram of Bangalore Machine Tools Cluster

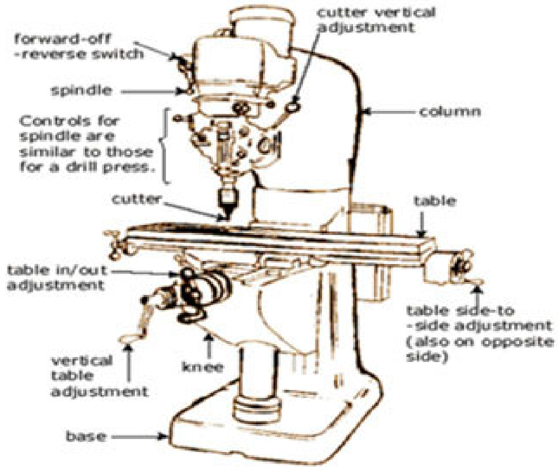
From the above figure, it is clear that major energy consuming process in typical manufacturing industry are stirring and drying operation. Drying operation will consume around 55% of total energy and stirring operation (including steam circulation in vessel) will consume around 45% of total energy.

2.3.2. Process Technology

Milling Process

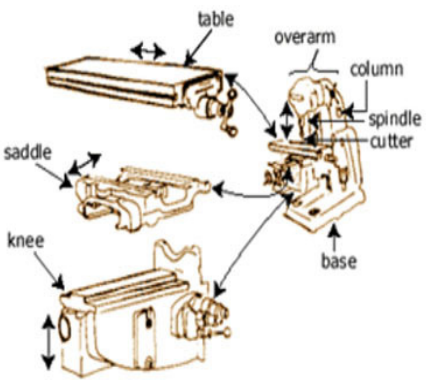
Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, work piece, fixture, and cutter. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to a platform inside the milling machine. The cutter is a cutting tool with sharp teeth, which is also secured in the milling machine and rotates at high speeds. By feeding the workpiece into the rotating cutter, material is cut away from this work piece in the form of small chips to create the desired shape.

Milling is typically used to produce parts that are not axially symmetric and have many features, such as holes, slots, pockets, and even three-dimensional surface contours. Parts that are fabricated completely through milling often include components that are used in limited quantities, perhaps for prototypes, such as custom designed fasteners or brackets. Another application of milling is the fabrication of tooling for other processes. For example, three-dimensional molds are typically milled. Milling is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that milling can offer, it is ideal for adding precision features to a part whose basic shape has already been formed.



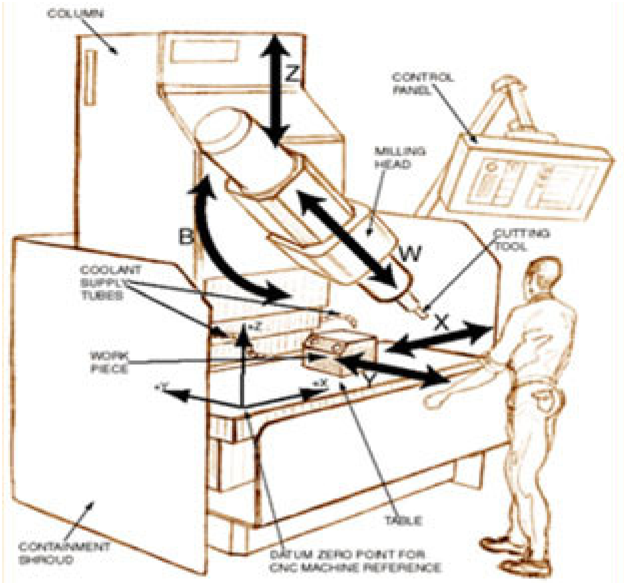
Milling is as fundamental as drilling among powered metal cutting processes. Milling is versatile for a basic machining process, but because the milling set up has so many degrees of freedom, milling is usually less accurate than turning or grinding unless especially rigid fixturing is implemented. For manual machining, milling is essential to fabricate any object that is not axially symmetric. Below is illustrated the process at the cutting area. A typical column-and-knee type manual mill is shown. Such manual mills are common in job shops that specialize in parts that are low volume and quickly fabricated. Such job shops are often termed 'model shops' because of the prototyping nature of the work.

The parts of the manual mill are separated below. The knee moves up and down the column on guide ways in the column. The table can move in x and y on the knee, and the milling head can move up and down.



CNC Milling: Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC mills can perform the functions of drilling and often turning. CNC Mills are classified according to the number of axes that they possess. Axes are labeled as x and y for horizontal movement, and z for vertical movement, as shown in this view of a manual mill table. A standard manual light-duty mill is typically assumed to have four axes: Table X, Table Y, Table Z and milling head Z.

A five-axis CNC milling machine has an extra axis in the form of a horizontal pivot for the milling head. This allows extra flexibility for machining with the end mill at an angle with respect to the table. A six-axis CNC milling machine would have another horizontal pivot for the milling head, this time perpendicular to the fifth axis.



CNC milling machines are traditionally programmed using a set of commands known as G-codes. G-codes represent specific CNC functions in alphanumeric format.

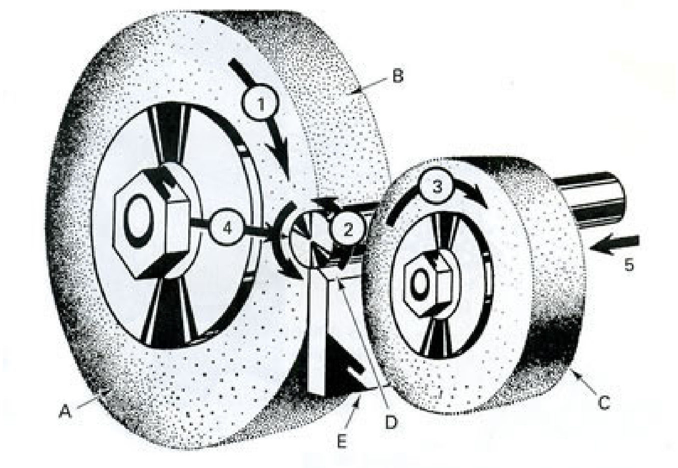
Grinding Process

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material.

In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with cutting fluid is necessary. For material removal, the method used in grinding is called abrasion. In other words, in grinding, an abrasive material rubs against the metal part and clears or removes tiny pieces of material. The process implies that instead of cutting like a lathe bit, the material is slowly and steadily worn away. This is because compared to the material being ground, the abrasive is harder. The grinding wheel actually acts like many hundreds of very small lathe bit, each cutting off some metal. The abrasive must be strong enough to bear any kind of forces acting upon it while grinding. Usually some sort of impact shock occurs when the abrasive comes in contact with the material. Grinding abrades material in a way similar to sanding. The grinding operation is performed on a several machines like the lathe and the mill, with the appropriate add-on accessories, the most important of which is the spindle.

Grinding can be of various types, like as follows:

- Surface grinding
- Centered grinding
- Centerless grinding
- Contour grinding



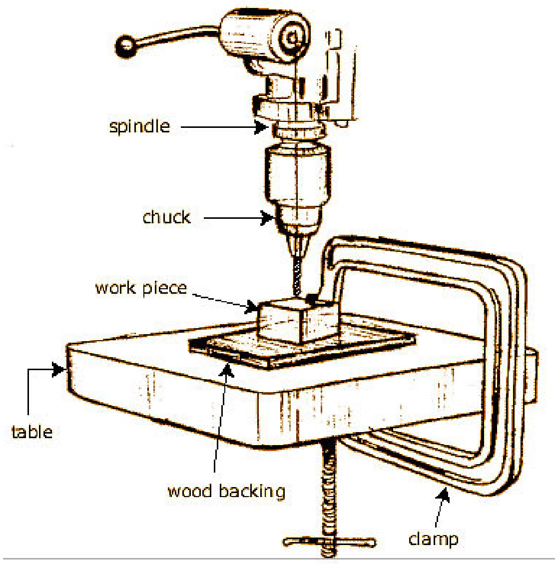
The basic need of the Grinding is the material is too hard to be machined economically. (The material may have been hardened in order to produce a low-wear finish, such as that in a bearing raceway.)

Tolerances required preclude machining. Grinding can produce flatness tolerances of less than ±0.0025 mm (±0.0001 in) on a 127 x 127 mm (5 x 5 in) steel surface if the surface is adequately supported.

Drilling Process

Drilling is the most common machining process whereby the operation involves making round holes in metallic and nonmetallic materials. Approximately 75% of all metal- cutting process is of the drilling operation. Drills usually have a high length to diameter ratio that is capable of producing deep hole, however due to its flexibility, necessary precaution need to be taken to maintain accuracy and prevent drill from breaking.

Drilled holes can be either through holes or blind holes. A through holes is made when a drill exits the opposite side of the work; in blind hole the drill does not exit the workpiece.



Drilled holes are characterized by their sharp edge on the entrance side and the presence of burrs on the exit side (unless they have been removed). Also, the inside of the hole usually has helical feed marks.

Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to corrosion at the stressed surface.

For fluted drill bits, any chips are removed via the flutes. Chips may be long spirals or small flakes, depending on the material, and process parameters. The type of chips formed can be an indicator of the machinability of the material, with long gummy chips reducing machinability.

When possible drilled holes should be located perpendicular to the work piece surface. This minimizes the drill bit's tendency to "walk", that is, to be deflected, which causes the hole to be misplaced. The higher the length-to-diameter ratio of the drill bit, the higher the tendency to walk. The tendency to walk is also preempted in various other ways, which include:

Establishing a centering mark or feature before drilling, such as by:

- Spot drilling

The purpose of spot drilling is to drill a hole that will act as a guide for drilling the final hole. The hole is only drilled part way into the work piece because it is only used to guide the beginning of the next drilling process.

- Center drilling

The purpose of center drilling is to drill a hole that will act as a center of rotation for possible following operations. Center drilling is typically performed using a drill with a special shape, known as a center drill. Center drills have a special numbering system.

- Deep hole drilling

Deep hole drilling makes reaching extreme depths possible. A high tech monitoring system is used to control force, torque, vibrations, and acoustic emission. The vibration is considered a major defect in deep hole drilling which can often cause the drill to break. Special coolant is usually used to aid in this type of drilling.

- Gun drilling

Another type of drilling operation is called gun drilling. This method was originally developed to drill out gun barrels and is used commonly for drilling smaller diameter deep holes. This depth-to-diameter ratio can be even more than 300:1. The key feature of gun drilling is that the bits are self-centering; this is what allows for such deep accurate holes. The bits use a rotary motion similar to a twist drill however; the bits are designed with bearing pads that slide along the surface of the hole keeping the drill bit on center. Gun drilling is usually done at high speeds and low feed rates.

- Trepanning

Trepanning is commonly used for creating larger diameter holes (up to 915 mm [36.0 in]) where a standard drill bit is not feasible or economical. Trepanning removes the desired diameter by cutting out a solid disk similar to the workings of a drafting compass. Trepanning is performed on flat products such as sheet metal, granite (curling stone), plates, or structural members like I-beams. Trepanning can also be useful to make grooves for inserting seals, such as O-rings.

➥ Micro-drilling

Micro-drilling refers to the drilling of holes less than 0.5 mm (0.020 in). Drilling of holes at this small diameter presents greater problems since coolant fed drills cannot be used and high spindle speeds are required. High spindle speeds that exceed 10,000 RPM also require the use of balanced tool holders.

➥ Drilling in metal

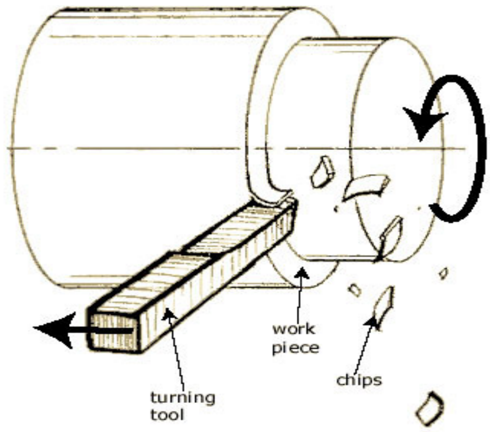
High speed steel twist bit drilling into aluminium with methylated spirits lubricant .Under normal usage, swarf is carried up and away from the tip of the drill bit by the fluting of the drill bit. The continued production of chips from the cutting edges produces more chips which continue the movement of the chips outwards from the hole. This continues until the chips pack too tightly, either because of deeper than normal holes or insufficient backing off (removing the drill slightly or totally from the hole while drilling). Cutting fluid is sometimes used to ease this problem and to prolong the tools life by cooling and lubricating the tip and chip flow. Coolant may be introduced via holes through the drill shank, which is common when using a gun drill. When cutting aluminum in particular, cutting fluid helps ensure a smooth and accurate hole while preventing the metal from grabbing the drill bit in the process of drilling the hole.

For heavy feeds and comparatively deep holes oil-hole drills can be used, with a lubricant pumped to the drill head through a small hole in the bit and flowing out along the fluting. A conventional drill press arrangement can be used in oil-hole drilling, but it is more commonly seen in automatic drilling machinery in which it is the work piece that rotates rather than the drill bit.

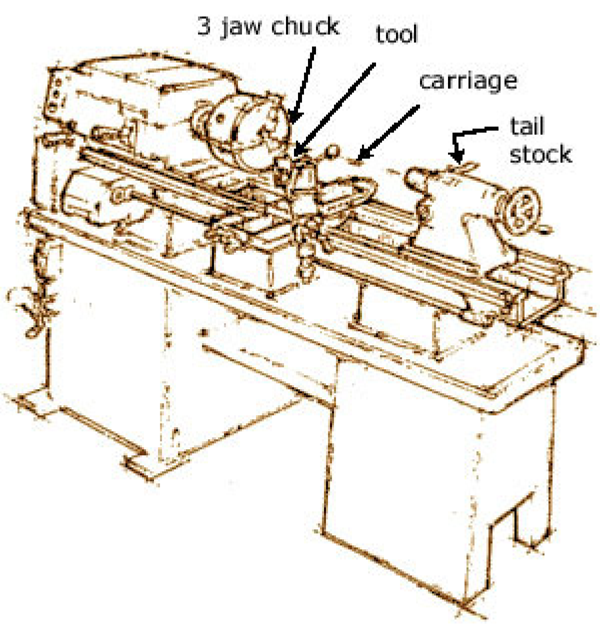
In computer numerical control (CNC) machine tools a process called peck drilling, or interrupted cut drilling, is used to keep swarf from detrimentally building up when drilling deep holes (approximately when the depth of the hole is three times greater than the drill diameter). Peck drilling involves plunging the drill part way through the work piece, no more than five times the diameter of the drill, and then retracting it to the surface. This is repeated until the hole is finished. A modified form of this process, called high speed peck drilling or chip breaking, only retracts the drill slightly. This process is faster, but is only used in moderately long holes otherwise it will overheat the drill bit. It is also used when drilling stringy material to break the chips.

Turning Process

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desired shape.



Turning is used to produce rotational, typically axi-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces. Parts that are fabricated completely through turning often include components that are used in limited quantities, perhaps for prototypes, such as custom designed shafts and fasteners. Turning is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that turning can offer, it is ideal for adding precision rotational features to a part whose basic shape has already been formed.



Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC. and is commonly used with many other types of machine tool besides the lathe.

When turning, a piece of material (wood, metal, plastic, or stone) is rotated and a cutting tool is traversed along 2 axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside (also known as boring) to produce tubular components to various geometries. Although now quite rare, early lathes could even be used to produce complex geometric figures, even the platonic solids; although until the advent of CNC it had become unusual to use one for this purpose for the last three quarters of the twentieth century. It is said that the lathe is the only machine tool that can reproduce itself.

The turning processes are typically carried out on a lathe, considered to be the oldest machine tools, and can be of four different types such as straight turning, taper turning, profiling or external grooving. Those types of turning processes can produce various shapes of materials such as straight, conical, curved, or grooved work piece. In general, turning uses simple single-point cutting tools. Each group of work piece materials has an optimum set of tools angles, which have been developed through the years.

The bits of waste metal from turning operations are known as chips (North America), or swarf (Britain). In some areas they may be known as turnings.

Turning specific operations include:

- Hard turning

Hard turning is a turning done on materials with a Rockwell C hardness greater than 45. It is typically performed after the work piece is heat treated.

The process is intended to replace or limit traditional grinding operations. Hard turning, when applied for purely stock removal purposes, competes favourably with rough grinding. However, when it is applied for finishing where form and dimension are critical, grinding is superior. Grinding produces higher dimensional accuracy of roundness and cylindricity. In addition, polished surface finishes of Rz=0.3-0.8z cannot be achieved with hard turning alone. Hard turning is appropriate for parts requiring roundness accuracy of 0.5-12 microns, and/or surface roughness of Rz 0.8–7.0 microns. It is used for gears, injection pump components, hydraulic components, among other applications.

- Facing

It is part of the turning process. It involves moving the cutting tool at right angles to the axis of rotation of the rotating workpiece. This can be performed by the operation of the cross-slide, if one is fitted, as distinct from the longitudinal feed (turning). It is frequently the first operation performed in the production of the work piece, and often the last-hence the phrase "ending up".

- Parting

This process is used to create deep grooves which will remove a completed or part-complete component from its parent stock.

- Grooving

Grooving is like parting, except that grooves are cut to a specific depth by a form tool instead of severing a completed/part-complete component from the stock. Grooving can be performed on internal and external surfaces, as well as on the face of the part (face grooving or trepanning).

Non-specific operations include:

- Boring

Machining of internal cylindrical forms (generating) a) by mounting work piece to the spindle via a chuck or faceplate b) by mounting work piece onto the cross slide and placing cutting tool into the chuck. This work is suitable for castings that are to awkward to mount in the face plate. On long bed lathes large work piece can be bolted to a fixture on the bed and a shaft passed between two lugs on the work piece and these lugs can be bored out to size. A limited application, but one that is available to the skilled turner/machinist. In machining, boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool (or of a boring head containing several such tools), for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole.

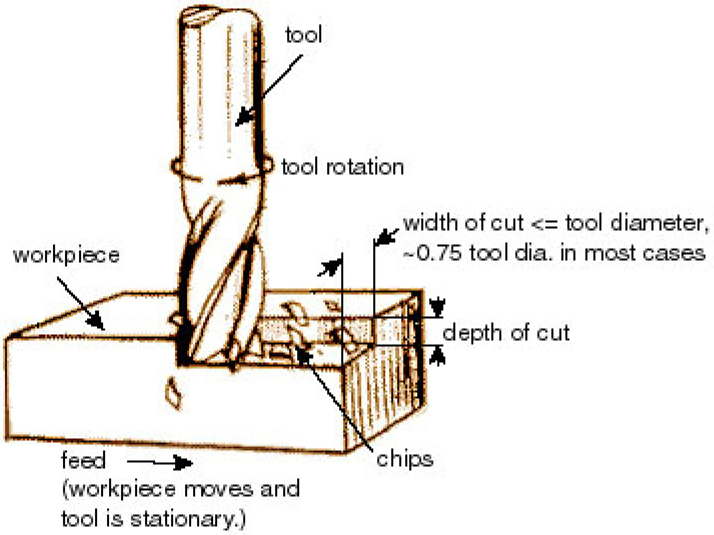
There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end. Lineboring (line boring, line-boring) implies the former. Backboring (back boring, back-boring) is the process of reaching through an existing hole and then boring on the "back" side of the workpiece (relative to the machine headstock).

- Knurling

The cutting of a serrated pattern onto the surface of a part to use as a hand grip using a special purpose knurling tool.Threading both standard and non-standard screw threads can be turned on a lathe using an appropriate cutting tool. (Usually having a 60, or 55° nose angle) Either externally, or within a bore. [Generally referred to as single-point threading. tapping of threaded nuts and holes a) using hand taps and tailstock centre b) using a tapping device with a slipping clutch to reduce risk of breakage of the tap threading operations include a) all types of external and internal thread forms using a single point tool also taper threads, double start threads, multi start threads, worms as used in worm wheel reduction boxes, lead screw with single or multi start threads. b) by the use of threading boxes fitted with 4 form tools, up to 2" diameter threads but it is possible to find larger boxes than this.

Machining Process

Conventional machining, one of the most important material removal methods, is a collection of material-working processes in which power-driven machine tools, such as lathes, milling machines, and drill presses, are used with a sharp cutting tool to mechanically cut the material to achieve the desired geometry. Machining is a part of the manufacture of almost all metal products, and it is common for other materials, such as wood and plastic, to be machined. A person who specializes in machining is called a machinist. A room, building, or company where machining is done is called a machine shop. Much of modern day machining is controlled by computers using computer numerical control (CNC) machining. Machining can be a business, a hobby, or both.



