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MASTER'S DEGREE THESIS

ENERGY MANAGEMENT IN PULP AND PAPER INDUSTRY: A CASE STUDY OF CACHAR PAPER MILL

Khagen Bora

Ljubljana, September, 2008

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Ljubljana, September, 2008 Khagen Bora

Author’s STATEMENT

I, Khagen Bora, hereby certify to be the author of this Master’s thesis that was written under mentorship of Prof. Dr Navenka Hrovatin and in compliance with the Act of Author’s and related Rights- Para.1, Article 21. I here with agree this thesis to be published on the website pages of ICPE and the Faculty of Economics.

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Glossary

APPM	Andhra Pradesh Paper Mills Ltd
BEE	Bureau of Energy Efficiency
BILT	Ballarpur Industries Limited
CE	Chief Executive
CIET	Canadian Institute for Energy Training
CIPEC	Canadian Industry Program for Energy Conservation
Cl_2	Chlorine gas
ClO_2	Chlorine Di-oxide
CO_2	Carbon di-oxide
CPM	Cachar Paper Mill
CPPRI	Central Pulp and Paper Research Institute
DCW	Decur Cum Washer
ECA	Energy Conservation Act
ECO	Energy Conservation Opportunities
EEA	Electricity Engineers' Association
EECA	Energy Efficiency and Conservation Authority
EM	Energy Manager
EMC	Energy Management Committee
EMO	Energy Management Opportunities
EMP	Energy Management Program
ESP	Energy Saving Proposal
ETP	Effluent Treatment Plant
EVO	Energy Valuation Organization
FO	Furnace Oil
FRP	Fibre Reinforced Plastic
GM	Genearl Manager
GSM	Gram per Square Metre
GJ	Giga Joule
HNL	Hindustan News Print Limited
HOD	Head of the Deapartment
HPC	Hindustan Paper Corporation
HVAC	Heating,Ventilating,and Air-conditioning
INR	Indian Rupees
kWh	Kilo Watt Hours
kg	Kilogram
LSHS	Low Sulfur Heavy Stock
MT	Metric Tonnes
m^3	Meter Cube
MTOE	Metric Tone of Oil Equivalent
NaOH	Sodium Hydro-oxide
NPM	Nagaon Paper Mill

NPPC	Nagaland Pulp and Paper Company
O_2	Oxygen
OECD	Organisation for Economic Co-operation and Development
PMV	Performance Measurement and Verification
RCF	Recyclable Fibre
RPM	Revolution Per Minute
SEP	Strategic Energy Planning
TERI	The Energy and Reserch Institute
TNPL	Tamil Nadu Newsprint and Papers Limited
UK	United Kingdom
UNIDO	United Nations industrial Development Organization
URL	Universal Resource Locator
USA,	United States of America
VFD	Variable Frequency Drive
WCPM	West Coast Paper Mill
WPP	Writing Printing Paper
WWW	World Wide Web

1. INTRODUCTION

1.1 Description of the problem

Paper is more than an industrial product. It is the cultural barometer of the nation. We need paper everyday for widening the frontier of our knowledge. Yet the per capita annual consumption of paper at about 4 kg in India is among the lowest in the world today (www.hindpaper.in).

The planned development in paper industry in India began only in post independence period. The growth however slowed down in sixties owing to the escalation of cost and scarcity of forest based raw materials. The stagnation fed to frequent shortage of cultural verities of paper causing hardship to common consumers. There are also the national tasks of developing the industrially backward regions for balanced socio economic growth. It was against this background on May 29, 1970 that the government of India set up Hindustan Paper Corporation Limited (HPC).

HPC group has four paper mills, two are units, and two are subsidiary companies. HPC is the holding company for Hindustan News Print Limited (HNL) and Nagaland Pulp and paper company Limited (NPPC). Nagaon Paper Mill (NPM) and Cachar Paper Mill (CPM) functions directly under HPC's control and their performance is reflected in HPC's operating results. Over a period of three decades, HPC has built up total capacity of about 335,000 tones (t) of paper and newsprint per year (www.hindpaper.in).

Pulp and paper industry is highly energy intensive. As per the schedule of Bureau of Energy Efficiency (BEE), India it ranks among the fifth energy intensive industries. The other energy intensive industries are aluminum, fertilizer, iron, steel, and cement. Indian paper industry consumes 4 million tones of coal and 2 million MWh of purchased electricity. Out of the total energy requirement of the pulp and paper production, 75-78% energy is used as process heat and 15-25% as electrical power. The energy requirement of the Indian paper industry is estimated to increase further in the years to come. There is large variation in energy consumption in Indian mills and mills in developed countries. Steam consumption in Indian mills varies from 6-16 t/t of paper. Electricity consumption variation is from 1200-2200 kWh/t of paper. Mills in developed countries use steam from 6-9 t/t of paper and power 1250-1550 kWh/t of paper. Most of the paper mills of India utilize coal as primary source of energy for generation of steam and electricity. In view of energy scenario the need for energy management and conservation is strongly felt. The study aims at various measures and means which can be applied in pulp and paper industry for energy management.

