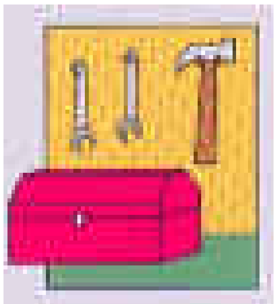


- It is well established that the quality and quantity of work are significantly enhanced by good housekeeping and adversely affected by poor housekeeping. Supervisors must expend the necessary effort to achieve and maintain a neat and orderly work environment.

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

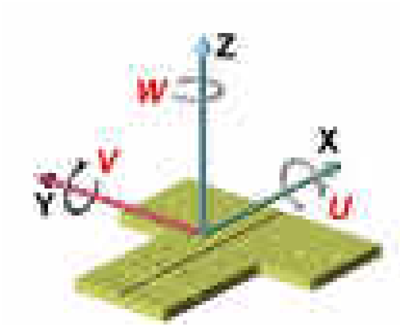
Machine tool units in organized sector have these characteristics such as; Customized technology, best R&D support from technology providers as well as high level of human resource on knowledge of technology etc. The Bangalore machine tools cluster is having the mixed type of process machinery at all. 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 recommended 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

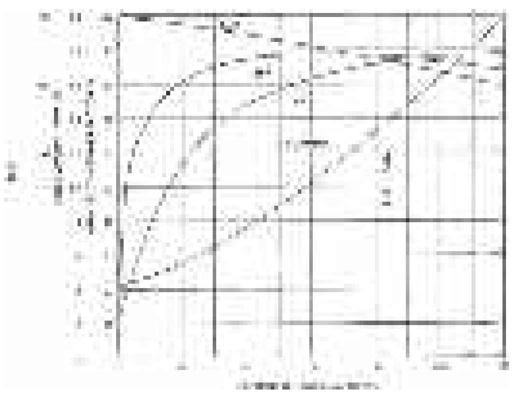
3.4.5.4 Issues in implementation:

- 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

3.4.6.2Benefits 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.

3.4.6.3Cost 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

3.4.6.4Issues 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

3.5.6.4 Issues 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.

3.5.7.2 Benefits 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

3.5.7.4 Issues 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.

3.5.8.2 Benefits 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.

3.5.8.3 Cost 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 $ø_1$	0.68
	$ø_1$	47.16
Expected Average power Factor	Cos $ø_2$	0.98
	$ø_2$	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

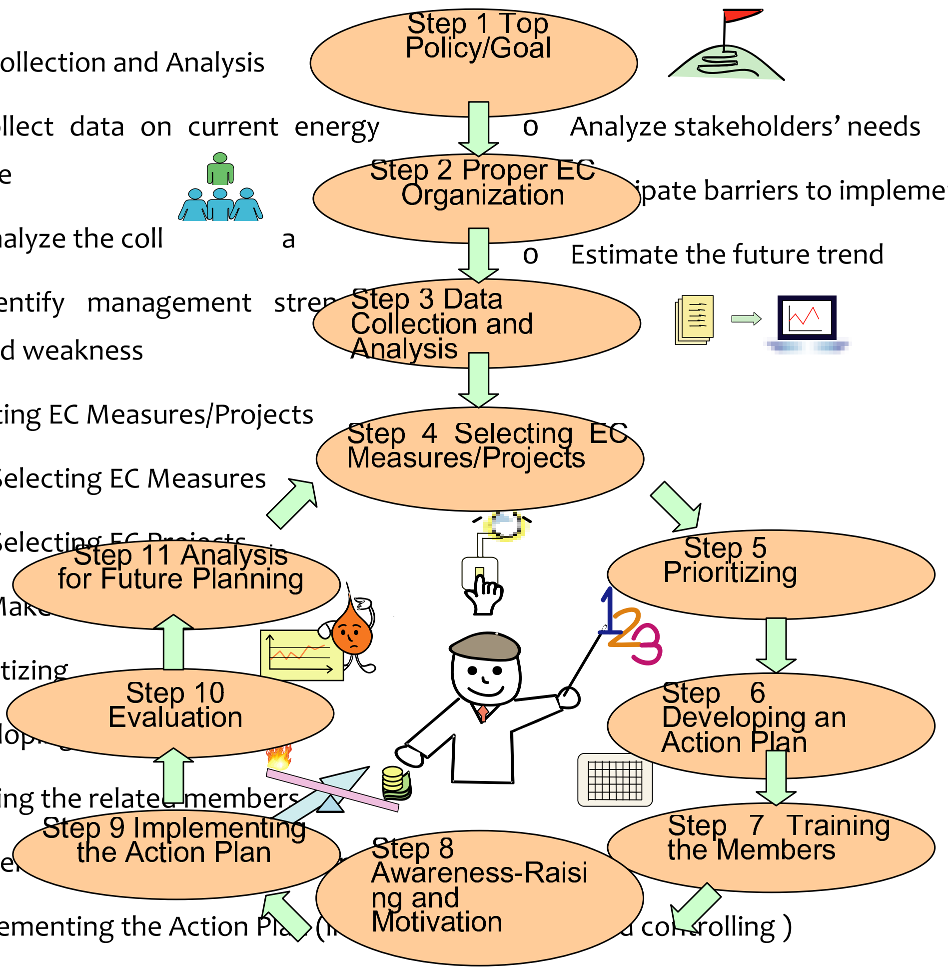
Energy Conservation is closely related also to the environmental issues. The problem of global warming or climate change is caused by emission of carbon dioxide and other Green House Gases (GHG). Energy Conservation, especially saving use of fossil fuels, shall be the first among the various countermeasures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

Steps of the Key Step Approach.