2.4 CURRENT POLICIES AND INITIATIVES OF LOCAL BODIES

Various incentive schemes of state and central government are available to the units. However, these incentives are available only for capital expenditure and are tied with availing of loan. There are no schemes available exclusively to promote energy efficiency projects. Financial Institutions like SIDBI offer credit at concessional interest rate for Energy Efficiency Projects , under the scheme of KFW line of credit & AFD line of credit. **The detailed schemes for energy efficiency is given in annexure - 5**

2.5 ISSUES RELATED TO ENERGY USAGE AND CONSERVATION AND BARRIER IN TECHNOLOGY UP GRADATION

Typically second tier industrial establishments in India lack the technical expertise to identify and evaluate energy efficiency technologies and products. They also do not have internal financial resources and need external capital to fund EE projects. Further, they need assistance in identifying and managing technical and financial risks. Major barriers in up-gradation of technology in the cluster are:

- Lack of awareness on energy efficiency

- Energy efficiency not on priority list
- Lack of instrumentation and non-availability of data
- Limited technical manpower
- Non availability of funds to implement energy conservation measures

2.5.1 Energy availability

Reliable and quality power is available in the cluster . Power cuts are imposed, mainly in peak season such as the summer. Some units have back up power in the form of emergency DG Sets to have incessant working. Some units operate only during the availability of state power supply.

Major Source of energy for the industry is Electricity. For running DG sets as alternative power supply source, some industries are making use of Diesel. There is no other form of energy usage. Availability of Diesel is not an issue for these industrial units.

2.5.2 Technological issues

Out of all the machinery required by the cluster for milling, turning, drilling etc, most of the machinery in small and medium enterprises is purchased on second hand from Europe at solvent value. When countries in Europe upgrade their technological requirements of the machines, they sell these old machines to India. Some small industries are banking on the locally produced machines for their requirement

None of the outside machinery supplier has any Dealership or Service Point in Bangalore. Thus, after sales service is always a problem for all the machinery.

Further more, non-availability of local quality consultants is the biggest roadblock in penetration of modern technology. There is only one Demonstration Centre under the control IMTMA to exhibit the working of new and modern machinery.

Every unit has different process and products . However, there is strong possibility of taking best practices of one unit to all other units.

2.5.3 Financial issues

The units in the cluster are favourable to the idea of taking loans. However, there are preconceived notions on investments of energy efficient technologies, that they support only economies of scale operations.

The units here are literally free of any encumbrances and are fit case for extension of loans.

It is strongly felt that rather than packaging the finances with incentives like lower interest rates and subsidy etc., the delivery mechanism of loans needs to be facilitated by proactive and transparent methodologies.

Above all, the extension of any such facility needs to be time bound and decision like yes or no should be given immediately and firmly in numerous cases, the banks initially agree for extending loan and then suddenly refuse in the last minute creating a situation of desperation among entrepreneurs.

CHAPTER - 3

3.0 Energy audit and technology assessment

3.1 ENERGY AUDIT AND TECHNOLOGY ASSESSMENT IN CLUSTER

A team of competitive engineers and energy auditors having excellent experience in the machine tools industies and SME clusters was involved in carrying out the study at Bangalore Machine tools cluster. A well planned methodology was followed to execute energy use and technology audit studies and to achieve the desired objectives of project. Major steps which were followed during the energy use and technology studies of the project are mentioned below:

- Identify areas of opportunity for energy saving and recommend the action plan to bring down total energy cost
- Identify areas of energy wastages in various sections and suggest measures for minimizing energy losses or suggest alternative energy saving measures that can effectively replace inefficient process
- Conduct energy performance evaluation and process optimization study
- Conduct efficiency test of equipments and make recommendations for replacement with more efficient equipment with projected benefits
- Suggest improved operation & maintenance practices
- Provide details of investment for all the proposals for improvement
- Evaluate benefits that accrue through investment and payback period

3.1.1 Pre-energy use & technology audit studies

Machine tool units in Bangalore SME cluster have organized themselves into different associations. However, Karnataka Small Scale Industries Association, Peenya Industrial Association, Bangalore Machine Tool manufacturers Association are such associations covering maximum number of industries of the cluster. A brief information and the major activities performed by these associastions is as follows.

Karnataka Small Scale Industries Association, Bangalore

Kassia is a premier voluntary state level non Govenment Institution of Small Scale Industrialists. It is a registered body under the Kamataka Societies Registration Act and is functioning on democratic lines with regular Annual General Body Meetings, election of Council Members and Office Bearers and adhering to the constitutional Byelaw and conventions.

It is managed by a Council of Management consisting of President, Vice President, the immediate Past President (Ex-officio Member) and 37 members directly elected by the General Body. Past Presidents and Special Invitees are also part of the system.

It is primarily responsible for policy formulation and imparting guidance and direction to the affairs of the Association.

A permanent Secretariat looks after the implementation of policies and day-to-day administration, under the guidance of the Office Bearers.

Kassia is an ISO-9001 -2001 certified organization.

Table 3.1: Details of Karnataka Small Scale Industries Association

Particulars	**Information**
Contact Person	Mr. S. S. Biradar
Profile	President
Contact Details	Karnataka Small Scale Industries Association, 2/106,17th Cross, Magadi Chord Road, Vijayanagar,Bangalore-560 040 Phone : 080 - 23358698 / 3250 Fax:080-23387279, E-mail:kassia@dataone.in Web: www.kassia.com

Peenya Industrial Association, Bangalore

The Peenya Industrial Complex established in the early 1970's is the biggest and one of the oldest Industrial Estates in the whole of South East Asia, located at the Northern part of the BangaloreCity. This complex comprising of the Peenya Industrial Area formed by KIADB and the Peenya Industrial Estate formed by KSSIDC which was started with a few industries is now spread over an area of about 40 sq.kms comprising about 4,000 Small Scale Industries and a few Medium Scale Industries.

Table 3.2: Details of Peenya Industrial Association, Bangalore

Particulars	**Information**
Contact Person	Mr. K.B. Arasappa
Profile	President
Contact Details	Peenya Industrial Association, 1st cross, 1st stage, Peenya Industrial Estate, Bangalore-560 058 Phone : 080-28395912/6351/6628 Web:www.peenyaindustries.com

Bangalore Machine Tool manufacturers Association, Bangalore

The association provided a platform for development of mutual understanding among the industries and discussions relating to common problems and identification of viable solution for that. Therefore, as a first step for making inroad in the cluster, the association and its office bearers were approached. Detailed discussions with the association were held on apprising the association about the objective of the project, tentative schedule of the activities being undertaken and expected project outcome.

The office bearers of associations were apprised about benefits of the project for the industries and the cluster. The association took up the task of dissemination of all this information among their respective member units. The outcome of this activity was introduction of project concept to the association and later on to the industry. This helped in identification of progressive and interested entrepreneurs out of the whole lot.

Table 3.3: Details of Bangalore Machine Tool Manufacturers' Association

Particulars	Information
Contact Person	Mr. Narendra. M. Dube
Profile	President
Contact Details	Bangalore Machine Tool Manufacturers' Association, 477/A ,4th Phase, Peenya Industrial Estate, Bangalore-560 058 Phone : 080-4080 5555, Fax:080-40805510 Mob.no:09343806661

3.1.2 Preliminary energy audit studies

21 numbers Preliminary Energy Audit studies were conducted in Bangalore machine tool cluster. The methodology followed in preliminary energy audit study is as presented below:

- Collection of past energy consumption details and energy bill
- List out major energy consuming areas of the plant
- Existing technology of various processes and utilities (latest or old, crude or efficient, local or reputed company make etc)
- Identification of the areas for special attention for low cost measures with quick payback period
- Understanding the detailed process with energy and material balance
- Establish specific energy consumption, if possible for the each typical equipment/process

- Identify the areas for detailed energy audit study and measurements required

3.1.3 Detailed energy audit studies

9 numbers Detailed Energy Audit studies were conducted in Bangalore machine tool cluster. Methodology followed in detailed energy audit study is presented below:

- Collection of past energy consumption details and energy bill
- List out major energy consuming areas of the plant
- Existing technology of various processes and utilities (latest or old, crude or efficient, local or reputed company make etc)
- Status of instruments installed in the plant and necessary instrumentation required for the detailed study
- Identification of the areas for special attention for low cost measures with quick payback period
- Understanding the detailed process with energy and material balance
- Monitoring & measuring of different parameters of various equipment / machines to evaluate performance
- Collection of operational data from various measuring instruments / gauges installed in the plant
- Compilation of design data/name plate details of various equipment from design manuals and brochures
- Discussions with concerned plant personnel to take note of operating practices and shop-floor practices being followed in the plant and to identify specific problem areas and bottlenecks if any with respect to energy consumption
- Critical analysis of data collected and parameters monitored
- Identification of energy wastage areas and quantification of energy losses
- Identification of suitable energy conservation measures for reducing energy consumption

3.2 OBSERVATIONS MADE DURING ENERGY USE AND TECHNOLOGY AUDIT

3.2.1 Manufacturing process and technology/equipments employed

The Bangalore machine tools cluster is having the mixed type of process machinery at all. In general, units in the cluster are having the conventional as well as the high-end CNC machinery for the various processes of tooling. The common process diagram for machine tools cluster is given and discussed in chapter – 2 in detail. The utility in the machining is not contributing significant therefore; it has been observed that the most of the units are using the old technologies in very inefficient manners. The compressed air system, electrical motors and lighting system mainly contributes to utility sections. The major observations in utility area is given in table 3.2

Table 3.4: Details of Peenya Industrial Association, Bangalore

Technology/Equipments	Major Observations
Air Compressors	The air compressors used in the cluster are reciprocating type with very old technology. The efficiency of these compressors found between 60% and 80% with the loadings also being rather low at times. The higher generation pressure was also observed.
Electrical Motors	The motors used in the cluster are normal motors of efficiencies between 60% and 80% with the loadings also being rather low at times. The power factor of these motors was observed to generally lower than the best operating 0.87.
Lighting System	The present lighting system of the units are conventional and using the FTL with conventional ballast, GLS and MVL which are consuming high electricity.

Major energy consuming equipments installed in typical machine tools units in Bangalore clusters are:

- Conventional Milling
- CNC Milling
- Conventional Turning Machine
- CNC Turning Machine
- Surface Grinding Machine
- Mixing Mill
- Vertical Turret Lathe
- Horizontal Boring Machine
- Drilling Machine
- Crane
- Hydraulic Press
- Heat Treatment Furnaces

3.2.2 Energy consumption profile & availability:

Electricity from the BESCOM grid is the primary source of electrical energy in general and does not use any thermal energy except for diesel for generating the power through Diesel generator. The detailed observation and analysis of the collected and measured data revels that the energy cost comprises about 5 - 8% of the total production cost. The major units having the LT connection from the BESCOM at 440 volt supply whereas some of the units have taken HT connection at 11 kV. The average electrical energy cost is Rs.4.57/- per unit (kWh).

The energy consumption profile of the Bangalore machine tool cluster is given in table 3.2.

Table 3.5: Energy Consumption Profile

Parameters	Unit	Energy Consumption Profile
Annual Electrical Energy Consumption	kWh/year	2,26,79,100
Annual Electrical Energy Consumption	GJ/Year	81,659
Diesel consumption for Electricity generation	Lt/Year	99,376
Annual Diesel consumption	GJ/Year	3,537
Total energy consumption	GJ/Year	85,196

The major energy consumption of the unit is in production area (Grinding, turning, milling and drilling) whereas utility (compressed air system) and general facility (Lighting and Computers) consumed a little fraction of total annual consumption. The process machinery consumes about 77% of the total energy consumption whereas utility section is consuming merely 23%.

Percentage energy consumption of various utilities in typical machine tool indusry, in overall energy consumption is furnished in the figure below:

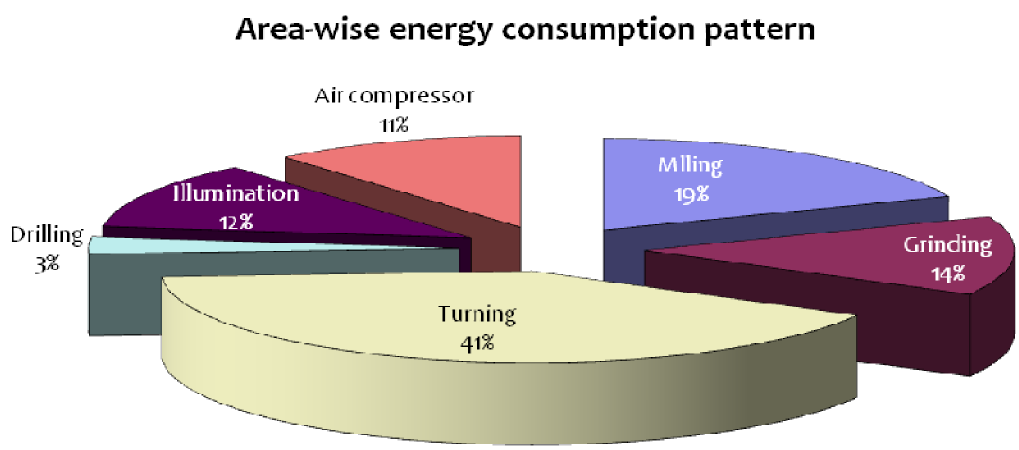


Figure 3.1: Energy consumption of different sections/utilities in Bangalore SME Cluster

3.2.3 Capacity utilization factor

These industries do not have a standard design or nameplate capacities per say. This is due to the nature of industry, which makes different types of products in large numbers catering to variety of industries cutting across all sectors. The production capacity is considered as the weight of the metal removed in case of components, accessories and SPM making industries. In case of Heat treatment, weight of the material treated has been considered as the production capacity.

Therefore, it is not possible to estimate the capacity utilization factor for these type of units in the cluster, however the plant operation or plant load factor is about 55%.

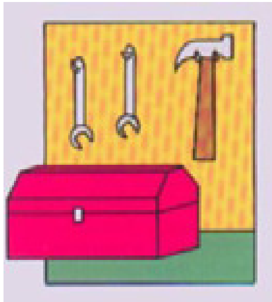
3.2.4 House keeping Practices

Majority of the Machine tool units in Bangalore Cluster maintain very poor operational practices in different utilities. There are no specific procedures to be followed in any of the units for the operation of the various equipments.

Good housekeeping is the best method of controlling the risks of injury and fire within a facility. Operating experience clearly indicates a significant increase in mishaps related directly to poor housekeeping practices. To be an effective risk management tool, housekeeping must include the following considerations:

- Storage space must be physically adequate for the volume of materials being stored. If it is inadequate, and adequate space cannot be obtained, dispose of the material.
- Stored materials must be in a stable configuration in order to permit safe access, avoid clutter, and minimize the hazard of falling materials.

- Materials stored together must be compatible. Materials must not contribute to, or cause ignition of, other materials, nor enhance their rate of combustion once ignited.
- The fuel load (amount of combustible material) within a storage area must be consistent with the fire detection system and the risk management criteria for the area and the building. Questions can be referred to the Ames Fire Marshal or the Safety Division.
- Working and walking surfaces should be dry, smooth, and free of general clutter and provide good traction for walking.
- Equipment and tools, especially those with sharp surfaces, must be kept in their designated storage location when not being used.



- It is well established that the quality and quantity of work are significantly enhanced by good housekeeping and adversely affected by poor housekeeping. Supervisors must expend the necessary effort to achieve and maintain a neat and orderly work environment.

Good housekeeping involves every phase of industrial operations and should apply throughout the entire premises, indoors and out. It is more than mere cleanliness. It requires orderly conditions, the avoidance of congestion, and attention to such details as an orderly layout of the whole workplace, the marking of aisles, adequate storage arrangements, and suitable provision for cleaning and maintenance.

A good housekeeping programme can start only when management accepts responsibility for it. Management must plan it in the first place and then make sure it consistently enforces the measures decided upon. The adoption of such a system will assist in promoting an effective housekeeping campaign.

Good housekeeping helps to create:

- Better working conditions
- Safer workplaces
- Greater efficiency.

It is not an unprofitable sideline. It is part of a good business.

3.2.5 Availability of data and information

The electricity is major and main energy source used in the cluster. The most of the units in the cluster is having the electricity bills and record of the diesel consumption data. A majority of the units do not have any online instrumentation or data monitoring systems to monitor the various operational parameters. Some of the units have installed some instruments for monitoring of various operational parameters in their units. Accuracy of the readings from those instruments is poor.

A majority of entrepreneurs in Bangalore Machine Tool cluster are very much open and sharing the energy consumption data like electricity bills copy etc.

3.3 TECHNOLOGY GAP ANALYSIS IN MACHINE TOOL INDUSTRIES

3.3.1 Technology up-gradation

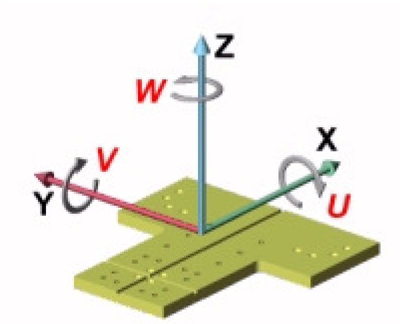
Machine tool units in organized sector have these characteristics such as; Customized technology, best R&D support from technology providers as well as high level of human resource on knowledge of technology etc. The Bangalore machine tools cluster is having the mixed type of process machinery at all. In general, units in the cluster are having the conventional as well as the high-end CNC machinery for the various processes of tooling.

From technology audit studies conducted in Bangalore Machine Tool cluster, below mentioned areas were identified for technology up gradations; those are:

- Conventional Milling Machine
- Conventional Lathe Machine
- Conventional Machine
- Conventional Horizontal Machine centre
- Conventional Grinding Machine
- Conventional Gear Grinding Machine
- Conventional Wire cut machine
- Conventional Turret Punch machine
- Conventional cutting machine
- Conventional Bending Machine
- Motors
- Reciprocating compressors

3.3.2 Process up-gradation

There is no major change in the process identified during the technology gap analysis however the five-axis machine may install in the units. 5 Axis Precision Machining allows machining of all 5 sides in one Set up. While this can certainly be a cost saving factor, 5 Axis machining is used more often for complex contour work, which may need simultaneous movement of all 5 Axes. Current generation 5 Axis machines offer excellent tolerances - as close as 3 microns.



3.4 MAIN ENERGY CONSERVATION MEASURES IDENTIFIED

3.4.1 Replacement of CNC milling, turning machines with CNC Turn –mill centre or new CNC Turn-mill centre

3.4.1.1 Background

Units is using the CNC milling and CNC turning in which operator have to job for milling and turning separatly. Turn/Mill Machines are machines that are capable of both rotating-workpiece operations (turning) and rotating-tool operations (namely milling and drilling). Generally these machines are based on lathes. The machine is typically recognizable as a horizontal or vertical lathe, with spindles for milling and drilling simply available at some or all of the tool positions. With a machine such as this, a part requiring a variety of operations can be machined in one setup, particularly if a subspindle allows the part to be passed from one spindle to another during machining. More recently introduced turn/mill machines depart from the lathe design into something much more like a hybrid machine—combining a lathe's chucks and spindles with the travels and milling power of a machining center. One of the most significant issues with these types of machines in general is figuring out just which parts to run on them. Many shops have discovered that, even though these machines developed from lathes, they are not necessarily limited to round parts. Various non-round parts can be machined on the same platform as efficiently, if not more efficiently, than on a machining center.

3.4.1.2 Benefits of proposals

Turn mill centres are widely used in manufacturing industry because these machine not only increase the productivity and quality but also increase the energy efficient milling and turning compared to existing one. Therefore, it is recommonded to Replace the CNC milling, turning machines with CNC Turn –mill centre

The major advantages of CNC turn mill centre are as follows

- reduction of cycle times and increased productivity due to two milling spindles
- covers a larger scope of flange-shaped work pieces
- requiring a high degree of turning and milling
- radial and axial machining at the main and counter spindle
- machining close to the work piece (no interference contour problems) and extended
- Y-machining due to the swiveling A-axis
- Energy recovery/energy shutdown

3.4.1.3 Cost benefits analysis

S. No.	Item/ description	Value
1	Cost of CNC Turn-Mill Centre, Rs.	5500000
2	Annual electricity Consumption cost of CNC Milling and CNC Turning (Separate), Rs./annum	45000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	9000
4	Machine hour rate for CNC Turn-mill centre, Rs./Hours	550
5	Machine hour rate for CNC machine, Rs./Hours	350
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs./Hours	200
7	No. of units produced, Nos./Annum	4000
8	Saving due to productivity, Rs./Hours	800000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0

S. No.	Item/ description	Value
10	Raw material cost, Rs./annum	400000
11	Saving in raw material cost, Rs./annum	0
12	Labour saving per month, Rs./month	6000
13	Annual savings due to Labour charges, Rs./years.	72000
14	Total savings, Rs./annum	881000
15	Pay back, Years	6.24

3.4.1.4 Issues in implementation:

- Lack of awareness on proposed energy conservation measure
- Cost of implementation

3.4.2 Replacement of conventional milling machines with CNC milling machine or new CNC milling machine

3.4.2.1 Background

Units is using the conventional milling machine in which the direction of rotation of cutter and the direction of feed of the work piece are opposite to each other. The cutting force is directed upwards. Hence the cutting increases from zero to maximum per tooth Cutter movement i,e., the thickness of the chip will be minimum at the begining and maximum at the termination of the cutter (i.e., depth of cut = t' mm). These conventional machines are old technology has disadvantages like

- Quality of surface generated will be slightly wavy
- Lubrication is difficult.
- Needs heavy fixture since the cutting force results in lifting the workpiece.
- Need of high skills work force.