Energy has an important place in our everyday life. The energy sector activities include extraction, conversion, transportation, and consumption of energy, and disposal of energy wastes.

Energy requirement is a quantitative measure of the total energy required for the manufacture of a product, including the energy used in converting materials, providing heating for the process, transporting, lighting and so on, typically it has units of mega joules per ton of product. Since it is related only to the number of energy units used in the manufacture of a particular mass of product. It can be used to make judgment about the energy efficiency with which a product is made (Barratt, 1996, p. 616).

The word environment depicts a vast area. The protection of the environment is vital for sustainable human development. Relevant factors of environment include food, water, energy, natural resources, toxic substances etc. Energy is one of the most important factors of environment. Energy management is critical to our future economic prosperity and environmental well-being. Energy is essential for the functioning of most of the industrialized world as well as developing and under developed nations. Yet at the same time energy production and consumption causes degradation of the environment of the industrialized world and it seems that developing countries are also facing the similar kind of problem. Energy management is one of the most critical issues for the future as so much of the world is dependent upon it.

Thus, we need to understand the traditional sources of energy, their quality, availability and environmental effects, as well as the potential alternatives for energy and the effects of these upon the natural environment and modern industrial economies. Over the past two hundred years, the use of primary energy sources in manufacturing or processing has evolved from simply using locally available resources, such as waterpower, firewood, or coal. Managing energy is now a basic feature in the global economy and environment.

In the past, man in his quest for better standard and quality of life has allowed all other considerations to take a back seat and this accelerated the process of environmental degradation and began to threaten the earth’s delicate ecological balance. It is also true that we can never allow the process of development to stall if the millions of its inhabitants are to lead a respectable standard of life. It is therefore necessary that the considerations of environment, economy, society, and performance should become the real basis for sustainable development on this planet, if life on our planet is to survive forever.

The increasing stress we put on resources and environmental systems such as water, land and air cannot go on forever. Especially as the world's population continues to increase along with the rise in industrial activities, the environmental impact to our system is continuously on the rise. Unless we start to make real progress toward reconciling these contradictions, we face a future that is less certain and less secure. We need to make a decisive move toward more sustainable development. Not just because it is the right thing to do, but also because it is in our own long-term best interests. It offers the best hope for the future. Unless special measures are taken, the earth is bound to lead to an unmanageable catastrophe.

Of late, energy efficiency technologies and waste management measures in the paper and pulp enterprises have received attention from all concerned - government policy makers, industry associations and enterprises- as possible means of enhancing quality and competitiveness, conserving resources and improving environmental standards.

According to recent estimates, energy savings could be as high as 20-25% in pulp and paper sector through appropriate measures like adoption of energy efficient technologies, training in energy audits, capacity building and information dissemination (UNIDO, 2005).

Energy management is the judicious and effective use of energy to maximize profits, minimize costs, and enhance competitive positions. This rather broad definition covers many operations from product and equipment design to product shipment. Waste minimization and disposal also presents many energy management opportunities. A whole systems viewpoint to energy management is required to ensure that many important activities will be examined and optimized (Capehart, 2003).

The objectives of energy management are as follows (Capehart, 2003):

1. Improving energy efficiency and reducing energy use, thereby reducing costs.
2. Cultivating good communications on energy matters.
3. Developing and maintaining effective monitoring, reporting and management strategies for wise energy usage.

Professional energy management is essential for the economical and efficient use of energy sources because it provides important insights and a secure basis for evaluation and effective optimization – for considerable cost savings and a comprehensive overview (Capehart, 2003).

The detailed examination of industrial systems that leads to the calculation of energy requirement is known as energy analysis. In practical sense, the energy analysis of any process or industrial system is a follow on from an energy audit, in which energy use at each point in the production process is monitored, measured, and recorded. An energy audit means accounting precisely for energy purchases and energy uses, for the various functions and processes carried out in an organization. Such an audit is often carried out in conjunction with an overall energy efficiency program and bearing in mind the fundamental links between energy use and environmental pollution.

Energy auditing of business can lead to significant savings in energy costs. Energy auditing can provide a basic walk-through to identify areas of potential savings. Alternatively, energy audit to provide a detailed analysis that could include a long-term review of energy usage, equipment performance, and business processes. These audits will recommend best tariff option, changes to processes, and payback periods for capital investments that will achieve energy savings.