- o Analyze stakeholders' needs
- o ...ipate barriers to implement
- o Estimate the future trend

➥ Data collection and Analysis
- o Collect data on current energy use
- o Analyze the coll... a
- o Identify management stren... and weakness

➥ Selecting EC Measures/Projects
- o Selecting EC Measures
- o Selecting EC Projects
- o 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.

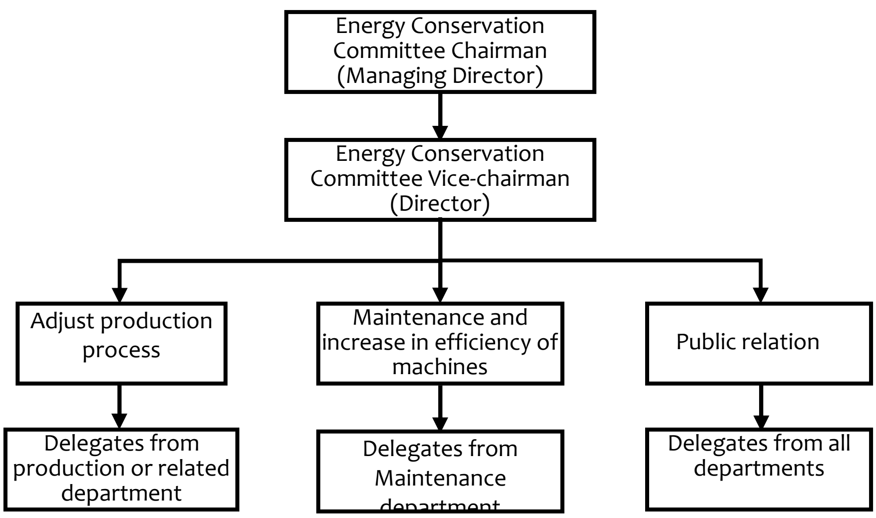


Figure 4.1: Example of energy conservation committee's organization

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.

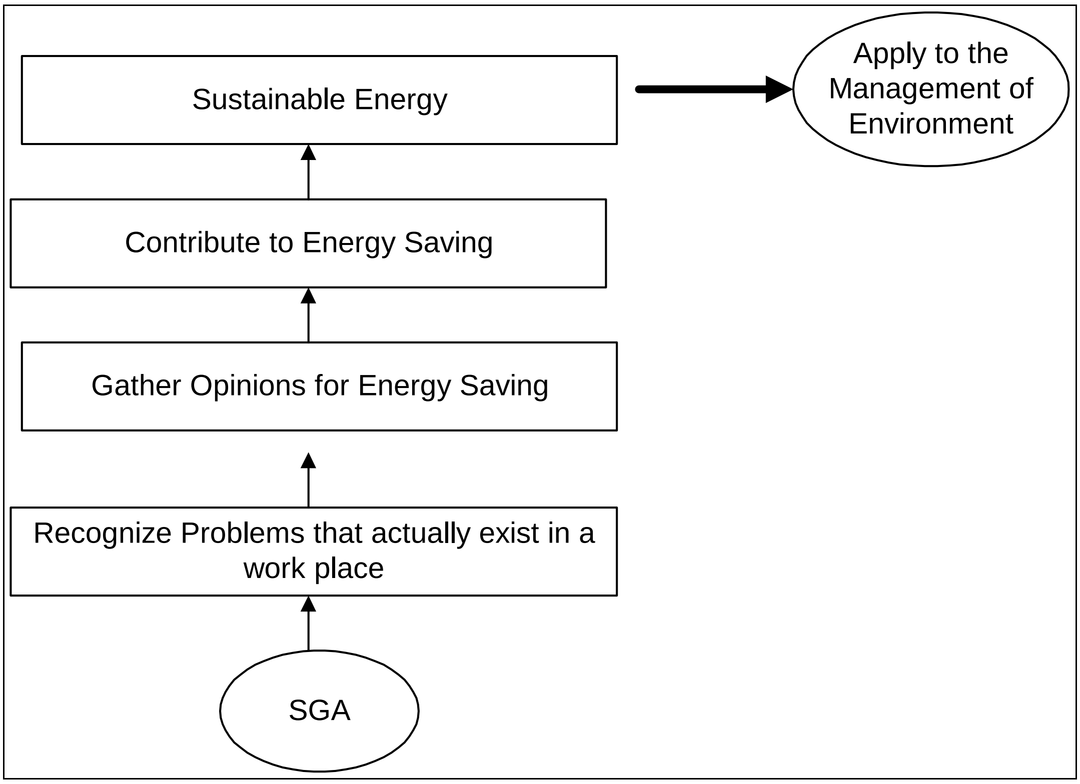


Figure 4.2: Relationship of SGA and energy saving

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.