3.4.2.2 Benefits of proposals

Computer Numerical Control (CNC) machines are widely used in manufacturing industry. Traditional machines such as vertical millers, centre lathes, shaping machines, routers etc. which required trained workfrorce for the operation, may be replaced by computer control CNC machines.

The major advantages of CNC machines are as follows

- CNC machines can be used continuously 24 hours a day, 365 days a year and only need to be switched off for occasional maintenance.
- CNC machines are programmed with a design, which can then be manufactured hundreds or even thousands of times. Each manufactured product will be the same.

- Less skilled/trained people can operate CNCs unlike manual lathes / milling machines etc., which need skilled engineers.
- CNC machines can be updated by improving the software used to drive the machines
- Training in the use of CNCs is available with 'virtual software'. This software allows the operator to practice using the CNC machine on the screen of a computer. The software is similar to a computer game.
- CNC machines can be programmed by advanced design software such as Pro/DESKTOP®, enabling the manufacture of products that cannot be made by manual machines, even those used by skilled designers / engineers.
- Modern design software allows the designer to simulate the manufacture of his/her idea. There is no need to make a prototype or a model. This saves time and money.
- One person can supervise many CNC machines as once they are programmed they can usually be left to work by themselves. Sometimes only, the cutting tools need replacing occasionally.
- A skilled engineer can make the same component many times. However, if each component is carefully studied, each one will vary slightly. A CNC machine will manufacture each component as an exact match.

3.4.2.3 Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Milling Machine, Rs.	7000000
2	Annual electricity Consumption cost of Conventional Milling Machine, Rs./annum	36000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	7200
4	Machine hour rate for CNC Milling Machine, Rs./Hours	700
5	Machine hour rate for Conventional machine, Rs./Hours	100
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs./Hours	400
7	No. of units produced, Nos./Annum	4000
8	Saving due to productivity, Rs./Hours	1600000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Raw material cost, Rs./annum	400000
11	Saving in raw material cost, Rs./annum	18000
12	Labour saving per month, Rs./month	2000
13	Annual savings due to Labour charges, Rs./years.	24000
14	Total savings, Rs./annum	1649200

S. No.	Item/ description	Amount (Rs)
15	Pay back, Years	4.24

3.4.2.4 Issues in implementation:

- Lack of awareness on proposed energy conservation measure
- Cost of implementation

3.4.3 Replacement of conventional lathes with CNC lathes or new CNC Lathes

3.4.3.1 Background

lathe is a machine tool for producing cylindrical, conical and flat surfaces. It can be used for drilling and boring holes which may be cylindrical or conical in shape. The basic engine lathe, one of the most widely used machine tools is very versatile when used by a skilled machinist. However, it is not particularly efficient when many identical parts must be machined as rapidly as possible. Whereas, Numerical control is based on the use of numerical data for directly controlling the position of the operative units of a machine tool in machine operation. Today, a more popular adaptation of the basic process of NC is called Computer Numerical Control or CNC. Machining and metalworking have been developed with computer technology. More efficiency output operations with even greater precision resulted from this marriage of machining and computers

3.4.3.2 Benefits of proposals

CNC Lathes are rapidly replacing the older production lathes (multispindle, etc) due to their ease of setting and operation. They are designed to use modern carbide tooling and fully utilize modern processes. The part may be designed by the Computer-aided manufacturing (CAM) process, the resulting file uploaded to the machine, and once set and trialled the machine will continue to turn out parts under the occasional supervision of an operator. The machine is controlled electronically via a computer menu style interface, the program may be modified and displayed at the machine, along with a simulated view of the process. The setter/operator needs a high level of skill to perform the process, however the knowledge base is broader compared to the older production machines where intimate knowledge of each machine was considered essential. These machines are often set and operated by the same person, where the operator will supervise a small number of machines (cell).

The design of a CNC lathe has evolved yet again however the basic principles and parts are still recognizable, the turret holds the tools and indexes them as needed. The machines are often totally enclosed, due in large part to Occupational health and safety (OH&S) issues.

With the advent of cheap computers, free operating systems such as Linux, and open source CNC software, the entry price of CNC machines has plummeted. For example, Sherline makes a desktop CNC lathe that is affordable by hobbyists.

3.4.3.3 Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Lathe Machine, Rs.	4000000
2	Annual electricity Consumption cost of Conventional Lathe Machine, Rs./annum	36000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	7200
4	Machine hour rate for CNC Lathe Machine, Rs./Hours	400
5	Machine hour rate for Conventional machine, Rs./Hours	80
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs./Hours	160
7	No. of units produced, Nos./Annum	4800
8	Saving due to productivity, Rs./Hours	768000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Raw material cost, Rs./annum	300000
11	Saving in raw material cost, Rs./annum	13500
12	Labour saving per month, Rs./month	2000
13	Annual savings due to Labour charges, Rs./years.	24000
14	Total savings, Rs./annum	812700
15	Pay back, Years	4.92

3.4.3.4 Issues in implementation:

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.4.4 Conversion of conventional machines into CNC machines

3.4.4.1 Background

Manual Machine often require intimate knowledge of the machine itself-an awareness of its various parts and their specific functions. Not surprisingly, their operators are usually the very same people who built or set them up in the first place. In contrast, CNC machine require a broader working knowledge of computers and software, since these will mostly run the machine's processes.

CNC and manual machines present ample conversion opportunities for the resourceful individual. That is, it's possible to actually turn a manual machine into a CNC one using conversion kits or parts obtained from suppliers. Users will also need to program the necessary tool paths for the machine via computer-aided design or manufacture (CAD/CAM) and test it out.

Non-techies who are interested in CNC lathes without the hassle need not fret, as easier alternatives do exist. There are service providers who can sell the machines at very affordable prices. The other thing is that their machines will even come with master software of their own. The programs are easily configurable to user specifications; they also possess features that can save on programming time.

3.4.4.2 Benefits of proposals

Computer Numerical Control (CNC) machines are widely used in manufacturing industry. The conversion of convention machine Traditional machines or in other words retrofitting of CNC in convention machine is common exercise conduing by developing units in machine tools induftries. It is recommonded to convert the bconventional machine in the the CNC machine.

3.4.4.3 Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of conversion into CNC Turret lathe, Rs.	4500000
2	Annual energy consumption of the plant, Rs./Annum	703482
3	Annual electricity cost for the turret lathe, Rs./annum	300000
4	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	60000
5	Machine hour rate for CNC, Rs.	450
6	Machine hour rate for conventional machine, Rs.	100
7	Saving due to productivity improvement as a result of reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	150
8	No. of units produced annually, Nos	4800
9	Annual Saving due to productivity improvement, Rs./annum	720000
10	Reduction in Rejection rate out of converting to CNC machine, %	0.045
11	Annual Raw material cost, Rs./annum	300000
12	Annual Saving in raw material cost, Rs./annum	13500
13	Labour saving per month, Rs./month	2000
14	Annual savings due to labour charges, Rs./annum	24000
15	Total savings, Rs./annum	817500
16	Pay back, Years	5.50

3.4.4.4 Issues in implementation:

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.4.5 Installation of 5-axis machine

3.4.5.1 Background

5 Axis Precision Machining allows machining of all 5 sides in one Set up. While this can certainly be a cost saving factor, 5 Axis machining is used more often for complex contour work, which may need simultaneous movement of all 5 Axes. Current generation 5 Axis machines offer excellent tolerances - as close as 3 microns.

The benefits of 5 axis CNC machine is the ability to machine complex shapes in a single setup. This reduces the machinist setup time and incerease the production rate. The main advantage of 5 Axis machining is the ability to save time by machining complex shapes in a single set-up. Additional benefit comes from allowing the use of shorter cutters that permit more accurate machining.

3.4.5.2 Benefits of proposals

Benefits of Positional 5 Axis Machining

- Ideal for machining deep cores and cavities
- Short cutters give increased accuracy and higher quality surface finish
- Allows the machining of undercuts
- Significant time benefits through use of only one set up

Benefits of Continuous 5 Axis Machining

- Ideal for Profiling parts
- Ideal for machining deep corners and cavities
- Shorter cutters give increased accuracy and higher quality surface finish
- Allows for machining with the flank or bottom of the tool
- Can be used with a full range of tool types
- Full gouge protection
- Can be used with models in STL format

Features and Functions

- Surface Finishing
- Swarf Milling
- Profiling
- Trimming:
- Pocketing
- Slotting

- Multi axis Drilling
- Integrated 5 Axis Post Processor

3.4.5.3 Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of 5 Axis Machine, Rs.	15000000
2	Annual energy consumption of the plant, Rs./Annum	141024
3	Annual electricity cost for the Conventional Machine, Rs./annum	72000
4	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	14400
5	Machine hour rate for CNC, Rs.	200
6	Machine hour rate for conventional machine, Rs.	1500
7	Saving due to productivity improvement as a result of reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	900
8	No. of units produced annually, Nos	4000
9	Annual Saving due to productivity improvement, Rs./annum	3600000
10	Reduction in Rejection rate out of converting to CNC machine, %	0.045
11	Annual Raw material cost, Rs./annum	400000
12	Annual Saving in raw material cost, Rs./annum	18000
13	Labour saving per month, Rs./month	2000
14	Annual savings due to labour charges, Rs./annum	24000
15	Total savings, Rs./annum	3656400
16	Pay back, Years	4.10

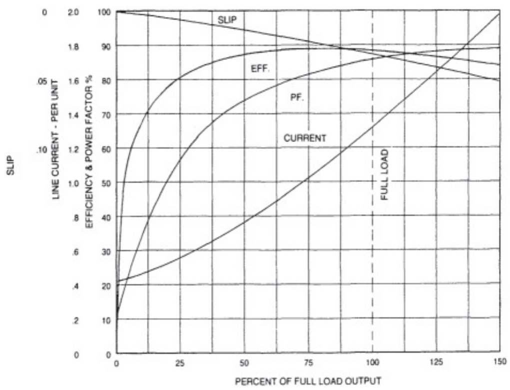
3.4.5.4 Issues in implementation:

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.4.6 Replacement of old, inefficient motors with energy efficient motors

3.4.6.1 Background

Most electric motors are designed to run at 60% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 6 to 10 hp; peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range of good efficiency varies with individual motors and tends to extend over a broader range for larger motors, as shown in Figure. A motor is



considered under loaded when it is in the range where efficiency drops significantly with decreasing load

3.4.6.2 Benefits of proposals

It is recommended to replace the present inefficient motors with energy efficient (Eff-1 IS 12915) motors. Energy efficient motors are manufactured using the same frame as a standard T-frame motor, however these have:

- Higher quality and thinner steel laminations in the stator.
- More copper in the windings.
- Optimized air gap between the rotor and stator.
- Reduced fan loses.
- Closer matching tolerances.
- A greater length.

3.4.6.3 Cost benefits analysis

Particular	Unit	Capacity - 1	Capacity - 2
Rated Installed Capacity of the Motor	kW	30	7.5
Present Rated installed Input Motor capacity	kW	34.3	8.99
Measured power consumption	kW	15.15	5.15
Present % Load on the motor		44.17	57.3
Estimated efficiency at present operating conditions	%	78	83
Actual shaft power required	kW	11.82	4.27
Proposed efficiency of energy efficient motor (eff1) at this load	%	92	88.5
Proposed input power to energy efficient motor (eff1)	kW	12.84	4.83
Reduction in operating power	kW	2.31	0.32
Proposed motor size	kW	22	7.5
Annual operating hours	Hours	4000	4000
Estimated saving potential	kWh/annum	9222	1280
Estimated cost saving	Rs./annum	42145	5850
Initial Investment	Rs.	90640	29249
Payback Period	Years	2.2	5.0

3.4.6.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.4.7 Replacement of Reciprocating compressors with screw compressors or new

screw compressors with VFD

3.4.7.1 Background

It is to be noted that the FAD of any compressor should not be less than 80% of their rated capacity in order to achieve optimum operational efficiency. This could be mainly due to wear and tear in the moving parts of the compressors, filter chocking, and age of the compressors. By replacing these reciprocating compressors with screw type compressors will lead to reduction of SPC.

3.4.7.2Benefits of proposals

The estimated SPC of new screw compressors (average) would be reduced at least to 0.19 kW/cfm at the operating pressure 6.0 – 7.0 kg/cm2 (g). It is to be noted that in screw compressors the unload power consumption can be eliminated by installing the variable frequency drive with feedback control. The pressure sensor can be provided at the discharge side of the compressors continuously senses the pressure and gives signal to the variable frequency drives. The other advantage of installing variable frequency drives are as follows

- Using variable frequency drive the operating pressure can be precisely controlled. There is no need to maintain a bandwidth as maintained in case of load/no-load control. This leads to reduction in average operating pressure of the compressor hence reduction in power consumption.
- The leakage in the compressed air system is proportional to the operating pressure. Since there is a significant reduction in operating pressure and hence significant reduction in leakage level.

3.4.7.3Cost benefits analysis

Parameters	Unit	Value
Required compressed air*	CFM	**55***
Required Pressure	kg/cm2, g	10
Existing Specific Power Consumption*	kW/CFM	0.307
Specific power consumption of New Compressor	kW/CFM	0.17
Reduction in Specific Power Consumption	kW/CFM	0.137
Operating Hours*	Hours	4200
Annual Energy Saving	kWh/annum	34718
Saving Potential	Rs./annum	158661
Initial Investment	Rs.	300000
Payback period	Years	1.89

**. The average value estimated based on the energy audits of the units in the cluster*

3.4.7.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.4.8 Optimisation of contract Demand and installation of MD controller

3.4.8.1 Background

The power supply to the facility is from BESCOM utility grid under the tariff schedule HT2a, with 100 kVA sanctioned contract demand. The minimum billing demand is 75 kVA (75% of the contract demand). The billing is based on two-part tariff with maximum demand recorded and the energy consumed in kWh. It has been observed that the plant has registered a maximum demand of 40 kVA and minimum of 22 kVA whereas the average annual demand is merly 29.5 kVA. the plant is paying the penalty of Rs. 98203 per year for unused demand.

3.4.8.2 Benefits of proposals

It is recommended to reduce the BESCOM contract demand to 55 kVA. It is also suggested that plant should install the demand controller to maintain the demand within allowed allocated demand.

3.4.8.3 Cost benefits analysis

The energy saving calculation is given below table.

Particular	Unit	Value
Present Contract Demand	kVA	100
Minimum Billing Demand	kVA	75
Demand Charges	Rs./kVA	180
Average Demand Charges paid	Rs./annum	162000
Average Recorded Demand	kVA	29.5
Actual Average Demand Charges	kVA/annum	63797.1
Overcharges due to high contract demand	Rs./annum	98203
Proposed contract demand	kVA	55
Proposed demand charges estimated	Rs./annum	86400
Net reduction in demand charges	Rs./annum	75600
Initial investment for demand controller	Rs.	22000
Payback Period	Months	3.5

3.4.8.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.4.9 Optimisation of compressor discharge pressure

3.4.9.1 Background

The instrument air required for operation in machine tools unit is 5.5 kg/cm2 (g) for instrument air and ~3 kg/cm2 (g) for service air. The plant has set the operating pressure of compressor at 9.0 kg/cm2 (g). The compressed air pressure varies depending upon the process requirement. The operating pressure of the compressors should be set in such way that the maximum pressure requirement of the plant can be met.

3.4.9.2Benefits of proposals

It is recommonded to reduce the operating pressure of compressor to 5.5 kg/cm2 (g) (upper cut off) and 5.0 kg/cm2 (g) (lower cut off).

The reduction in the operating pressure for design pressure at utilization end will reduce the operation and maintenenace cost of the plant because at high presure operation of compressors lead to more bear & tear losses.

3.4.9.3Cost benefits analysis

The saving calculation is given in table.

Parameters	*Unit*	*Value*
Present operating pressure	kg/cm2 (g)	9
Proposed operating pressure	kg/cm2 (g)	5.5
Present operating power	kW	3.2
Proposed operating power	kW	2.7115
Saving in operating power	kW	0.5
Energy saving potential	kWh/annum	2009.7
Energy charges	Rs./kWh	4.93
Annual saving	Rs./annum	9908

3.4.9.4Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.4.10 Installation of Del-star convertors

3.4.10.1Background

The Power factor and efficiency of the motor depends on percentage loading of the motor. The application of automatic delta-star controller for these motors will save the energy consumption as the controller senses the load and operates the motor either in delta or in star mode.

3.4.10.2Benefits of proposals

It is recommended to install Auto Del-Star controllers for these motors to improve the efficiency during no-load and or low load operation period.

3.4.10.3Cost benefits analysis

The Energy Saving calculation is given below table.

Electrical Motor	Average Power Consumption (kW)	% Loading Operational
Drilling Machine Main Motor	1.54	17.01
Cylindrical Grinding (Killen Berger -1)	2.28	20.47
Cylindrical Grinding (Killen Berger -2)	2.73	24.49
Cylindrical Grinding (Killen Berger -3)	3.58	32.05

Particulars	Unit	Value
Energy Saving potential	kW	1.55
Annual hours of operation	Hrs	3000
Annual energy savings	kWh/year	4660.5
Power Cost	Rs./kWh	4.57
Annual value of power savings	Rs./year	21298
Investment	Rs.	56000
Payback Period	Years	2.6

3.4.10.4Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.4.11 Installation of Energy saver for welding machines

3.4.11.1 Background

Welding sets are not on load although they are permanently kept switched on. During the non use period the welding set consumes power, although at a lower level compared to the power consumed when welding operation is going on. However the non-use period power is quite substantial and this Energy can be saved only by switching off the set manually. Since this is not a practical proposition, the sets are permanently kept switched on.

The ENERGY SAVER is ideal for use with both types viz. Transformer and Rectifier types to SAVE ENERGY.A contactor is to be provided, if not already provided to carry out the switching operation.

3.4.11.2Benefits of proposals

In the SEMI AUTOMATIC MODEL, the Electronic unit automatically switches off the set, by cutting off supply to the Contactor, when the welding set is not in use for the factory preset time interval of about 15 seconds. This time interval can be increased or decreased, if the requirement is indicated at the time of ordering. TO CONTINUE WELDING, the set will have to be switched on manually using a micro switch or reset button provided.

3.4.11.3Cost benefits analysis

Particulars	Unit	Value
Make of Machine		KEJE ARC
Machine Serial No.		XXXXXXX
Machine Type		ARC Welding Transformer
No Load Current	(Amps)	2.8,2.7,2.5,2.9
Avg. No Load Current	(Amps)	2.725
No Load Consumption Power Consumption	(Watts)	V*I*COSΦ
No Load Consumption Power Consumption	(kW)	0.54
No. of Shifts per Day		2.00
Total No. of operating Hours per Day	(Hours/Day)	12.00
Idle Hours	(Hrs /Shift)	1.5
Idle No Load Consumption/Shift	(kWh /Shift)	0.81
Idle Consumption/Day	(kWh/Day)	1.615
Total Working Days	(Days/Annum)	300
Annual Energy Saving	(kWh/Annum)	484.37
Cost of Electricity	(Rs/kWh)	5.16
Annual Energy Saving	(Rs/Annum)	2499.34
Investment for Welding Energy Saver	(Rs)	7500
Pay back	(Years)	3.00

3.4.10.4Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.4.12 Improvement insulation of Furnace

3.4.12.1 Background

To carry the performance of the furnace, w e observed insulation lining of furnace and found weak result in high temperature at the skin of furnace. The temperature range of the furnace outer surface was in the range of 95 - 110 °C (ambient temperature – 31 °C). The average value of surface temperature is estimated to be 100 °C). The expected outside surface temperatures should be about 75°C.

3.4.12.2Benefits of proposals

It is recommended to apply ceramic coating to the inside surface of the furnaces. This will reduce the radiation losses. This will save 39,700 kWh of energy valued at Rs.1, 88,800/-. The investment is Rs.61, 000/- The Detailed Energy Saving Calculation is given below table.