The process of managing energy should be regarded as a business cost similar to other business costs including raw material and labor. The effort required to manage energy effectively will vary between companies and depends on the company size, and energy intensity (energy costs expressed as a percentage of total company costs) and the current level of efficiency. It is not unreasonable for a company starting out in energy management to achieve a significant reduction in their energy bills by good housekeeping measures alone. This cost saving has a straight positive impact on the profit, yet is very often overlooked by firms who perceive energy management as not central to the business or not “strategic enough” to warrant management attention. However, as costs are rising and margins are being squeezed, introducing strategic energy management into a firm makes clear business sense and clearly should be a priority for the management.

However, managing energy does not necessarily require a formal system; any firm can improve their energy performance by following a few simple techniques. As with any business strategy, strategic energy management incorporates a few fundamentals (Parish, 2008, p. 8-9):

1. get senior management commitment
2. assess current situation
3. set goals and targets
4. establish an action plan
5. allocate resources
6. implement plan
7. review and evaluate.

Energy strategy spans a number of the key functions within a firm and therefore requires cooperation and commitment from all. Senior management provide the leadership and set direction; finance department are involved to ensure that most appropriate purchasing decisions are made; production department as the key user, ensures that energy is used appropriately; engineering department ensures that plant is operated and maintained efficiently and human resource are involved to facilitate training and help generate a culture of energy awareness.

The most successful energy management strategies typically involve the setting up of an energy management team with participants from each of the functions mentioned above. This team would support a dedicated energy manager with responsibility for the coordination of energy management activities. Depending on the size of the business, this may or may not be a full-time, dedicated post. The team in association with senior management would establish an energy management policy, which should include general aims and specific energy cost reduction targets, timetables and budgetary limits, the methods to be employed and the organization of management resources. The energy manager should set up a system to collect, analyze and report on energy consumption and costs.

The next step is to assess how, when and why energy is used in the organization through an energy review or audit. An energy audit establishes energy use patterns, the potential for energy and cost savings, and can include recommendations for actions for improving energy efficiency. The typical energy audit examines the use of the main utilities including electricity, gas, oil, and water. This audit may be carried out internally if sufficient expertise is available in-house, but very often is carried out by independent, expert energy consultants.

Based on the findings and recommendations of the energy audit, a prioritized action plan should be drawn up. Energy and cost savings and the required investment will be listed for all items in the action plan. The projects should be implemented in order of priority as set out in the action plan.

The energy team should report results and progress to management and staff on a regular basis. An energy management plan or strategy will be more effective if its results are reviewed annually and the action plan revised. The review should at least detail actions undertaken during the year and projects and implementation plans for the next 12 months. Adjustments can be made to targets in light of business requirements e.g. a company may decide to make additional products that require a higher energy input.

The business practices employed by firms to gain and sustain competitive advantage are similar to the techniques employed by firms to maximize their energy efficiency. In the current climate of price uncertainty and increasing environmental obligations, the management of resources to provide increased profit margins and additional efficiency can only be of positive benefit to businesses. Therefore, it can be concluded that, in order to have proper and effective utilization of energy and to reduce impact on the environment it is imperative to adopt energy management practices.

HPC mills are under tremendous economic and environmental pressures in the last few years. Being economically competitive in the global market place and meeting increasing environmental standards to reduce air and water pollution have been the major driving factors in the most of the recent operational cost and capital investment decisions of the organization. So in order to meet the critical objectives for short-term survival and long-term success, energy management can be used as a tool in the organization.

The energy consumption pattern for manufacturing pulp and paper in HPC exceeds national and international standard. So thesis aims to study the present energy consumption pattern in each process involved in manufacturing and find out the energy conservation opportunities, which can be implemented, and measures where energy consumption can be reduced.

According to the Energy Conservation Act (2001) India, Bureau of Energy Efficiency (BEE), specify the norms for processes and energy consumption standards for any equipment and appliances, which consume, generate, transmit, or supply energy. The energy intensive industries specified by BEE are required to get energy audit conducted by an accredited energy auditor with regards to quantity of energy consumed or norms and standards of energy consumption.

Accordingly, energy management has been adopted by HPC management and energy audit was carried out in 2006-07 at Cachar Paper Mill by Central Pulp and Paper Research Institute (CPPRI), which is an external accredited auditor of BEE. So based on the audit-report energy conservation opportunities will be found out, and analyzed.