3.4.12.3Cost benefits analysis

The energy and operational cost saving that can be achieved by use of specific type of insulation is estimated and is given in Table

Particulars	GCF -2	GCF-3	FAC-2
Surface Temperature (°C)	100.00	100.00	75.00
Ambient Temperature (°C)	35.00	35.00	35.00
Surface heat losses (kcal/m^2/hr)	769.96	769.96	420.42
Surface area (m^2)	0.41	0.65	0.28

Particulars	GCF -2	GCF-3	FAC-2
Surface Heat losses (kcal/hr)	313.62	500.98	118.92
Circumference of the Furnace			
Surface Temperature (°C)	75.00	75.00	75.00
Ambient Temperature (°C)	35.00	35.00	35.00
Surface heat losses (kcal/m²/hr)	420.42	420.42	420.42
Surface area (m²)	3.39	4.58	2.26
Surface Heat losses (kcal/hr)	1427.04	1923.86	951.36
Bottom of the Furnace			
Surface Temperature (°C)	75.00	75.00	75.40
Ambient Temperature (°C)	35.00	35.00	35.00
Surface heat losses (kcal/m²/hr)	420.42	420.42	425.57
Surface area (m²)	0.41	0.41	0.28
Surface Heat losses (kcal/hr)	171.24	171.24	120.37
Total Heat losses of the furnace (k.Cal/Hr)	1911.90	2596.08	1190.65
% Surface Heat Loss	5.12	5.47	5.21
Savings in Electricity /Hour)	2	3	1
Annual Hours of operation (Hours/Annum)	6000	6000	6000
Annual Energy Saving (kWh/Annum)	13339	18112	8307
Annual Value of Power Saving (Rs./Annum)	63360	86033	39458
Investment			
Surface Area (S.qm)	4.21	5.63	2.83
Application area (S.qm/l)	1.07	1.07	1.07
Quantity Reqd (l)	4.50	6.03	3.03
Unit Price supply and applicant (Rs/l.)	4500.00	4500.00	4500.00
Cost(Rs.)	20265.92	27127.54	13619.57
Payback Period (Years)	0.32	0.32	0.35

3.4.10.4Issues in implementation

- Lack of awareness on proposed energy conservation measure

3.5 ENERGY CONSERVATION & TECHNOLOGY UPGRADATION PROPOSALS

3.5.1 Replacement of conventional Horizontal Machine enter with CNC Horizontal Machine Centre or new CNC Horizontal Machine enter

3.5.1.1 Background

Conventional Horizontal Machine has the same sort of x–y table, but the cutters are mounted on a horizontal arbor across the table. A majority of horizontal machines also feature a +15/-15 degree rotary table that allows milling at shallow angles. Requires intimate knowledge of the machine itself-an awareness of its various parts and their specific functions.

3.5.1.2 Benefits of proposals

CNC horizontal machining centers offers a wide selection of rigid and powerful machines for every application – every model designed and built to the exacting standards set by Gene Haas. These rugged machines have the capacity to cut alloy steels, stainless steels, cast iron and high-nickel alloys, yet also provide the speed necessary for aluminum alloys. Horizontal CNC machines centre tend to be mass-production oriented, with multi-pallet changers, bigger spindles, faster feeds, intergal rotary tables/tombstone fixtures, et cetera.

The form factor and ergonomics of a horizontal machine make it better suited for production work, while a vertical machine is a little easier to work around in for shorter jobs, but scaling to mass production can be difficult.

3.5.1.3 Cost benefits analysis

S. No.	Item/ description	Unit
1	Cost of CNC Horizontal Machining Center, Rs.	15000000
2	Annual electricity cost , Rs./annum	36000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	7200
4	Machine hour rate for CNC, Rs./hours	1500
5	Machine hour rate for conventional machine, Rs./hour	300
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	600
7	No. of units produced annually, Nos.	4800
8	Annual Saving due to productivity improvement, Rs./annum	2880000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./hour	300000
11	Saving in raw material cost annually, Rs./hour	13500
12	Labour saving per month, Rs./month	2000
13	Annual savings due to labour charges, Rs,/annum	24000
14	Total savings, Rs./annum	2924700
15	Pay back, Years	5.13

3.5.1.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.5.2 Replacement of conventional Grinding Machine with CNC Grinding Machine or new CNC Grinding Machine

3.5.2.1 Background

The conventional Grinding Machine is designed for the grinding of workpieces in individual as well as small and large series production operations. It is ideal in all sectors where small precision components are produced. It is very easy to operate and the machine can be reset within a very short time. The design also allows the operator to concentrate fully on the grinding process.

Conventional grinding machines can be broadly classified as:

S. Surface grinding machine © Internal grinding machine

(b) Cylindrical grinding machine (d) Tool and cutter grinding machine

Disadvantages of a conventional grinder are:

- It does not grind concentrically with enters.
- Large diameter short workpiece are difficult to control in the process
- It may not improve workpiece perpendicularity.

3.5.2.2 Benefits of proposals

The CNC grinding machine has advanced features and hence is a great tool to use .The grinding machine consists of several parts .

- A wheel which spins at the desired and required speed.
- A bed with a head which enables the machine to hold the piece together.
- The grinding machine can be controlled and regulated to move over the work piece according to the manner of requirement of grinding it.

The biggest advantage of using this machine is that you can control and maneuver it to your own convenience and yet get a perfect result at the end of the day.

3.5.2.3 Cost benefits analysis

S. No.	Item/ description	Unit
1	Cost of CNC Grinding Machine, Rs.	5000000
2	Annual electricity cost for conventional machine, Rs./annum	24000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	4800
4	Machine hour rate for CNC, Rs./Hour	500
5	Machine hour rate for conventional machine, Rs./hour	100

6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	200
7	No. of units produced annually, Nos.	4800
8	Annual Saving due to productivity improvement, Rs./annum	960000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./Month	2000
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	1002300
15	Pay back, Years	4.99

3.5.2.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.5.3 Replacement of conventional Gear Grinding Machine with CNC Gear Grinding Machine or new CNC Gear Grinding Machine

3.5.3.1 Background

Gear grinding is a finishing process to remove the considerable amount of metal/material after the heat treatment operation to obtain the pre determined quality of the gear. Gear griding process required high degree of the dimentional accuracy. Whereas, these conventional gear grinding machines are old technology has disadvantages like

- Quality of surface generated will be slightly wavy
- Lubrication is difficult.
- Needs heavy fixture since the cutting force results in lifting the workpiece.
- Need of high skills work force.

3.5.3.2 Benefits of proposals

CNC gear grinding machines are extremely accurate, reliable and feature integrated gear inspection and automatic machine correction.Ground spur gears and helical gears are not only suited to the mining and rail industries, where optimum quietness is a criterion, but any other application that has the need for environmentally friendly, highly efficient gearing. This machine optimising the production efficiency of the machine are 3D measurement and correction probes. These improve production rates by removing the need for off-machine inspection. As a result, parts can be placed in the machine, accurately ground and then measured, and any deviations automatically corrected before completion of the cycle.

3.5.3.3 Cost benefits analysis

S. No.	Item/ description	Unit
1	Cost of CNC Gear Grinding Machine, Rs.	70000000
2	Annual electricity cost for conventional machine, Rs./annum	60000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	12000
4	Machine hour rate for CNC, Rs./hour	7000
5	Machine hour rate for conventional machine, Rs./hour	500
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	4000
7	No. of units produced annually, Nos	4800
8	Annual Saving due to productivity improvement, Rs./annum	19200000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./Month	2000
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	19249500
15	Pay back, Years	3.64

3.5.3.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.5.4 Replacement of conventional Gear Hobbing Machine with CNC Gear Hobbing Machine or new CNC Gear Hobbing Machine

3.5.4.1 Background

Hobbing is a machining process for making gears, splines, and sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the workpiece by a series of cuts made by a cutting tool called a hob. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities. It is the most widely used gear cutting process for creating spur and helical gears and more gears are cut by hobbing than any other process since it is relatively quick and inexpensive.

3.5.4.2 Benefits of proposals

Automatic work cycle electro-hydraulic machines rely on electrically controlled and hydraulically or mechanically performed functions with proximity switches, cams, etc. With programmable logic controller, only cycle programming is done through console and electro-mechanical programming device. CNC control brought the real revolution of built-in flexibility. Various CNC axes.

Improved accuracy

Highly accurate linear measuring permits very close tolerance on size. On some machines, machine- mounted temperature and displacement sensors detect dimensional variations in the machine structure due to variations in operating or ambient temperatures. The control system automatically compensates for the deviations, and guarantees almost constant size of gears produced in a lot. Individually controlled cutter and workpiece rotation permit best cutting parameters at finish generation stage. It results in reduced radial runout, pitch error, and improved surface finish. The new generation of CNC gear shaping machines are claimed to be capable of producing AGMA class 11 or DIN 6 gears on production runs. Minimum shoulder clearance is also reduced because of accuracy of stroke reversal. This makes a compact design possible. CNC positively improves both lead and pitch accuracy.

Reduced setup time

On a CNC gear machine, a number of setting activities are eliminated depending on number of axes under NC control –

- Index and feed gears are not to be changed.
- Stroke positioning/stroke length is not to be set.
- Rapid motion and feed distances of the radial traverse (worktable or cutter column) are not to be adjusted manually.
- Radial feed is not to be adjusted and set for multi-cut cycle.
- Cutter spindle stroking speed is not to be set.
- Direction of cutter relieving from external gear cutting is not to be changed for up cutting or for cutting internal gear.

Reduced Cycle Time

On CNC machine, the cycle time is reduced because of two main reasons:

- All rapid traverses can be set more accurately because of linear transducers on slides.

- Best possible combination of stroking speed, rotary feed and radial infeed reduces the cycle time to minimum.

3.5.4.3 Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Gear Hobbing Machine, Rs.	20500000
2	Annual electricity cost for conventional machine, Rs./annum	60000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	12000
4	Machine hour rate for CNC Hobbing Machine, Rs./hour	2050
5	Machine hour rate for conventional machine, Rs./hour	400
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	850
7	No. of units produced annually, Nos	4800
8	Annual Saving due to productivity improvement, Rs./annum	4080000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./month	2000
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	4129500
15	Pay back, Years	4.96

3.5.4.4 Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.5.5 Replacement of conventional Wire cut machine with CNC Wire cut Machine or new CNC Wire cut Machine

3.5.5.1 Background

In wire electrical discharge machining (WEDM), also known as wire-cut EDM and wire cutting, a thin single-strand metal wire, usually brass, is fed through the workpiece, submerged in a tank of dielectric fluid, typically deionized water. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.

3.5.5.2Benefits of proposals

CNC wire-cut machines are generally used in the production of sophisticated molds and dies. CNC wire cut EDM is equipped with a user friendly industrial CNC controller which features PC-based design, standard canned cycles, quick and easy setups and resetting after a wire break.

3.5.5.3Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Wire cut Machine, Rs.	6000000
2	Annual electricity cost for conventional machine, Rs./annum	60000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	12000
4	Machine hour rate for CNC Wire cut Machine, Rs./Hour	600
5	Machine hour rate for conventional machine, Rs./Hour	100
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time , Rs.	300
7	No. of units produced annually, Nos.	4800
8	Annual Saving due to productivity improvement, Rs./annum	1440000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./month	2000
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	1489500
15	Pay back, Years	4.03

3.5.5.4Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.5.6 Replacement of conventional Turret Punch Machine with CNC Turret Punch Machine or new CNC Turret Punch Machine

3.5.6.1 Background

A turret punch press machine comprising a frame consisting of a base frame portion, column portions extending from the base frame portion, and an upper frame portion horizontally extending from the column portions. The upper frame portion is divided into first and second upper frame portions, a hammer and a hammer driving mechanism are attached to the first upper frame portion. An upper turret of paired ones, each having plural die halves at the circumferential rim portion thereof, is attached to the second upper frame portion, whereas another lower turret is attached to the base frame portion.

3.5.6.2 Benefits of proposals

The CNC Turret Punch Press gives remarkable productivity for the components having many perforations or requiring many punches. It is able to punch 3mm in M.S., 4mm in Aluminium & 1.6mm in S.S. and has vast tooling potential for the increased versatility. This means ability to produce variety of components without re-tooling. This results in significant saving in production cost and noticeable increase in productivity.

This has a great impact on job work cost and so we are able to do job work with excellent quality at affordable cost.

Benefits of CNC Turret Punch Press

- The CNC Turret Punch Press gives high productivity in an economical way.
- It has the ability to produce variety of components without re-tooling and thereby saving in production cost.
- It is best suitable for regular and repetitive job work.

3.5.6.3Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Turret Punch Machine, Rs.	12000000
2	Annual electricity cost for conventional machine, Rs./annum	60000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	12000
4	Machine hour rate for CNC Turret Punching, Rs./Hour	1200
5	Machine hour rate for conventional machine, Rs./Hour	200
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	600
7	No. of units produced annually, Nos	4800
8	Annual Saving due to productivity improvement, Rs./annum	2880000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./month	2000

S. No.	Item/ description	Amount (Rs)
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	2929500
15	Pay back, Years	4.10

3.5.6.4Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

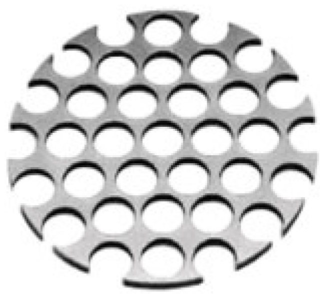
3.5.7 Replacement of conventional Cutting Machine with CNC Laser Cutting Machine or new CNC Laser Cutting Machine

3.5.7.1 Background

Conventional cutting machines are equipped with various blades that's moves in a specific way. The necessary relative movement between the cutting machine and the material has to be correspondence with the cutting contour. To understand this new method, let's first examine the conventional method, which uses an abrasive wheel. Abrasive wheels cut a path equal to the thickness of the wheel and deposits most of that debris inside the hose being cut or up the exhaust chute, although a portion may be sucked away by an exhaust system. This method creates melted rubber, molten metal, and abrasive grit in the air which necessitates the exhaust system.

The abrasive wheel cuts using friction from grains of abrasive stone that come in contact with the hose materials and grind them away. As the abrasive grains become loaded up with melted rubber and steel, they break off and allow new sharp abrasive grains to be exposed and continue to melt more hose rubber and steel braiding. If the abrasive grains in the wheels are too fine, they load up after a few cuts, and the wheel starts cutting out of square. When the wheel becomes gummed up with melted rubber, it must either be replaced or cleaned. Both of these add substantial cost to the hose cutting process.

3.5.7.2Benefits of proposals



Laser cutting produces part shapes by cutting sheet material using an intense laser beam. In CNC laser cutting a beam of high-density light energy is focused through a tiny hole in a nozzle. When this beam strikes the surface of the work piece, the material of the work piece is vaporized. CNC laser cutting offers low cost for prototype and short runs since no physical tooling is needed. Heat distortion is minimal and typically limited to about 10% of material thickness. Laser cut parts generally remain flat.

One notable advantage is that the CNC laser cutting process yields minimal burrs. CNC Laser Cutting Design Considerations

- Minimize holes and cutouts.
- Rounded corners are slightly preferable.
- Edges may not be as smooth as milling or punching.
- Edge quality is usually better for thinner materials.
- Some spots along the edge, such as where the cut ends may be less smooth when laser cut.
- Sharp inside corners of the part may have a slight rounding due to beam radius of approximately 0.02 – 0.04".
- Edge burrs are usually minimal and deburring of edges is usually not necessary but should be considered for a smoother edge.
- Thin flimsy structures, such as shapes where a high percent of material is removed and long slots may experience some warping.

3.5.7.3Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Laser Cutting Machine, Rs.	55000000
2	Annual electricity cost for conventional machine, Rs./annum	60000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	12000
4	Machine hour rate for CNC laser cutting Machine, Rs./Hour	5500
5	Machine hour rate for conventional machine, Rs./Hour	500
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	4000
7	No. of units produced annually, Nos	4800
8	Annual Saving due to productivity improvement, Rs./annum	19200000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./month	2000
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	19249500
15	Pay back, Years	2.86

3.5.7.4Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.5.8 Replacement of conventional Bending Machine with CNC Bending Machine or new CNC Bending Machine

3.5.8.1 Background

Bent tube products are employed in manufacturing many kinds of products such as fluid arrangements, furniture, transport apparatus, and mechanical parts, as required for reduction of production cost and weight. For basic bending methods of tubes, (1) rotary-draw bending, (2) press bending, and (3) roll bending, have been commonly used. The rotary-draw bending is the most standard method used on rotary-type bending machines, which can be powered, manual, or numerically controlled. The draw bending consists of the rotating bending form, clamping die, and pressure die. The workpiece is secured to the bending form by a clamping die. As the bending die rotates, it draws the workpiece against the pressure die. These machines handle about 95% of tube bending operations. The press bending method uses simple tooling and is quick and easy to set up. The major advantage of press bending is its high production capabilities but it has less accuracy. Roll benders use the basic principal of force applied between three rotating rolls. The material enters the rolls and roll pressure causes it to yield on the underside of the center roll.

3.5.8.2Benefits of proposals

Besides these conventional techniques, a new flexible CNC bending machine which is based on the MOS bending method has been developed. MOS bending is a versatile and flexible method for a free-form circular tube. However, this method can not bend a square or rectangular tube. For the hydroforming of space frame components, there are the increasing needs for three-dimensional free-form bending profiles of noncircular tubes.

Energy efficiency is an outstanding feature of the servo-electric CNC bending machine. Combine this with a smart system, which will pull up automatically even if a thinner material is inserted and the company can save wasted material and time.

3.5.8.3Cost benefits analysis

S. No.	Item/ description	Amount (Rs)
1	Cost of CNC Bending Machine, Rs.	4000000
2	Annual electricity cost for conventional machine, Rs./annum	60000
3	Energy saving as a result of VFDs, feed power drawn from individual motors, antifriction guideways and ball screws @20%, Rs./annum	12000

S. No.	Item/ description	Amount (Rs)
4	Machine hour rate for CNC Bending Machine, Rs./hour	400
5	Machine hour rate for conventional machine, Rs./hour	100
6	Productivity saving due to reduction in Set up time, better enhanced cutting parameters, reduction in tool change time, Rs.	300
7	No. of units produced annually, Nos.	4800
8	Annual Saving due to productivity improvement, Rs./annum	1440000
9	Reduction in Rejection rate out of replacement by CNC machine, %	0.045
10	Annual Raw material cost, Rs./annum	300000
11	Saving in raw material cost annually, Rs./annum	13500
12	Labour saving per month, Rs./month	2000
13	Annual savings due to labour charges, Rs./annum	24000
14	Total savings, Rs./annum	1489500
15	Pay back, Years	2.69

3.5.8.4Issues in implementation

- Lack of awareness on proposed energy conservation measure
- High Initial cost of implementation

3.6 OTHER ENERGY RECOMMENDATIONS

ECM – 1 Power factor improvement and installation of APFC Panel

During the energy audit study of power sources, the power parameters of electricity board supply (BESCOM) were also studied and analysed to identify the deviation from the rated and operational pattern as per installed equipments and machinery in the plant and the applied tariff for power supply. In this context, the power factor was also studied at main incomer feeder of the unit. It has been observed that the power factor at main comer is about 0.73 which is considered to be very poor side. The unit is facing the penalty of about Rs. 1500 per month from the BESCOM for maintaining the power factor below the specific limit.

It is recommended to improve the power factor to unity at main incomer level by applying the fixed capacitor banks or automatic power factor controller. The estimated capcitor bank requirment to maintain the power factor of the unit is 20 kVAr.

The Capacitor requirement calculation is given below table.

Particulars	Units	Values
Maximum operating power of the plant	kW	18.8
Average power Factor observed	Cos ϕ_1	0.68
	ϕ_1	47.16
Expected Average power Factor	Cos ϕ_2	0.98
	ϕ_2	11.48
Capacitor Required	kVAr	16.45
Recommended capacitor	kVAr	20
Saving Potential	Rs./year	18000
Implementation Cost	Rs.	11000
Payback Period	Months	7.3

ECM – 2 Replacement of conventional tube lights with energy efficient ones

In maintenance & facility areas about 78 numbers Fluorescent TL with 40W and 36 W with conventional ballast is provided. The conventional ballast consumes about 12 W, which is nearly 33% of lamp wattage.

The electronic ballast consumes only 2W and has additional advantage of wide voltage variation, enhances life of the Fluorescent tube. Further the T5 lamp with electronic ballast would consume about 30 W as against 52 W by fitting with normal ballast, without compromise in the lux level.

It is recommended to replace all 78 nos. of FTL provided in maintenance & facility areas with T5 lamp with Electronic choke. T5 retrofit lamps are available, which can be fitted into the existing fixture for 36 W. Later, replacement of lamp alone can be done as and when required.

Particulars	Unit	Existing		Proposed
Type of lamp	-	40W/4ft FTL	36W/4ft FTL	T5 Lamp
Wattage of lamps	W	40	36	28
Watt loss per ballast	W	12	12	2
No. of lamps to be replaced	No.	20	58	78
Average Operating Hours per day	Hours/Days	8	8	8
Operating day /year	No.	350	350	350
Energy consumption	kWh/year	2912	7795.2	6552
Energy savings	kWh/year			4155
Energy Cost	Rs./kWh			4.57

Particulars	Unit	Existing		Proposed
Energy cost savings	Rs./ year			18989
Initial cost / lamps	Rs.			750
Initial investment cost	Rs.			58500
Payback period	Months			3.1

ECM – 3 Installation of Lighting saver

The Fluorescent TL require rated voltage supply initilaly during the ignition of the charges and lateron can we operate at voltage level of 190 V without affecting the lux discharge level. Now a days, T-5 Fluorescent TL with electronics ballst can be ignite at 190 volt also. Reduction in voltage saves a significant amount of electrical energy in the lighting system.

It is recommended to provide lighting transformer/ voltage regulating controller for lighting circuits.

Particulars	Units	Values
Total Lighting Energy Consumption of the plant	(Watts)	2468
Present Voltage of the Lighting System(V_1)	(Volts)	225
Use of Voltage Controller for lighting circuit and reduce voltage		
Operating Voltage with Voltage Controller (V_2)	(Volts)	200
Total Lighting Energy Consumption of the plant With Voltage Controller (W_2)	Watts	1950.02
% of Energy Saving Potential per Hour	(%)	20.99
Energy Saving per Hour With Voltage Controller	(kWh)	0.52
Lighting Hours of operation per day	(Hours/Day)	12.00
Annual Operating days (Days/Annum)	(Days/Annum)	300.00
Annual Hours of operation	(Hours/Annum)	3600.00
Annual Energy Savings	(kWh/Annum)	1864.71
Energy cost	(Rs/kWh)	4.57
Annual Value of Energy savings	(Rs/Annum)	8521.73
Total Investment for Voltage Controller	(Rs)	15000.00
Payback Period	(years)	1.76

3.7 AVAILABILITY OF TECHNOLOGY SUPPLIERS/LOCAL SERVICE PROVIDERS FOR IDENTIFIED ENERGY CONSERVATION PROPOSALS

Technology suppliers/local service providers are identified for the technologies mentioned in section 3.4 of this chapter. The local services provider for majority of the local service providers are in cluster.

Details of the identified technology supplier/local service providers in Bangalore Machine Tool cluster are furnished in Annexure – 2 and same is attached along with this report.

3.8 IDENTIFIED TECHNOLOGIES FOR DPR PREPARATION

In the conventional machinine tool manufacturing process, the cost of energy and quality of the output is purly dependent on the skilled man power whereas Numerical Control (NC) refers to the automation of machine tools that are operated by abstractly programmed commands encoded on a storage medium, as opposed to manually controlled via handwheels or levers, or mechanically automated via cams alone.

In modern CNC systems, end-to-end component design is highly automated using computer-aided design (CAD) and computer-aided manufacturing (CAM) programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine via a postprocessor, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools-drills, saws, etc.-modern machines often combine multiple tools into a single "cell". In other cases, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine.

Based on the production capacity and process requirements and type pf tolls manufacturing, various types of CNC based on the application like Milling, Turning and Lathes macjines are selcted for technology upgradation in the Bangalore Machine Tool cluster. From energy use and technology audit studies carried out in Bangalore Machine Tool cluster, revealed that the conventional process equipments/utilities installed are of inefficient, time consuming and inferior quality, and consuming more energy. There is considerable potential in all cluster units for energy conservation by replacing the old/conventional technology/equipments with Advance, Numerical Controlled and energy efficient technologies/equipments.

The selected technologies/equipments considered for preparation of detailed project reports is given in table below.

Item/ Description	Potential for Replication, %
Replacement of CNC milling, turning machines with CNC Turn –mill centre or new CNC Turn-mill centre	25
Replacement of conventional milling machines with CNC milling machine or new CNC milling machine	36
Replacement of conventional lathes with CNC lathes or new CNC Lathes	36
Conversion of conventional machines into CNC machines	8
Installation of 5-axis machine	36
Replacement of conventional Horizontal Machine centre with CNC Horizontal Machine Centre or new CNC Horizontal Machine centre	23
Replacement of conventional Grinding Machine with CNC Grinding Machine or new CNC Grinding Machine	15
Replacement of conventional Gear Grinding Machine with CNC Gear Grinding Machine or new CNC Gear Grinding Machine	18
Replacement of conventional Gear Hobbing Machine with CNC Gear Hobbing Machine or new CNC Gear Hobbing Machine	18
Replacement of conventional Wire cut machine with CNC Wire cut Machine or new CNC Wire cut Machine	18
Replacement of conventional Turret Punch machine with CNC Turret Punch Machine or new CNC Turret Punch Machine	20
Replacement of conventional cutting machine with CNC Laser Cutting Machine or new CNC Laser Cutting Machine	20
Replacement of conventional Bending Machine with CNC Bending Machine or new CNC Bending Machine	20
Replacement of old, inefficient motors with energy efficient motors	30
Replacement of Reciprocating compressors with screw compressors or new screw compressors with VFD	30

CHAPTER – 4

4.0 Systematic Approach for Energy Conservation by TEM/SGA

4.1 INTRODUCTION

Energy is one of the most important resources to sustain our lives. At present we still depend a lot on fossil fuels and other kinds of non-renewable energy. The extensive use of renewable energy including solar energy needs more time for technology development.

In this situation Energy Conservation (EC) is the critical needs in any countries in the world.

Of special importance of Energy Conservation are the following two aspects:

- Economic factors
- Environmental impacts

4.1.1 Economic factors of Energy Conservation

Energy saving is important and effective at all levels of human organizations – in the whole world, as a nation, as companies or individuals. Energy Conservation reduces the energy costs and improves the profitability.

Notably, the wave of energy conservation had struck the Indian intelligentia 3 years earlier when a Fuel Policy Committee was set up by the Government of India in 1970, which finally bore fruits three decades hence in the form of enactment of the much awaited Energy Conservation Act, 2001 by the Government of India. This Act made provisions for setting up of the Bureau of Energy Efficiency, a body corporate incorporated under the Act, for supervising and monitoring the efforts on energy conservation in India.

Brief History of energy efficiency movement in India and associated major milestones are as follows

- 1974: setting up of fuel efficiency team by IOC, NPC and DGTD (focus still on industry)
- 1975: setting up of PCAG (NPC main support provider) : focus expanded to include agriculture, domestic and transport
- 1978: Energy Policy Report of GOI: for the first time, EE as an integral part of national energy policy – provided detailed investigation into options for promoting EE
- Post 1980, several organizations started working in EC area on specific programs (conduct of audits, training, promotion, awareness creation, demonstration projects, films, booklets, awareness campaigns, consultant/product directories)

- Some line Ministries and organizations like BICP, BIS, NPC, PCRA, REC, Ministry of Agriculture, TERI, IGIDR, CSIR, PETS (NPTI)
- State energy development agencies
- Industry associations
- All India financial institutions

The Government of India set up Bureau of Energy Efficiency (BEE) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy. This will be achieved with active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors

Private companies are also sensitive to energy costs, which directly affects their profitability and even their viability in many cases. Especially factories in the industrial sectors are of much concern, because reduced costs by Energy Conservation mean the more competitive product prices in the world markets and that is good for the national trade balance, too.

4.1.2 Environmental impacts of Energy Conservation

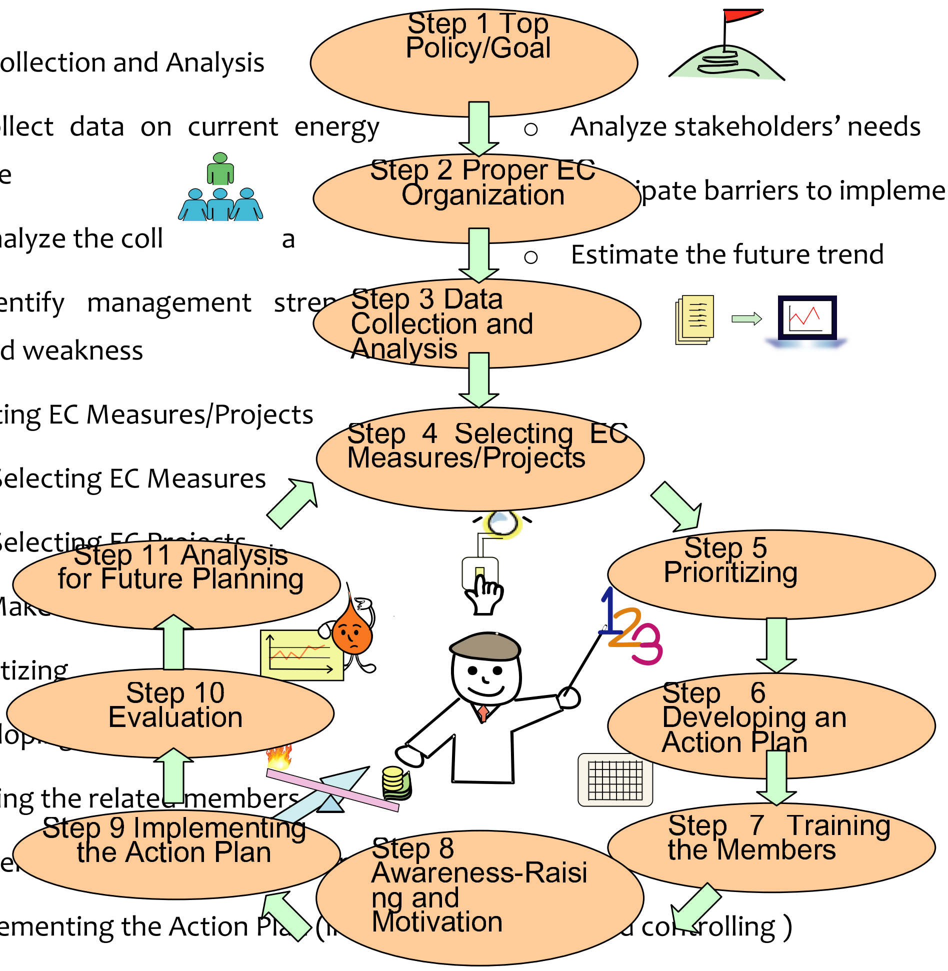
Energy Conservation is closely related also to the environmental issues. The problem of global warming or climate change is caused by emission of carbon dioxide and other Green House Gases (GHG). Energy Conservation, especially saving use of fossil fuels, shall be the first among the various countermeasures of the problem, with due considerations of the aforementioned economic factors.

4.2 TOTAL ENERGY MANAGEMENT (TEM)

Every point in factories has potential for Energy Conservation. Total Energy Management is implemented, by all the people's participation, step by step utilizing "Key Step Approach" in a systematic manner, as shown below:

- Top management policy/Goal
  - Develop a policy statement
  - Set targets
- Proper EC Organization including Assignment of Energy Manager
  - Establish proper EC organization (utilizing SGA)
  - Assignment of Energy Manager

- Data collection and Analysis
  - Collect data on current energy use
  - Analyze the coll… a
  - Identify management stren… and weakness
  - Analyze stakeholders' needs
  - …ipate barriers to implement
  - Estimate the future trend
- Selecting EC Measures/Projects
  - Selecting EC Measures
  - Selecting EC Projects
  - Mak…
- Prioritizing
- Develop…
- Training the related members
- Aware…
- Implementing the Action Pla… (… controlling)



- Evaluation (Management review)
- Analysis for future planning (Standardization and Dissemination)

The following figure shows these Key Steps for implementing Energy Conservation activities.

Each step is explained in this order as below:

Step 1 :Top Management policy/Goal

It is the most important for the success of Energy Conservation activities within companies or factories to have clear and official commitment of top management – either the corporate top (senior) management or factory managers. The top (senior) management shall announce explicit commitment to the Energy Management (or Energy Conservation) and behave along this line – for example, participate in EC (Energy Conservation) events and encourage the people there for EC promotion.

This Handbook is primarily meant for Energy Managers for the use of EC promotion within factories, on the assumption that top management has already committed to that. However, there may be cases where top management would learn about Energy Management (or Energy Conservation) by this Handbook, or Energy Managers would make efforts to persuade top management to support or commit to Energy Management (or Energy Conservation) with the help of this Handbook.

- Develop a policy statement

  It is desired that the top (senior) management announces the "Energy Policy Statement". This is very effective to let people inside and outside the company clearly know the management's commitment to Energy Management (or Energy Conservation). The format of the energy policy statement is various, but it usually includes the goal or objective of the company and the more concrete targets in the field of Energy Management (or Energy Conservation). It often shows the major measures and timetables. The statement shall match the company's mission statement or overall management strategy plan.

- Set targets

  The targets shall be concrete and specific so that everyone can understand it.

Step 2 : Proper EC Organization including Assignment of Energy Manager

In some countries, where the EC Promotion Act is in force, the designated factories have obligation of assigning Energy Managers. In relation to Energy Management, however, the word "Energy Managers" is here used as a Manager or a Coordinator, separate from the above-said legal obligation, who works exclusively for Energy Management (or Energy Conservation) purposes, ranging from gathering energy-related information to drafting EC plans/programs and promoting or coordinating during implementation. To the proper Energy Management, this type of Energy Manager is indispensable. How to position this Energy Manager within the company organization is also an important issue and needs careful decision. In some cases, Energy Committee, with members from the major departments, may be formed to assure the company-wide or factory-wide cooperation, as shown in the following figure.

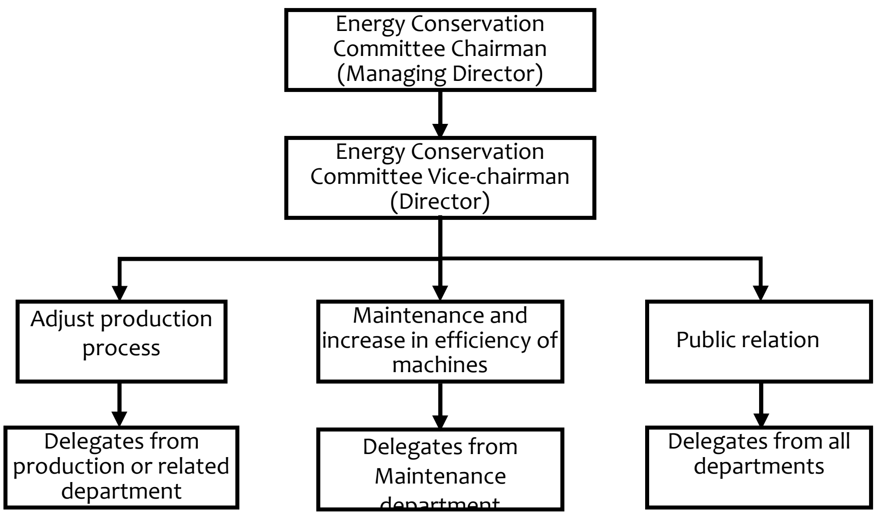


Figure 4.1: Example of energy conservation committee's organization

Actually there are many ways of forming EC organization, depending on the situation of factories or institutions, such as the size, kind of business, etc. In any case, it is very effective to utilize SGA (Small Group Activities) and there are also many ways to do that. The important thing is to design and make out the organization carefully to meet the purpose. In practical sense to do that, there may be the following five widely applicable ways of establishing the organization.

- Utilize Line (Formal) Job-related Organization for TEM purpose
- Use TPM Organization for TEM purpose
- Use TQM Organization for TEM purpose
- Add Employee Suggestion System to Energy Conservation Organization for TEM purpose
- Utilize another organization for TEM purpose
- The easy and practical way may be starting from easy form of TQM, or QCC (Quality Control Circle) activities.

Furthermore, because TPM is closely related to job-related organization, (1) and (2) may be often give the same kind of results. (An example of this form is shown in Part 3, 2 "How is SGA related to Energy Conservation?".

Step 3 : Data collection and Analysis

Before trying to make out any future programs or action plans, it is essential for the company or factory management to understand the current situation in a proper and accurate manner. This includes not only the status of their own operation but also other relevant information such as competitors' operation, circumstances around the company and their trend in future, positioning the company itself in the local and global markets, and so on.

The key steps for this purpose are shown below:

- Collect data on current energy use and analyze them

  The current data of energy consumption shall be obtained by measurement, calculation or estimation for the individual operation units (energy cost centers) with classification of kinds of energy (fuels types, utility types, etc.). The data shall be gathered regularly and arranged/summarized daily, weekly, monthly, by seasons or annually. Then the data shall be checked for the past historical trend and interpreted with relation to operational modes and production scales. That shall also be utilized for the forecast of future trends.

- Identify Management Strength and Weakness

  Then the data shall be compared with the best practice data or benchmarks in the industry. If such reference data are hardly available, the historical data of their own operation and estimated data for the competitors would be utilized for this purpose. At the same time, the strength and the weakness of the company shall be evaluated considering the competitors' situations in the local and global markets. This would serve the purpose of making out a realistic Energy Management plan later.

- Analyze stakeholders' needs

  Stakeholders are top (and senior) management, middle managers, staff/engineers and workers/operators. Other stakeholders in the normal business sense, such as the shareholders and lenders, need not be considered here for the moment. The needs and intention of those stakeholders shall be summarized and taken into consideration.

- Anticipate barriers to implement

  Making out a realistic and practical program also needs consideration of anticipated barriers for the implementation of Energy Management program or action plan. Some possible examples of such barriers are:

  - Insufficient understanding and support by top management
  - Insufficient understanding and cooperation of managers within factories
  - Insufficient awareness of people to get successful results
  - Insufficient capability of people due to lack of training
  - Insufficient available technology due to lack of information
  - Insufficient availability of manpower for EC activities within factories
  - Insufficient budget for EC activities due to the company's financial status

- Estimate the future trend

- The future trend of energy supply-demand balance is estimated based on checking and analysis of the historical data. That data of future trend would also be a basis of the program of excellent Energy Management.

In analyzing the collected data and developing ideas of Energy Conservation, it is very often useful to think of the following techniques of finding problems and solutions:

Suppress	- Using during the time in which it is not necessary to use. Examples include using electricity before or after working hours or when there is no one working.
Stop	- Using equipment when it is not necessary. Examples include using all lightings during break time.

Reduce - Amount, pressure, temperature, speed, or brightness, or quality that exceed requirement. Examples include reducing intensity of lighting if not necessary.

Prevent - Prevent leakage or loss of energy. Examples include reducing space that leads to outside in order to prevent the leakage of heat into air.

Improve - Improve or repair machines to increase efficiency or modify manufacturing process to the one which enables us to conserve energy more. Examples include changing transparent sheet over the roof.

Store - Re-use the discarded energy. Examples include re-using heat from exhaust fume in order to reduce use of electric heater to warm heavy oil.

Change - Change how to use, type of energy, or energy sources to a suitable one from technical or economic point of view. Examples include changing the grade of heavy oil to an appropriate one or changing furnace systems or welding machines to the ones that use gas.

Increase production - Examples include improving production process. This will lead to the reduction of energy usage per production amount.

Step 4 : Selecting EC Measures/Projects

Based on the aforesaid understanding of the current status and position of the company (factory), various EC measures are studied and many EC Projects are proposed. Comparison among these measures and projects are made with consideration of a lot of factors, such as technical, economic, intangible, and so on.

Then a plan/program is developed based on these study results. To do this, it is very important to consider the following issues:

The plan/program shall be realistic, practical and attainable with due consideration of many related elements and management resources of the company or factory. It also shall be expressed in terms of the measurable or quantifiable parameters, including Fuel Usage Index, Electricity Usage Index, Energy Usage Index, etc. It usually includes a lot of managerial measures of Energy Management (or Energy Conservation) promotion activities such as motivation techniques, means to improve awareness, training, and so on. In other words, the following items are often useful in comparing and selecting alternative plans:

- Effects of energy conservation: Activities that can conserve energy more than others are more promising.
- Investment amount: Activities that require less investment are more promising.
- Pay-back period: Activities with short pay-back period for investment amount in equipment are more promising because all energy conservation will be profits after pay-back period.
- Length of implementation: Activities that can be performed in a short period are more promising because they do not influence production process of the factory.

- Number of personnel required: Activities that require a large number of personnel tend to be burdensome.
- Importance to executives and reputation of the company: Some activities provide little financial benefit but cause good image or reputation.
- Risk of the project: Some activities bring about big financial benefits but involve high risk from various factors. In this case projects have less importance.

Step 5 : Prioritizing

Many EC measures and projects are prioritized based on the internal studies including comparison among their alternatives, in the manner explained in the above.

Step 6 : Developing an Action Plan

The priority consideration then gives birth to the Action Plan. The plan shall be clear, practical and comprehensive with proper schedule and budgeting. Shown below is an example of such a plan.

Table 1: Example of energy saving plan

Detail of the plan	Length (Months)						Person in charge	Budget	Inspected by
	1	2	3	4	5	6			
1. Turn off electricity when there is no one around	←———	———	———	———	———	———→	Mr.Prayat		
2. Turn off air-conditioner 30 minutes before stop working	←———	———	———	———	———	———→	Miss Aom		
3. Reduce welding machine's current according to the specification of the metal used for welding	←———	———	———	———	———	———→	Mr. Matthayas		
4. Close welding machine after working	←———	———	———	———	———	———→	Miss Thanom		

Step 7 : Training the related members

This issue is very important to secure the success of project Implementation, because the people is the most important resources that determines the success of the plan.

Step 8: Awareness-raising and Motivation

To have the total power of "all members' participation" combined together, it is also very crucial how to raise awareness and motivation of related people within the company (or factory). Shown below is an example of awareness raising plan.

Table 4.1: Example of awareness raising campaign

Detail of the plan	Length (Months)						Person in charge	Budget	Inspected by
	1	2	3	4	5	6			
1. Display the results of energy conservation every month	*	*	*	*	*	*	Mr.Prayat	-	Mr. Laaied
2. Evaluate every month	*	*	*	*	*		Miss Aom	-	Mr. Laaied
3. Perform energy conservation activity every 6 months	*					*	Mr. Matthayas	-	Mr. Laaied
4. Perform "Finding measures" activity in order to make energy conservation plan	*					*	Miss Thanom	-	Mr. Laaied
5. Provide rewards to sections that have achieved high efficiency						*		-	

Step 9 : Implementing the Action Plan (including monitoring and controlling)

The organizational force established in the said planning step shall be utilized fully to ensure smooth implementation of the program. Energy Manager and/or the committee shall continue working to promote the activities and report to top management on the status quo.

The actual records of implementation shall be closely watched and monitored. If some problems arise, or some variance between the planned figures and the actual record is observed, then necessary actions shall be taken immediately.

Step 10 : Evaluation (Management Review)

After the program is completed, the report shall be submitted to the top (senior) management. The results shall be assessed and analyzed for any good and bad points. The lesson shall be utilized as a feedback in the subsequent plan/program. Thus the activities are repeated to form a cyclic movement. The result of evaluation must be announced on the board in order to inform employees, so that they will be given motivation for the next activities. Evaluation can be divided into 2 types as follows.

- Short-term evaluation for the follow-up of the performance
- Long-term evaluation for the evaluation of the whole project that will be used for the future planning

Evaluation can be made in the following 3 levels.

- Self Audit: Self evaluation that is made in a small group or a department based on the predefined form. (Inspection may be made every month.)

- Upper Manager Audit: Evaluation that is made by the section/department manager intended to raise performance of the activity. (Inspection may be made every 3 month.)
- Top Management Audit: Evaluation made by the executives of the organization that will be used for the evaluation of annual bonus. (Inspection may be made every 6 month.)

In some cases, top management could think of adopting external people (outside consultants) to evaluate the results of Energy Conservation activities. Even in those cases, internal evaluation should be made to gain the fruits as much as possible.

Step 11 : Analysis for future planning (Standardization and Dissemination)

The successful results and the lessons learned are to be analyzed and arranged into the standard form which can be easily utilized by anyone in the factory. The standardized documents or information are to be disseminated all over the company.

Moreover, Energy Conservation should be incorporated as a part of daily jobs and performed continuously in a systematic manner. For this purpose, activities for energy conservation must be incorporated as a part of company's basic or business plan. If a problem is found as a result of evaluation, improvement or modification will be done and the objectives will be achieved. If the results reach or exceed the objective, information must be gathered in order to set it as a "Work Standard," which will be used in setting a new activity plan.

4.3 SMALL GROUP ACTIVITIES (SGA)

Small Group Activity (SGA) gives employees the problem solving tools they need to eliminate obstacles to Total Productivity, the cumination of zero break-downs, zero defects, and zero waste. Enterprising employees identify the problem, be it in "man, material, method, or machine," and develop cost-effective and practical methods for solving the problem.

4.3.1 Importance of SGA

SGA are activities by group of employees at operator (working Group) level. They aim to solve problems that occur at the place taken care of by each employee and put emphasis on participation and team work. Factories can apply small group activities to many kinds of work along with normal work or other measures that are already underway. The burden on employees will not increase because of small group activities. They are not only bringing benefits to factories but also boosting the knowledge and ability in performing jobs of employees, improving communication among employees, increasing creativity, and make it possible to express their own proposal with less hesitation to management. As a result, employees will start to think "This is our problem." This SGA can be applied to Energy Conservation, too, with successful results, as shown in Figure.

4.3.2 How SGA leads to Energy Conservation

An excellent example of organizational structure that promotes energy management emphasizing participation is that they form overlapping small groups as in figure 14. The feature of this structure is that a small group for energy management is distributed to various sections as in figure 15, which is a recipe for success of Total Energy Management (TEM) and makes various communications and management of activities more efficient and effective.

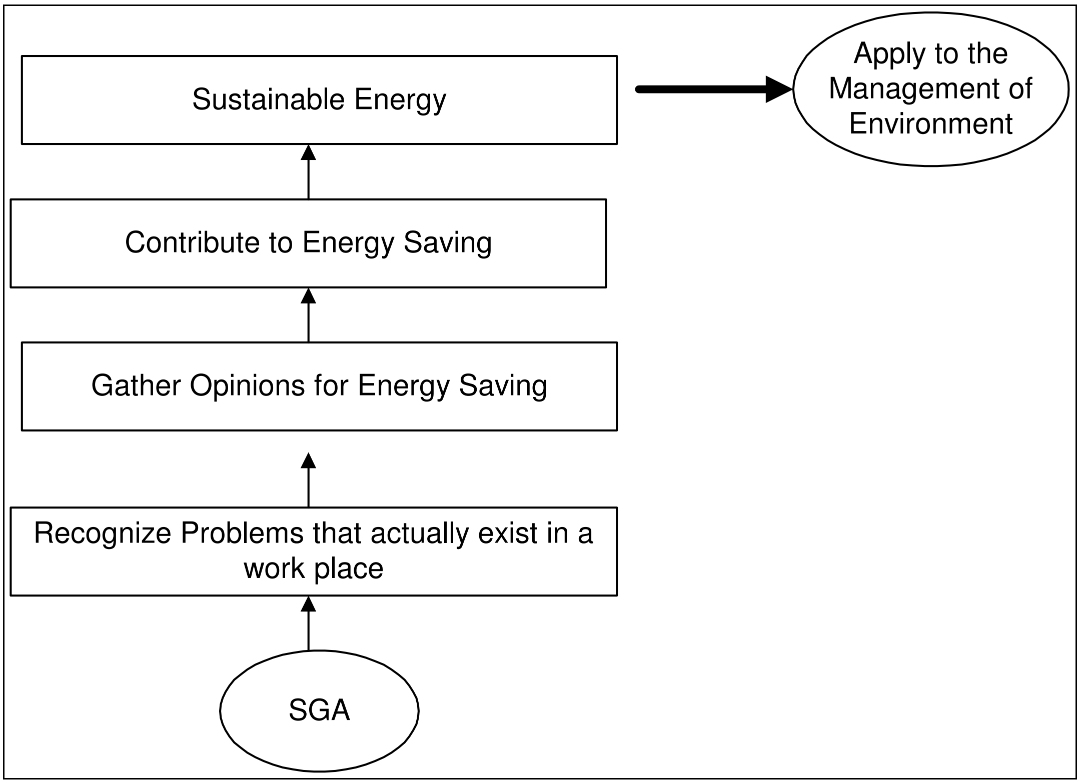


Figure 4.2: Relationship of SGA and energy saving

Small group activities for total energy management (TEM) are the activities in which employees of all levels in production or management, starting from the top to the bottom, participate in order to reduce loss related to their own job by improving their job. In order for the activities to succeed, management of all levels must provide support in necessary training and equipment, communication of policies, and the setting of problems to solve.

Small group activities for TEM can be divided into 4 or 5 levels depending on the scale of the organization. This division is in order to emphasize the fact that everyone must improve in their job under the responsibility to each other. It also enables us to make improvement without overlapping. The following example shows utilizing the existing job-related organization as much as possible, as already mentioned in Part 2, 2."Strategy for Improving the Efficiency of Energy Usage further", Step 2 Proper EC Organization including Assignment of Energy Manager.

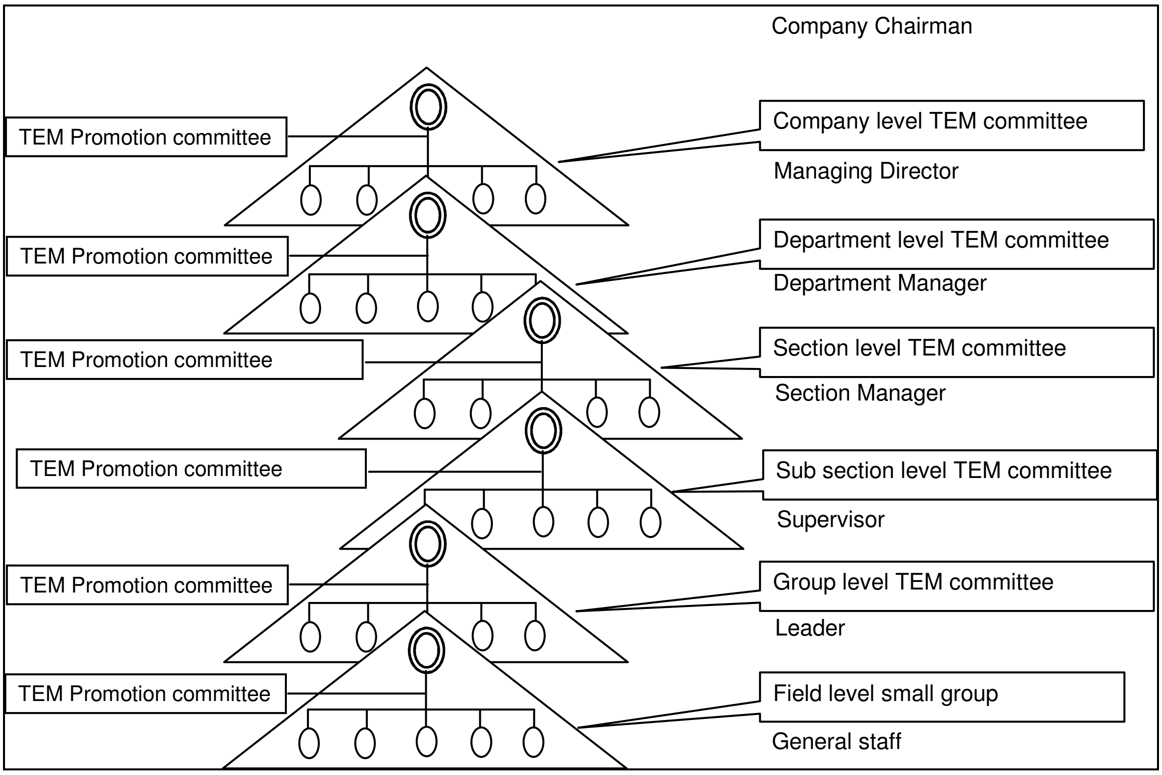


Figure 4.3: Example of Organizational Structure with Overlapping

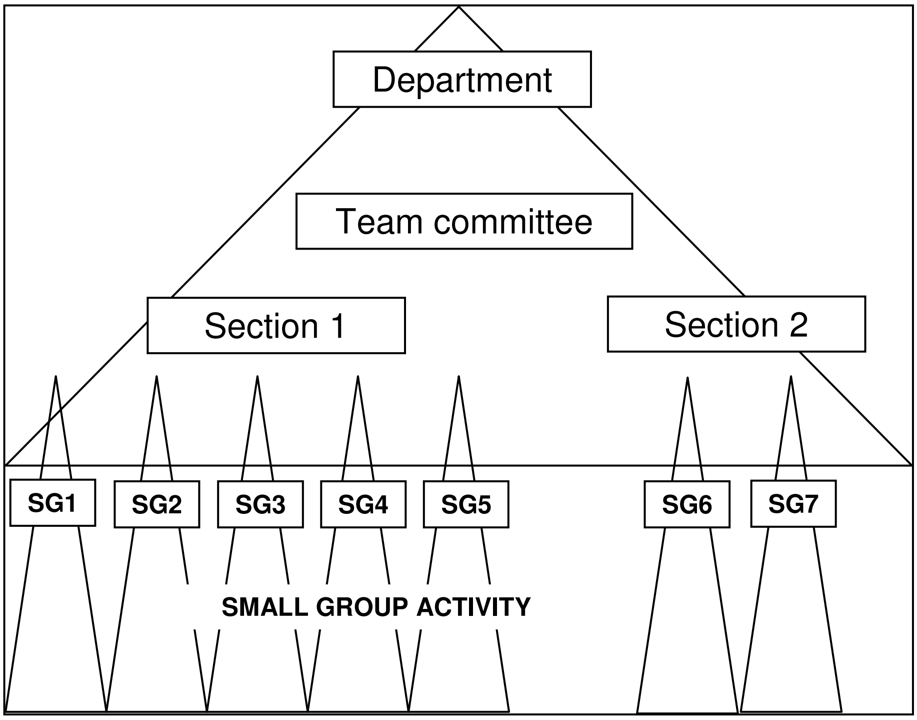


Figure 4.4: Positioning of SGA in Main Job Structure

4.3.2.1 Executives level

- Define the policy and target for Total Energy Management

- Follow-up and manage activities to make sure that activities are implemented according to the policy
- Consider opinions and suggestions from the promotion office
- Consider reports from promotion committee from various levels

4.3.2.2 Level of Total Energy Management promotion office

- Make sure that whole activities are done in the correct direction, without delay and smoothly
- Find a suitable method that makes it possible to implement activities continuously and without slowdown
- Listen to opinions and suggestions from small groups in order to use for improving
- Provide advice for Total Energy Management to various groups
- Persons in charge of the office must be those with good personal relationship, friendly, and with spirit of good service

4.3.2.3 Medium level

- Define the policies of each department that are consistent with the policy of the Total Energy Management and the target of the company
- Define numerical targets to sub-groups apart from the target of the company as a whole
- Follow-up the progress in order to provide to sub-groups
- Report the progress along with suggestions and opinions to upper level committee periodically

4.3.3 Workers/Operators level

- Implement small group activities with various themes and achieve target
- Report progress and problems encountered during implementation to upper level committee periodically
- Ask for support, suggestions, and opinions from upper level committee

4.3.4 Responsibility of Energy Conservation committee

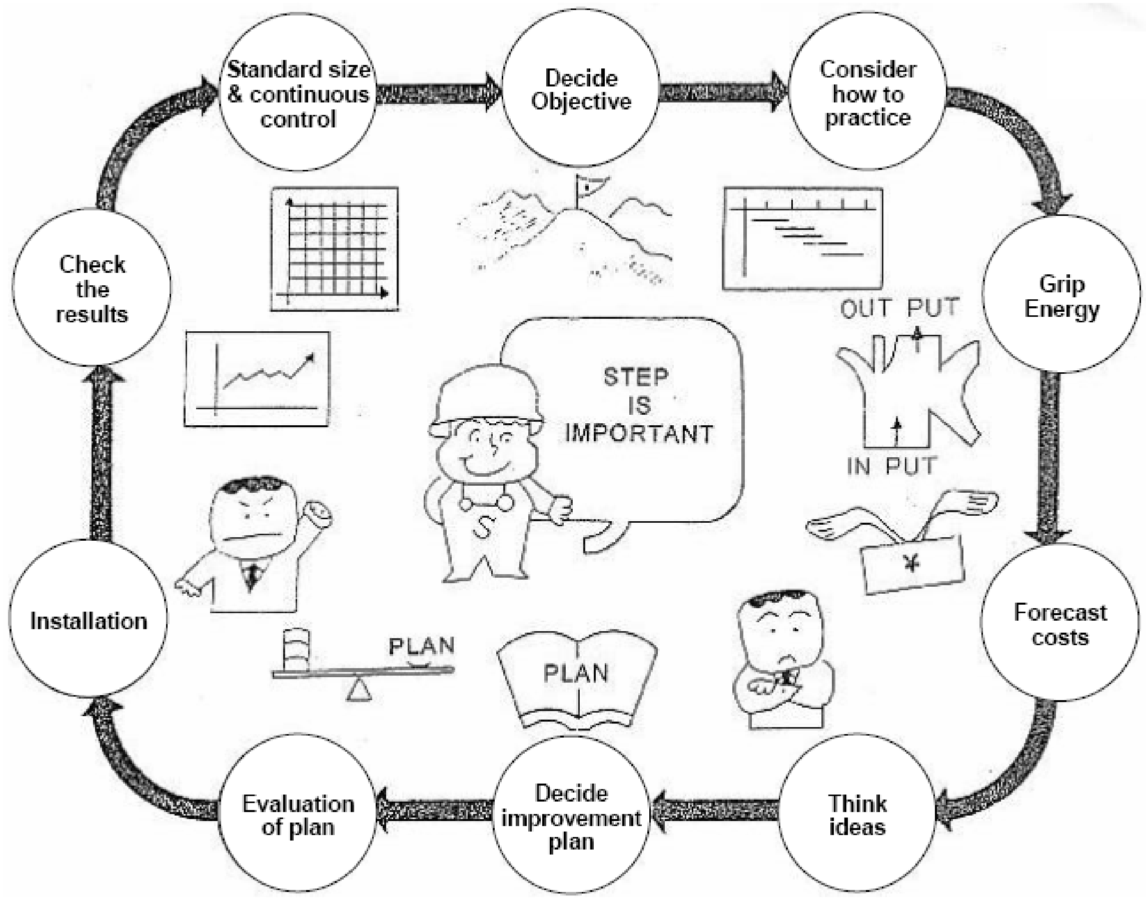
- Gather and analyze information on costs related to energy every month
- Analyze and solve problems related to energy
- Find a method for energy conservation
- Prepare energy conservation plan

- Follow-up the result of implementing the plan
- Perform activities such as public relationship for encouraging employees to participate
- Offer training to small group in each department

4.4 STEPS OF SMALL GROUP ACTIVITIES FOR ENERGY CONSERVATION

Small group activities for Energy Conservation can be done by using "10 Stages for Success", based on "PDCA Management Cycle", as shown below and in pictorial forms

- Plan: Make an efficient plan in order to improve operation



- Do: Implement according to the plan
- Check: Check if implementation was according to the plan
- Act: Judge what to improve, what to learn and what to do from what we have checked

SGA circle

Please note that these stages are substantially the same as "Key Steps" explained earlier, but put more stress on utilization of SGA. So readers could read and use either method up to their preference.

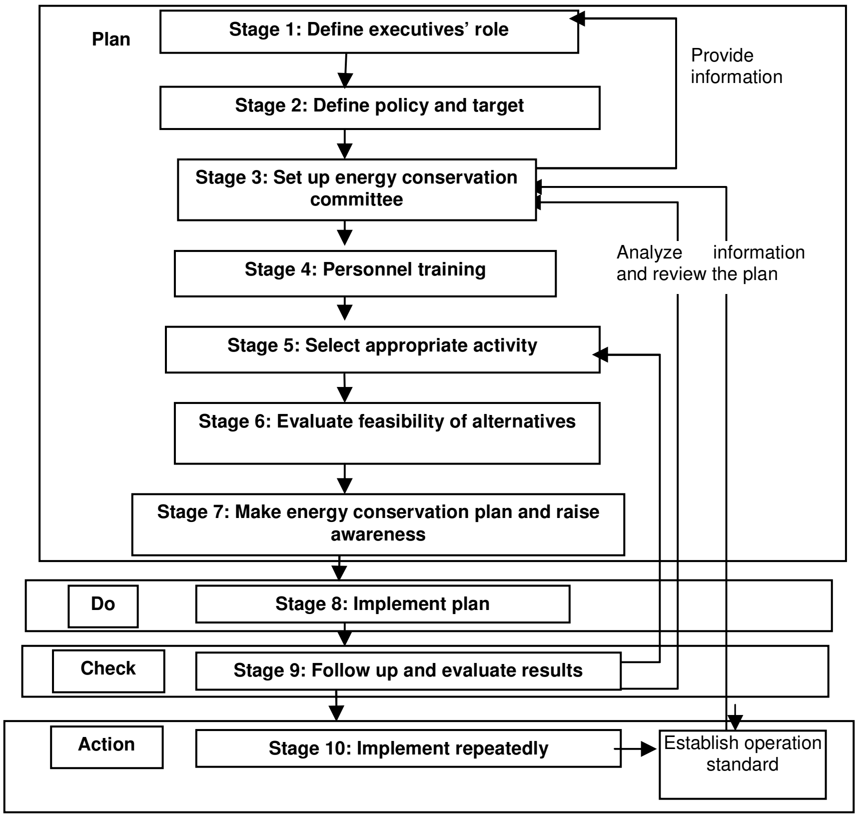


Figure 4.5: 10 Stages for Success

4.4.1 Stage 1: Define Executive's Role

In promoting small group activities, support must be provided such as basic environmental support. Therefore, executives must provide follow up support to employees of their companies.

- Establish a special unit that provides support to small group activities
- Prepare a system for managing small group activities in the company
- Prepare annual plan for small group activities
- Prepare a venue for meeting, consultation, advice or suggestion
- Establish a system for giving rewards to high achieving employees
- Establish a reporting system starting from informing what to do until reporting of the results
- Establish a fair system for evaluating results
- Establish a system for providing support and training to employees

4.4.2 Stage 2: Define Policy and Target

- Executives must announce a policy of supporting small group activities.

- Energy conservation committee must act as an advisor in order to set a numerical target that is consistent with total energy management (TEM) policy and the target of the organization. Specific targets must be set for each group.

We can see that responsibilities in stages 1 and 2 are mainly those of executives and committee. Responsibility of employees will become clearer from stage 3 and afterwards.

4.4.3 Stage 3: Set up Energy Conservation Committee

The principle of small group activities (SGA) is to divide into groups based on the scope of responsibility. The size of the group will depend on the size of organization. However, size of the group should not be too large. Usually a size of 5 to 10 persons is considered appropriate. It is important to define responsibilities clearly so that every member of the group can have their responsibility and participate in the activities.

4.4.4 Stage 4: Personnel Training

This stage will help employees to have more knowledge and understanding, have new ideas, and have more belief in their own responsibility.

4.4.5 Stage 5: Select Appropriate Activity

In doing small group activities, each member must be able to think, express their own ideas, and make decisions based on reality and by investigating electrical equipment, machines, and office equipment that exist in the area of their responsibility. Items to consider include size, number, where to use, situation of usage, current situation, and the number of hours usage per day.

By this we can evaluate the current situation of energy usage. Also by judging if there are more machines than needed, we can choose suitable activities and real problems for the organization.

4.4.6 Stage 6: Evaluate feasibility of alternatives (Analyze problems and decide on the measures and activities in each point)

Each group will gather ideas on the reasons for the problems, obstacles, and how to solve problems in order to decide on the problems, measures, and importance of activities and thus evaluate on the feasibility of activities to do based on advice from department manager. Basically, the following activities are not suitable for small group activities.

- Highly technical issues
- Issues that require a long time or many people to implement

We have identified the following problems through small group activities.

- Issues on material quality or production that influence energy usage
- Behavior on energy usage
- Efficiency of machines or equipment that uses energy

- Awareness toward environment and energy usage
- Safety costs for energy conservation

4.4.7 Stage 7: Make Energy Conservation Plan and Raise Awareness

Each group must prepare its activity plan. Generally, implementation for small group activities takes 6 months to 1 year. Activities to be implemented should correspond to the objectives of each group. Besides, it might help to listen to opinions of all organizations in order to receive support from all other organizations.

4.4.8 Stage 8: Implement Plan

Implement according to the plan of each group.

4.4.9 Stage 9: Follow Up and Evaluate Results

After implementing the plan, each member of small groups will follow up and evaluate the result by analyzing result, search for strong and weak points of activities, find a way to improve the activities and report on general achievement.

4.4.10 Stage 10: Implement Repeatedly

Energy conservation is an activity that must be implemented repeatedly. Therefore, it is necessary to implement each activity repeated and make improvement to each activity. If we are satisfied with the results, by achieving the objectives of activities, we should provide rewards in order to give motivation for continuing the small group activities and implement creative activities.

Dos and Don'ts in Energy Conservation

- Don't Emphasize the mistakes in the past. It is better to talk about the present.
- Don't Be worried about the theory or principles. Don't spend too much time in discussion or analysis of problems in meeting rooms.
- Don't Think that an activity can be done perfectly from the beginning. It is necessary to do the job continuously by having experiences and judging by ourselves.
- Do Start with an activity that requires small amount of investment.
- Do Raise awareness so that all employees understand the necessity and importance of energy conservation and participate in it.
- Do Start the activity now without postponing to tomorrow.
    - Tools that are Used Often for Small Group Activities for Energy Conservation

4.5 5S

5S is a contraction derived from the Japanese words Seiri, Seito, Seiso, Seiketsu, and Shitsuke. It is simple methodology that is also extremely useful in practical and realistic life. 5S is a set of actions to be followed through every day activities to advance the operational surroundings and circumstances. 5S is made in order to provide fortification to every personage in diverse profitable and industrialized fields. 5S is an extremely practical contrivance and skill set for anyone who wants to generate a more prolific environment within the workplace or who wants to make it their profession to make other people's businesses more proficient and productive. 5S occupy a list of products including eyewear, ear protectors and safety gears. Look into these different products that make up the significance of an industrialized security supply. Lean Six Sigma experts promise or guarantee for the efficiency of 5S as an enlightening enhancement to better working surroundings in an association. If you dig up Six Sigma guidance that is paid for by your company, you will be in a position to work for your company and make things better for you as well as for everyone. 5S is very useful in lots of industries and job markets, but can often fail simply because of the lack of recognition concerning changes in the office.

5S consists of five steps that are crucial for the completion of 5S. The 5S steps are described as follows-

- Seiri / Sort- This is very logical term in, which identification of the contents take place, data base of the products have been created and, then any kind of sorting take place just to arrange the products and removal of unwanted items. Classification of the products is necessary, which is called Red Tagging. It is important just to identify factors, right from whether it is needed, existing amount obligatory amount, occurrence of necessity, and so on.

- Seito / Systemize- This step in 5S process consists of removal of unwanted items permanently and one more task that to be take place is decision that means you have to decide that what is required to be in what place. Place the items in such manner that you could retrieve them within 30 seconds of requirement.
- Seiso / Brush away/ Sweep- Examine al the items on the daily basis. The process is not that much time consuming, but essential to clean up your workplace and most required in 5S. The conscientiousness to keep the office clean should be circulated between everyone in the group.
- Seiketsu / Homogenize- This important step of 5S involves the visual control, which is important to keep your organization well- organized and clean. It is a complete evaluation to improve the working conditions.
- Shitsuke / Self Control- This step is quite essential, but critical because it involves all the discipline to ensure the 5S standards, it also takes charge of dedication and commitment.

4.6 QCC (QUALITY CONTROL CIRCLE)

QCC (Quality control circle) means controlling quality through group activities. For this, it is necessary to work hand in hand and achieve objective quality or customers' request. With this, we can find weak points, find the cause of problems, gather ideas for problem solving and systematically prepare quality and thus, solve problems such as material loss, production costs, working hours, or productivity. This is also a very useful tool to tackle with Energy Conservation problem. So many factories or institutions are encouraged to utilize this tool.

CHAPTER – 5

5.0 Conclusion

5.1 SUMMARY

In this section summary of energy use and technology studies conducted in Bangalore Machine Tool cluster is discussed, which include identified energy conservation measures, its energy & monetary benefits, payback period, issues in implementation are discussed. Details of the same are furnished in table below:

Table 5.1: Summary of Maintenance/General House Keeping proposals in Bangalore Machine Tool Cluster

S. No	Housekeeping practices/No cost energy conservation measures	Issues in implementation
1	Proper tightening/tensioning of belts in various drives	➥ Lack of awareness EC measure
2	lubrications of gear systems	➥ Lack of awareness EC measure
3	Cleaning of compressor filters regularly	➥ Lack of awareness EC measure
4	Switch off the lights after completion of work	➥ Lack of awareness EC measure
5.	Continuous monitoring of Compressed air leakage	➥ Lack of awareness EC measure

Table 5.2: Summary of energy saving proposals in Bangalore Machine Tool Cluster

S. No	Energy conservation measure	Annual energy/Fuel saving kWh/annum	Annual Monetary saving (Rs. lakh)	Implementation cost (Rs. lakh)	Simple payback period (years)	Applicable to number of units in cluster (Nos.)	Annual cluster saving potential of particular EC measure(Rs. lakh)
1	Replacement of CNC milling, turning machines with CNC Turn –mill centre	-	8.81	55.0	6.2	25	220.3

S. No	Energy conservation measure	Annual energy/Fuel saving kWh/annum	Annual Monetary saving (Rs. lakh)	Implementation cost (Rs. lakh)	Simple payback period (years)	Applicable to number of units in cluster (Nos.)	Annual cluster saving potential of particular EC measure(Rs. lakh)
	or new CNC Turn-mill centre						
2	Replacement of conventional milling machines with CNC milling machine or new CNC milling machine	-	16.49	70.0	4.2	36	593.6
3	Replacement of conventional lathes with CNC lathes or new CNC Lathes	-	8.12	40.0	4.9	36	292.3
4	Conversion of conventional machines into CNC machines	-	8.17	45.0	5.5	8	65.4
5	Installation of 5-axis machine	-	36.56	150.0	4.1	36	1316.2
6	Replacement of old, inefficient motors with energy efficient motors	10502	0.48	1.2	2.5	50	24.0
7	Replacement of Reciprocating compressors with screw compressors or new screw compressors with VFD	34718	1.59	3.0	1.9	60	95.2
8	Optimisation of contract Demand and installation of MD controller	-	0.76	0.2	0.3	15	11.4
9	Optimisation of compressor discharge pressure	2009	0.09	-	0.0	75	6.9
10	Installation of Del-star convertors	4660	0.21	0.6	2.7	50	10.5
11	Installation of Energy saver for	485	0.03	0.1	3.0	10	0.3

S. No	Energy conservation measure	Annual energy/Fuel saving kWh/annum	Annual Monetary saving (Rs. lakh)	Implementation cost (Rs. lakh)	Simple payback period (years)	Applicable to number of units in cluster (Nos.)	Annual cluster saving potential of particular EC measure(Rs. lakh)
	welding machines						
12	Improvement insulation of Furnace	39758	1.89	0.6	0.3	15	28.4
	Total Energy/Cost reduction Possibilities using Proposed Recommendations in the Bangalore Machine Tool Cluster						**2664.3**

Table 5.3: Summary of EC and Technology Up-gradation proposals in Bangalore Machine Tool Cluster

S. No.	Item/ Description	Annual Monetary saving (Rs. lakh)	Implementation cost (Rs. lakh)	Simple payback period (years)	Potential for Replication, %	Annual cluster saving potential of particular EC measure(Rs. lakh)
1	Replacement of conventional Horizontal Machine centre with CNC Horizontal Machine Centre or new CNC Horizontal Machine centre	29.247	150	5.13	23	672.7
2	Replacement of conventional Grinding Machine with CNC Grinding Machine or new CNC Grinding Machine	10.023	50	4.99	15	150.3
3	Replacement of conventional Gear Grinding Machine with CNC Gear Grinding Machine or new CNC Gear Grinding Machine	192.495	700	3.64	18	3464.9
4	Replacement of conventional Gear Hobbing Machine with CNC Gear Hobbing Machine or new CNC Gear Hobbing Machine	41.295	205	4.96	18	743.3

S. No.	Item/ Description	Annual Monetary saving (Rs. lakh)	Implementation cost (Rs. lakh)	Simple payback period (years)	Potential for Replication, %	Annual cluster saving potential of particular EC measure(Rs. lakh)
5	Replacement of conventional Wire cut machine with CNC Wire cut Machine or new CNC Wire cut Machine	14.895	60	4.03	18	268.1
6	Replacement of conventional Turret Punch machine with CNC Turret Punch Machine or new CNC Turret Punch Machine	29.295	120	4.10	20	585.9
7	Replacement of conventional cutting machine with CNC Laser Cutting Machine or new CNC Laser Cutting Machine	192.495	550	2.86	20	3849.9
8	Replacement of conventional Bending Machine with CNC Bending Machine or new CNC Bending Machine	14.895	40	2.69	20	297.9
	Total Energy/Cost reduction Possibilities using Proposed Recommendations in the Bangalore Machine Tool Cluster					**10033**

Table 5.4: Summary of other energy conservation proposals in Bangalore Machine Tool Cluster

S. No.	**Item/ Description**	**Annual energy/Fuel saving kWh/annum**	**Annual Monetary saving (Rs.)**	**Implementation cost (Rs.)**	**Simple payback period (years)**
1	Power factor improvement and installation of APFC Panel	-	18000	11000	0.61
2	Replacement of conventional tube lights with energy efficient ones	4155	18989	58500	3.08
3	Installation of Lighting saver	1865	8521	15000	1.76

5.2 SUMMARY OF LEVEL OF AWARENESS ON ENERGY EFFICIENCY AND ENERGY CONSERVATION PRODUCTS IN THE CLUSTER

Level of awareness on energy efficiency and energy conservation products in the Bangalore Machine Tool cluster is poor, due to below mentioned reasons.

- Lack of awareness on the Energy efficiency
- Lack of organizational commitment
- Narrow focus on Energy
- Not clear about their existing level of operations and efficiency, due to lack of instrumentation & non availability of Energy consumption data
- Limited manpower
- Lack of trained manpower
- Limited information on new technologies
- Cost of Energy conservation options

Major energy sources being used in cluster are the Electrical energy and Diesel. Annual electrical energy consumption and Diesel Consumption in Bangalore cluster is around **2,26,79,100 kWh** and **99,376 litres** respectively. Total energy consumption in the Bangalore Machine Tool cluster is around **85,196 GJ.** After implementation of proposed energy conservation measures, the possibilities of reduction the energy/cost of the cluster is estimated to be about Rs. 2664 Lakh per annum. However these implementation will required the investment of Rs. 11376 Lakh initially. The payback period estimated for these proposals is about 4.2 years, which is very acceptable to the cluster.

ANNEXURE – 1: DETAILED TECHNOLOGY ASSESSMENT REPORT

Most of the Machine Tool industries in unorganized sector i.e. especially machine tool industries in Bangalore Cluster has these characteristics, low engineering, limited technology innovation and poor R&D base as well as low level of human resource on knowledge of technology, operational skill etc. This sector also faces deficiencies such as the lack of access to technology and technology sharing and the inadequacies of strong organizational structure, professional attitude etc.

Comprehensive Study conducted at various Bangalore units in Bangalore Machine Tool cluster to assess the technology gap in different processes and utilities.

The various factors, which influence the management towards implementation energy efficiency and energy conservation projects in chemical units in Bangalore Machine Tool cluster, are:

- Energy efficiency and energy conservation is low cost investment option which reduces energy consumption
- The energy efficiency improvement will enhance the plant management to be competitive in local and global markets by reducing production cost
- The energy efficiency and conservation measures reduces GHG emissions because of low carbon dioxide and particulate emissions
- Energy efficiency and conservation is a viable strategy to meet future energy needs of the expanding plans in the industry
- The energy efficiency and conservation places no financial and administrative burden as no separate manpower is required and only training of operation and maintenance of the technologies adopted is envisaged
- The return on investment is attractive with lower pay back periods.

Technical gap in analysis in below mentioned areas are identified and details are presented below sections:

Equipments/Systems	Areas/Operation
Sealed Quenching Furnaces	Quenching
Forced Air Circulation Furnaces	Tempering
Gas Carburising Furnaces	Carburising and Case Hardening
Bogie Hearth Furnace	Stress Relieving/ normalising
Annealing Furnace	Annealing
Electrical Motors	Utility
Air Compressors	Utility

Furnaces

Thermal efficiency of furnaces is the ratio of heat delivered to a material and heat supplied to the heating equipment.

The purpose of a heating process is to introduce a certain amount of thermal energy into a product, raising it to a certain temperature to prepare it for additional processing or change its properties.

The main losses in the furnace are:

- Heat storage in the furnace structure
- Losses from the furnace outside walls or structure
- Heat transported out of the furnace by the load conveyors, fixtures, trays, etc.
- Radiation losses from openings, hot exposed parts, etc.
- Heat carried by the cold air infiltration into the furnace
- Heat carried by the excess air used in the burners.

Based on the data measured/collected from the plant during energy audit, The efficiency calculations of the GCF and FAC furnaces are given below:

Particulars	**GCF-2**	**GCF-3**	**FAC-2**
Furnace Efficiency- Direct Method			
Energy Consumption per Hour (kWh)	43.45	55.23	26.58
Heat Input per hour (kcal/Hr)	37367.00	47497.80	22858.80
Weight of the Material In Furnace (Kgs)	500.00	800.00	800.00
Initial Temperature of the Furnace (^{O}C)	836.00	495.00	140.00
Final Temperature of the Furnace (^{O}C)	920.00	600.00	228.00
Temperature Rising per Hour (^{O}C)	84.00	105.00	88.00
Specific Heat (kcal/kgs/degC)	0.12	0.12	0.12
Heat Utilized for material Heating per Hour (kcal/Hr)	5040.00	10080.00	8448.00
Efficiency (%)	13.49	21.22	36.96

The results of measurements, observations and analysis of the Bogie Hearth Furnace is given in table.

Particulars	**Bogie Hearth Furnace**
Heat Inputs:	
Kerosene oil Consumption per Hour (Lts)	7.06
Kerosene Consumption (kg)	5.65
Calorific Value (kcal/kG)	9000.00
Heat Input (kcal)	50832.00
Energy Consumption per Hour (kWh)	39.62
Heat Input per hour (kcal/Hr)	34073.20
Total Heat Input per Hour (KCal/Hr)	84905.20
Weight of the Material In Furnace (Kgs)	800.00
Initial Temperature of the Furnace (^{O}C)	253.00

Particulars	Bogie Hearth Furnace
Final Temperature of the Furnace (^{O}C)	760.00
Temperature Rising per Hour (^{O}C)	507.00
Specific Heat (kcal/kgs/degC)	0.12
Heat Utilised for material Heating per Hour (kcal/Hr)	48672.00
Efficiency	57.33

The detailed study has been carried out for evaluating operating efficiency of the furnace and to identify measures, which can affect fuel savings. The following sections present the performance assessment and measures for reducing energy consumption. The details of the performance of the Annealing furnace are furnished below:

Particulars	Annealing Furnace
Energy Consumption per Hour (kWh)	33.79
Heat Input per hour (kcal/Hr)	29059.40
Weight of the Material In Furnace (Kgs)	1000.00
Initial Temperature of the Furnace (^{O}C)	410.00
Final Temperature of the Furnace (^{O}C)	504.00
Temperature Rising per Hour (^{O}C)	94.00
Specific Heat (kcal/kgs/degC)	0.12
Heat Utilised for material Heating per Hour (kcal/Hr)	11280.00
Efficiency	38.82

It can be seen that the furnace efficiencies have been varying from 13 to 57%. These are short term evaluations based on field data. In order to make a precise heat balance, design data and full cycle time temperature and energy consumption data is required, which is beyond the scope of the present assignment. The expected efficiency of electrical resistance heated furnace should be about 60% at about 70 to 80% of the designed

Electrical Motors

The energy audit of electrical motors installed in this machine tools manufacturing unit was carried out to study, analyse and identify the potential for energy conservation opportunity. The study included motors installed in the manufacturing process as well as in utility section of the plant. The study focussed broadly on the following three aspects, which have bearing on energy efficiency of motors:

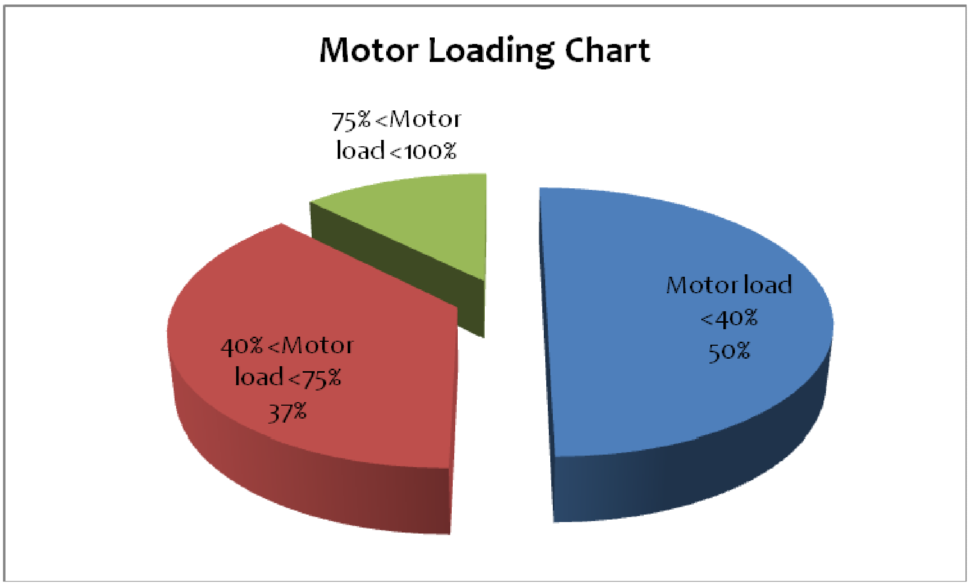
- Loading of motors
- Nature of load (fixed or variable)
- Motor operating efficiency and energy saving options

The details of the measurements taken and observation made about each of the above three aspects are detailed in the following sections.

The drives in the unit associated with the various production machinery and utility section as suggested by the plant personnel were considered for the energy audit study and electrical parameters logged for a period to study the behaviour of these motors. The results are given in table.

Machine Name	Rated Capacity, kW	Voltage, Volt	Current, Amp	Power factor, pf	Active Power, kW	Loading, %
CNC Machine 5002 (Turning)	5.75	387	4.75	0.54	1.72	29.9
CNC - Milling VMC (ABC 5020)	5.75	407	6.25	0.72	3.17	55.2
CNC 5019 Turning	5.75	421	5.86	0.53	2.26	39.4
CNC 5000 Turning	7.5	408	6.72	0.8	3.80	50.7
Conversion Machine 5014	3.75	408	2.55	0.53	0.96	25.5
Air Compressor	7.5	412	11.46	0.75	6.13	81.8
CNC Turning Machine - 5018	7.5	413	7.39	0.6	3.17	42.3
CNC Turning Machine - 5001	7.5	402	6.39	0.51	2.27	30.3

From the table, the health of the motor was analysed by checking their operation loading pattern. Motor loadings were calculated by dividing measured input power by the designed input power at full load condition. In most of the cases designed input power is calculated by dividing shaft power by designed efficiency. In case design details are not available, designed full load motor efficiency is assumed equal to that of other motors of same make.



The operational loading of the plant, taken as a whole has been given in Figure. From this figure, it may be observed that under-loaded motors i.e. below 40% is in the population (50%) in the plant whereas the optimum loaded motors are very few. Motors are loaded in the range of 40% to 75% and 75% to 100% is only 37 % & 13% respectivly. There are no motors have been found to be over

100% loaded. Air compressor motor are found to be most optimally loaded in comparison to other sections of the plant.

Electrical Motors

Compressors are designed to deliver a fixed quantity of air at certain pressure. But, due to ageing, wear and tear or poor maintenance, compressor may not be able to deliver the same volume of air as specified by the manufacturer in the nameplate. By performing the FAD (Free Air Delivery) test, actual output of a compressor with reference to the inlet conditions can be assessed. This test determines the pumping capacity of the compressors in terms of FAD, i.e. air pumped at atmospheric conditions. Following tests are generally carried out for evaluating the operating capacity of compressors.

- Pump-up test
- Suction velocity method

The pump-up test of a compressor needs isolation of the air receiver and compressor from rest of the plant. During the study, standby receiver used to conduct the test by pump-up method however leakage test also could not be done due to continuous operation of the plant.

Based on the data measured/collected from the plant during energy audit, the actual output of the compressors with respect to suction condition was calculated and is given in Table.

Particulars	Unit	Value
Rated Capacity	M3/Min	1.17
Operating Pressure	kg/cm2	9
Initial Pressure	kg/cm2	0
Atmospheric pressure	kg/cm2	1.013
Capacity of Receiver	M3	0.27
Additional holdup of volume	M3	0.01
Pump-up time	Seconds	120
Actual FAD	M3/Min	1.02
Actual Free Air Delivery	(NM^3/Hr)	61.4
Isothermal Power	KW	3.4
Motor input power	KW	6.2
Efficiency of Motor	%	83
Shaft input power	KW	5.16
Isothermal Efficiency	%	66.1

It is to be noted that the FAD of any compressor should not be less than 80% of their rated capacity in order to achieve optimum operational efficiency.

Another important parameter to determine the performance of compressors is the specific power consumption (SPC) – power consumed per cfm of compressed air delivery. For a double acting reciprocating compressor, the recommended SPC should always be less than 0.14

kW/M3/hr at 6 – 7 bar (g) pressure. However, it was measured to 0.172 kW/M3/hr, which were appropriate.

Plant is operating one compressor to fulfil the demand of Instruments/Service. The pressure requirement of the compressed air is about 5.0 – 5.5 kg/cm2 (g) for instruments and about 5.5 kg/cm^2 (g) for bottling plant and 3.0 kg/cm2 (g) service air requirements. Hence, the plant has set the minimum and maximum pressures at 7.5 – 8.0 kg/cm2 (g) for all applications in the plant considering the line losses. By separating the generation of compressed air for the areas and reducing the generation pressure, the plant will be able to reduce the power consumption of the compressed air systems significantly.

Air compressor is connected with the motor drive by V-belts. The plant may use corrugated V-belts or poly V-belts, which increases the tension of the belts as well as reduces the slips. This would offer an energy saving potential of 3 – 5%.

ANNEXURE – 2: DETAILS OF TECHNOLOGY/SERVICE PROVIDERS

Energy Audit study/Energy Conservation studies

System & Solution India
D-1/25, Sector – 4, Vinay Nagar
Gwalior – 747012 (Madhya Pradesh)
sasindia@live.com
http://www.sasindia.tk

Energy Efficient Lighting System

Asian Electronics Ltd,
D-11, Road No: 28,
Waghle Industrial Estate, Thane 400604,
Tel: +91-22-2583 5504

Energy Efficient Electrical Motors

Crompton & Greaves
No. 562/640, I Floor Janardhan Towers
Bannerghatta Main Road , Bilekahalli
Bengaluru - 560076
Karnataka India

Auto-Star-Delta Starter

Samson Trading Co.
9, Kakad Complex,
Marol Pipe Line,Below Hotel Sun-n-sheel,
Andheri East,Mumbai - 400059
91-91-22-2830 0376
http://www.samsonpumps.net

Vijay Energy Products Pvt, Ltd,
Sagar Apartments, G.F-23,
Gopalakrishna Road, T Nagar, Chennai - 600017.
+91-44-28156540/28152906.

Maximum Demand Controller

Sun Electro Control Systems Pvt Ltd
No.112/4, Nr Peenya 2nd Stage,
18th Crs, Doddanna Indl Estate, Peenya IInd Stage,
Bangalore – 560058
www.sunelectrocontrols.com
www.sunecs.com

Khodays Control Systems PVT LTD
No.B-187, 5TH MN,2ND STG,
Peenya Indl Estate,
Bangalore - 560058

CNC Machine Converter/Retrofitting of CNC

Evgreen

No.5, 12th main , Kempamma Layout,
Lakshmidevinagar, Opp.
I.R.PolynTechnic, Peenya III Phase,
Bangalore-560058,
Phone no: 080 – 41228897, 41228897, 22724598,
srinivasan@evgreenindia.com

SHREE ENGINEERING
"Anupam" Apartment, Flat No.08,
Right Bhusari Colony, Paud Road,
Pune – 411029. Maharashtra, India.

Lighting Transformer

Beblec (India) Pvt. Ltd
134, Sipcot Industrial Complex,
Hosur, 635 126 Tel: 91-4344- 276358,
www.beblec.com

ES Electronics
483, 4th Main Road, Nagendra Block,
B S K 1st Stage, Bangalore 560 050
Tel: 91- 80-25727836

Shepherd Transformer Industries
C-132, Ghatkopar Industrial Estate,
L.B.S. Marg, Ghatkopar (W),
Mumbai 400 086, Tel: 91-22-2500 8480

CNC Machine/CNC Technology Providers

Ace Micromatic Machine Tools Pvt.Ltd
Plot no.533, 10th main,
4th Phase, Peenya Industrial area,
Bangalore-560058

Haas Automation,
Manav Marketing Pvt Ltd
430-431,12TH cross,
4th Phase,Peenya Industial Area,
Bangalore 560058
India
Phone:91-80-4117 9452/53
Fax: 91-80-4117 9451
manav@giasbg01.vsnl.net.in

Jyoti CNC automation Pvt.ltd,
No.7, 6th Main Road, Shrikanteswara Nagar,
Mahalakshmipuram Lay out,
Bangalore

DMG Mori Seiki India Machines and Services Pvt Ltd
"Parimala Towers" #64 Jalahalli Camp Cross,Off MES Road, Yeshwanthpur
IN-560022 Bangalore.
Phone: +91 80 40896508

Mazak company,
Concord Towers,
14th Floor, UB City,
Bangalore

ANNEXURE – 3: QUOTATIONS OF TECHNO COMMERCIAL BIDS FROM SERVICE/TECHNOLOGY PROVIDERS

DMG MORI SEIKI

DMG — innovative technologies
www.gildemeister.com

Price Specification

DMU 60 monoBLOCK

Highlights

- High speeds with 0.7 g acceleration as standard, up to 30 m/min feed and rapid traverse and fast axes for advanced mould making applications
- Tool magazines with 24 pockets as standard.
- Multi-purpose machine with 3 axes as standard, optional 3+2, 4 or 5 axes
- Compact monoBLOCK® design and low machine height with a large work area and a long z-traverse together with an integrated scraper-band chip conveyor as standard

DECKEL MAHO
DMU 60 monoBLOCK

Price Specification

EUR

Basic machine

P-A0348*	DMU 60 monoBLOCK Universal Milling Machine 730 mm x 560 mm x 560 mm / Main drive: Motor spindle 12,000 rpm 15 kW / 20 hp (40% duty cycle); 10 kW / 13.5 hp (100% duty cycle) Spindle taper SK 40 to DIN 69871 Tool clamping to DIN 69872 Manual swivel milling head Tool change system pick-up 24 magazine pockets SK 40 Rigid table 1,000 mm x 600 mm Chip conveyor 3D CNC control
P-B0052*	3D control Heidenhain iTNC 530
P-C0176*	NC rotary table integrated in rigid table d 600 mm / d 23.6 in 1,000 mm x 600 mm / 39.4 in x 23.6 in 1x T-slot 14 H7 / 0.55 H7 (alignment slot, table centre) 8x T-slots 14 H12 / 0.55 H12 (clamping slots) distance between slots: 63 mm / 2.4 in max. table load: 500 kg / 1,100 lbs Basic machine without rigid table
P-W0246*	Controlled NC swivel milling head (B-axis) incl. hydraulic clamping Spindle offset 100 mm / 4 in Swivel range -120°/+30° Traverse range X-axis reduced by 100 mm / 4 in
P-K0220*	Infrared measuring probe Type Renishaw PP60 optical (OMP 60) SK 40 or optionally chosen spindle taper
P-G0004	Spray pistol with pump 1 bar/40 l/min 14.5 psi/10.4 gallon/min (theoretical pump performance)
P-H0021	Electronic handwheel iTNC 530

DMG MORI SEIKI 05/08/2010
Transport zone: India: Sheva/Chennai/Mumbai

P-G0054*	Package for tropical climate for ambient temperature max. 40° Celsius includes air conditioner electrical cabinet and active cooling for motor spindle

Services machine

P-P0862	Packing sea crate basic machine with tool magazine 24 magazine pockets
P-P1040	Dispatch basic machine

The total cost of the machine on CIF Chennai basis will be EUR 298,730=00

The best package price on CIF Chennai basis will be EUR 220,000=00

DMG / MORI SEIKI

DMG — innovative technologies
www.gildemeister.com

Price Specification

CTX 310 eco V3 Turn Mill Center

Highlights

_ VDI 30 revolver with 12 tool stations, up to 6 driven tools, and C-Axis
_ User-friendly Siemens 810D with ShopTurn, direct DMG SMARTkey for individual use
_ Simple programming – 15" TFT SlimLinePanel
_ Comprehensive tool management with visual representation
_ Visual support for setup and diagnosis
_ Highly dynamic spindle motor with 11 KW, 112 Nm and 5,000 rpm
_ Digital drives and linear roller guideways in all axes for highest dynamics and superb precision
_ Automatically traversing tailstock for superior machining flexibility

DMG / MORI SEIKI | 05/08/2010
Transport zone: India: Sheva/Chennai/Mumbai | Page 2 of 2

FAMOT
CTX 310 eco

Price Specification

EUR

Basic machine

C-A2675	CTX 310 eco V3 Turning centre with CNC control and SlimLinePanel, incl. Chip Tank Hydraulic hollow clamping attachment, max. bar capacity Ø 51 mm Hydraulic chuck 3 jaws 210 mm, make Autogrip, type 3H08-Z140
C-A1710*	CNC control SIEMENS SINUMERIK 810D with ShopTurn
C-P7100	Chip Removal Package: - chip conveyor - additional set (3 pieces) of soft jaws (210mm) - 4 colour signal lamp
C-Z2310	Coolant Spray Gun
Services	
C-O3134	Despatch costs machine
C-Y0006	Seafreight Packing: wooden base and vacuum foil

The Total cost of the machine on CIF Chennai basis will be EUR 77,000=00

The best package price on CIF Chennai basis will be EUR 56,000=00

CTX 310 eco / Series FEF103 valid 29/11/2010 - 25/03/2011 / Price status: 05/08/2010

ANNEXURE – 4: ELECTRICAL TARIFF

LOW TENSION PLANS-5 (LT-5)

Tariff Schedule - LT-5 Applicable to:

Heating & Motive power (including lighting) installations of industrial Units, Workshops, Poultry Farms, Sugarcane Crushers, Coffee Pulping, Cardamom drying, Mushroom raising installations, Flour, Huller & Rice Mills, Wet Grinders, Milk dairies, Dry Cleaners and Laundries having washing, Drying, Ironing etc., Bulk Ice Cream and Ice manufacturing Units, Coffee Roasting and Grinding Works, Cold Storage Plants, Bakery Product Mfg. Units, KSRTC workshops/Depots, Railway workshops, Drug manufacturing units and Testing laboratories, Printing Presses, Garment manufacturing units, Bulk Milk vending Booths, Swimming Pools of local Bodies, Tyre retreading units, Stone crushers, Stone cutting, Chilly Grinders, Phova Mills, pulverizing Mills, Decorticators, Iron & Red-Oxide crushing units, crematoriums, hatcheries, Tissue culture, Saw Mills, Toy/wood industries, Viswa Sheds with mixed load sanctioned under Viswa Scheme, Cinematic activities such as Processing, Printing, Developing, Recording theatres, Dubbing Theatres and film studios, Agarbathi manufacturing unit., Water supply installations of KIADB & industrial units, Gem & Diamond cutting Units, Floriculture, Green House, Biotech Lab, Hybrid seed processing unit. Information Technology industries engaged in development of hardware & Software, Silk filature units, Aqua Culture, Prawn Culture, Brick manufacturing units, Silk / Cotton colour dying, Stadiums maintained by Govt. and local bodies, Fire service stations, Gold / Silver ornament manufacturing units, Effluent treatment plants, Drainage water treatment plants, LPG bottling plants and petroleum pipeline projects, Piggery farms, Analytical Lab. for analysis of ore metals, Satellite communication centers, Mineral water processing plants / drinking water bottling plants and soda fountain units.

Tariff Schedule - LT-5 (a)

Fixed Charges :	a) Rs.25/- per HP for 5 HP and below.	
	b) Rs. 30/-per HP for above 5 HP and below 40 HP.	
	c) Rs.40/- per HP for 40 HP & above but below 67 HP.	
	d) Rs.110/- per HP for 67 HP & above.	
Demand based tariff	Optional*	
Fixed Charges :	Above 5 HP and less than 40 HP	Rs. 50 per KW of billing demand
	40 HP and above but less than 67 HP	Rs. 70 per KW of billing demand
	67 HP and above	Rs. 160 per KW of billing demand
Energy Charges :	0-500 units	330 paise per unit
	501-1000 units	415 paise per unit
	Above 1000 units	435 paise per unit

Tariff Schedule - - LT-5 (b)

Fixed Charges :	a) Rs.20/- per HP for 5 HP and below.

	b) Rs. 25/-per HP for above 5 HP and below 40 HP.	
	c) Rs.35/- per HP for 40 HP & above but below 67 HP.	
	d) Rs.100/- per HP for 67 HP & above.	
Demand based tariff	Optional*	
Fixed Charges	Above 5 HP and less than 40 HP	Rs. 40 per KW of billing demand
	40 HP and above but less than 67 HP	Rs. 60 per KW of billing demand
	67 HP and above	Rs. 150 per KW of billing demand
Energy Charges :	0-500 units	330 paise per unit
	501 to 1000 units	390 paise per unit
	Above 1000 units	425 paise per unit

HIGH TENSION PLANS HT-2(A)

Tariff Schedule - HT-2(a) Applicable to:

Industries, Factories, Workshops, Universities, Educational Institutions belonging to Government, Local bodies, Aided Institutions, Hostels of all Educational Institutions, Research & Development Centres, Industrial Estates, Milk dairies, Rice Mills, Phova Mills, Roller Flour Mills, News Papers, Printing Press, Railway Workshops/KSRTC Workshops/ Depots, Crematoriums, Cold Storage, Ice & Ice-cream mfg. Units, Swimming Pools of local bodies, Water Supply Installations of KIADB and other industries, all Defence Establishments. Hatcheries, Poultry Farm, Museum, floriculture, Green House, Bio Technical Laboratory, Hybrid Seeds processing Units, Stone Crushers, Stone cutting, Bakery Product Manufacturing Units, Mysore Palace illumination, Film Studios, Dubbing Theatres, Processing, Printing, Developing and Recording Theaters, Tissue Culture, Aqua Culture, Prawn Culture, Information Technology Industries engaged in development of Hardware & Software, Drug Mfg. Units, Garment Mfg. Units, Tyre retreading units, Hospitals run by Charitable Institutions & ESI Hospitals, Nuclear Power Projects, Stadiums maintained by Government and local bodies. And also Railway Traction, Effluent treatment plants and Drainage water treatment plants other than local bodies, LPG bottling plants, petroleum pipeline projects, Piggery farms, Analytical Lab. for analysis of ore metals, Saw Mills, Toy/wood industries, Satellite communication centers, and Mineral water processing plants / drinking water bottling plants.

Tariff Schedule - HT-2(a)(i)

Demand Charges :	Rs.180/- per KVA of billing demand per month.	
Energy Charges :	For the first one lakh units	430 paise per unit
	For the balance units	465 paise per unit
Applicable to :	Railway Traction and Effluent Treatment Plants.	
Demand Charges :	Rs.180/- per KVA of billing demand per month.	
Energy Charges :	430 paise per unit for all the units.	

Tariff Schedule - HT-2(a)(ii)

Demand Charges :	Rs.170/- per KVA of billing demand per month	
Energy Charges :	For the first one lakh units	430 paise per unit
	For the balance units	460 paise per unit
Applicable to :	Railway Traction and Effluent Treatment Plants.	
Demand Charges :	Rs.180/- per KVA of billing demand per month.	
Energy Charges :	430 paise per unit for all the units.	

TOD Tariff applicable to HT 2(a)(i) & (ii) category at the option of the Consumer.

Time of Day	Increase + / reduction (-) in energy charges over the normal tariff applicable
22.00 Hrs to 06.00 Hrs	(-) 80 paise per unit
06.00 Hrs to 18.00 hrs	0
18.00 Hrs to 22.00 Hrs	+ 80 paise per unit

ANNEXURE – 5: FINANCIAL SCHEMES AVAILABLE WITH LOCAL BANKS FOR IMPROVING ENERGY EFFICIENCY IN CLUSTER

1. Credit linked capital Subsidy scheme (CLCSS)

Under this scheme, the ministry of MSME is providing subsidy to upgrade technology (Machinery/plant equipments). Subsidy limit per unit is Rs. 15 lakh or 15% of investment in eligible machinery/Plant equipments whichever is lower. For more details of the scheme visit:

www.laghu-udyog.com/scheme/sccredit.htm

2. SIDBI Financing Scheme for Energy Saving Projects in MSME sector under JICA Line of Credit

The Japan International Corporation Agency (JICA) has extended a line of credit to SIDBI for financing Energy Saving projects in Micro, Small and Medium Enterprises (MSMEs). This project is expected to encourage MSME units to undertake energy saving investment in plant and machinery to reduce energy consumption, enhance energy efficiency, reduce CO2 emissions, and improve the profitability of units in the long run.

Eligible Sub Projects/ Energy Saving Equipment List under JICA line of Credit:

- Acquisition (including lease and rental) of energy saving equipments, including newly installing, remodeling and upgrading of those existing
- Replacement of obsolete equipments and/or introduction of additional equipment which would improve performance
- Equipments/ Machinery that meets energy performance standards/Acts
- Introduction of equipments that utilize alternative energy sources such as natural gas, renewable energy etc., instead of fossil fuels such as Oil and Coal etc.
- Clean Development Mechanism (CDM) projects at cluster level that involves change in process and technologies as a whole, duly supported by technical consultancy will be eligible for coverage.

Financial parameters:

The financial parameters for appraising the project are:

Parameter	Norms
Minimum Assistance	Rs. 10 lakh
Minimum promoters contribution	25% for existing units; 33% for new units
Interest rate	The project expenditure eligible for coverage under the line will carry a rate of

Parameter	Norms
	interest rate of 9.5-10% p.a
Upfront fee	Non-refundable upfront fee of 1% of sanctioned loan plus applicable service tax
Repayment period	Need based. Normally the repayment period does not extend beyond 7 years. However, a longer repayment period of more than 7 years can be considered under the line if necessary

Eligibility criteria for units (Direct assistance):

- Existing units should have satisfactory track record of past performance and sound financial position.
- Projects will be screened as per Energy Saving List, which is available in SIDBI website.
- Units should have minimum investment grade rating of SIDBI.
- Projects which may result environmental impacts and negative social impacts are also not eligible under this scheme.

For further details eligible energy saving equipments/machinery, projects can be financed under this scheme and details of scheme, please contact the nearest SIDBI branch office or refer to SIDBI website (www.sidbi.in)

3. Scheme for Financing Energy Efficiency Projects

PURPOSE:

- Financing SMEs for acquisition of equipments, services and adopting measures for enhancement of energy efficiency/conservation of energy.

ELIGIBILITY

- SME units financed by bank as also other units desirous of shifting their account to Bank of Baroda.

LIMIT:

- Upto 75% of the total project cost, subject to maximum of Rs. 1/- crore. (Minimum amount of loan Rs. 5/- Lakhs).

Project cost may include the following:

- Cost of acquisition/modification/renovation of equipment/software.
  - Cost of alterations to existing machinery.
  - Cost of structural / layout changes.
  - Cost of energy audit/consultancy.
  - Preparation of Detailed Project Report (DPR).

RATE OF INTEREST:

- Bank's BPLR from time to time.

REPAYMENT :

- Maximum 5 years, including moratorium, if any.

SECURITY :

a. For Sole Banking Accounts:
Extension of first charge on all fixed assets.

b. For Consortium/Multiple Banking Accounts:
first charge on equipments acquired out of loan and collateral, if any, with the total security coverage being not less than 1.25.

Grant from IREDA:

- IRDEA, at present, gives a grant of Rs. 25,000/- for projects costing Rs. 1/- crore or below to meet partial cost of Energy Audit. This grant is available for the first 100 projects (SME Sectors only) approved by them.

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