1.1 Purpose of the thesis

Hindustan Paper Corporation is a public sector enterprise of the government of India. HPC is having two paper mills in Assam each having a capacity of 100,000 tone(t) of finished paper per annum and one mill in Kerala (Hindustan Newsprint Limited) also with capacity of 100,000 tone of newsprint annually which are currently operational. Revival of one mill at Nagaland with a capacity of 66,000 tone per annum is going on. These mills use bamboo and wood as the main raw material for paper production. HPC is operating at more than its capacity in the last few years of operation. By nature, paper production industry is a very energy intensive. HPC mills are under tremendous economic and environmental pressures in the last few years to meet the stringent environmental standard to reduce water and air pollution. In order to do so it is essential to use energy management as a tool in the organization.

Therefore, the purpose of the thesis is to study the energy consumption pattern of the various processes involved in paper manufacturing and to find out possible means and ways through which energy management can be improved, which in turn will help in development and competitive edge of the corporation.

1.3 Objectives of the thesis

As the energy management is a comprehensive subject, it is not possible to consider every aspect of it. In order to limit my study the following objectives are considered for the thesis.

1) To study the energy requirement in various processes of paper manufacturing.
2) To compare the energy consumption in various processes of manufacturing with the national and international standards.
3) To find out various means and ways to reduce consumption of energy without affecting the manufacturing process.
4) To reduce the manufacturing cost of the paper by adopting the energy conservation practices.

1.4 Methodology of study

The research methodology of the thesis consists of combination of exploratory and a case study. To begin with, the exploratory research has been carried out to find out what is happening, to seek new insights, to ask questions and asses phenomenon in a new light. It was helpful in deeper understanding of the problem. The energy management is a vast area. Initial focus was broad and narrowed down progressively as thesis progressed.

Accordingly, the first step was in developing a theoretical framework of energy management based on detailed literature survey of the subject with the help of relevant books, journals and various web sites related to the subject.

The second step was analysis of energy consumption of the company and find out energy conservation opportunities, based on the observation and documentary analysis of the energy audit carried out in Cachar paper mill.

Secondary data was used in the thesis. Secondary data were collected from various publications and official records available in the organization. Both qualitative and quantitative analysis has been carried out in the research. The data collected has been analyzed.

1.5 Limitation of the thesis

The purpose of this study is to understand the concepts of energy management and its implementation. The area of energy management is very vast and within the limitations of time and resources, it has not been possible to discuss all the aspects in this study.

Most of the analysis for the study has been carried out from secondary data collected from a number of sources. There have been limitations in obtaining latest and current data for quite a few cases and projections have been used from the past trends to arrive at certain figures.

1.6 Structures of chapters

The thesis has been presented in five chapters with the bibliography at the end. In the first chapter, which is the present one, a brief description of the problem handled in the thesis has been given. The purpose of the thesis, methodology adopted, the limitations, schemes of the various chapters are presented. Chapter two provides overview of energy management, need of energy management. It also provides an overview of setting up and running an effective energy management program. In chapter three, the concepts of energy audit and procedure for carrying out energy audit in a business establishment have been discussed. In chapter four, the trends of the mill and energy analysis have been carried out by use of secondary data. Based on analysis, energy conservation opportunities have been identified and proposed for implementation based on simple pay back calculations. In chapter five, the entire study and findings have been summarized.

2. ENERGY MANAGEMENT

2.1 Concept of energy management

2.1.1 Introduction

The concept of energy management has started in 1970's after the first oil shock in the USA. In the late 80's energy management has become an essential part of economy in USA. The certified energy management program of the association of energy engineers become popular and started a very steep growth curve. About the same time, in1989 the impact of the Natural Gas Policy Act, began to be felt. Now energy managers found they could sometimes save significant amount of money by buying "spot market" natural gas and arranging transportation. In recent days, almost each of the business establishment felt the need of the energy management.

Energy management and climate change represent significant challenges to both environmental protection and sustainable economic growth. These challenges, in turn, offer the public and private sectors exciting new opportunities in areas including energy efficiency and renewable energy technologies. To maximize these opportunities, organizations must be aware of the most recent developments in energy technologies, deregulation, and climate change policy to map out a successful business strategy.

Energy use directly affects the environment through the extraction and consumption of natural resources for fuel and air emissions and climate changes resulting from the combustion of fossil fuels. The environmental degradation resulting from climate change is multi-faceted. One simple way of addressing the complex issues related to climate change is to increase energy efficiency and the use of renewable energy, thereby reducing greenhouse gas emissions.

2.1.2 What is energy management?

Energy management may be defined as the judicious and effective use of energy to maximize profits, minimize costs, and enhance competitive positions (Caphert et al, 2003).

Another comprehensive definition is: “the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems” (BEE,2004).

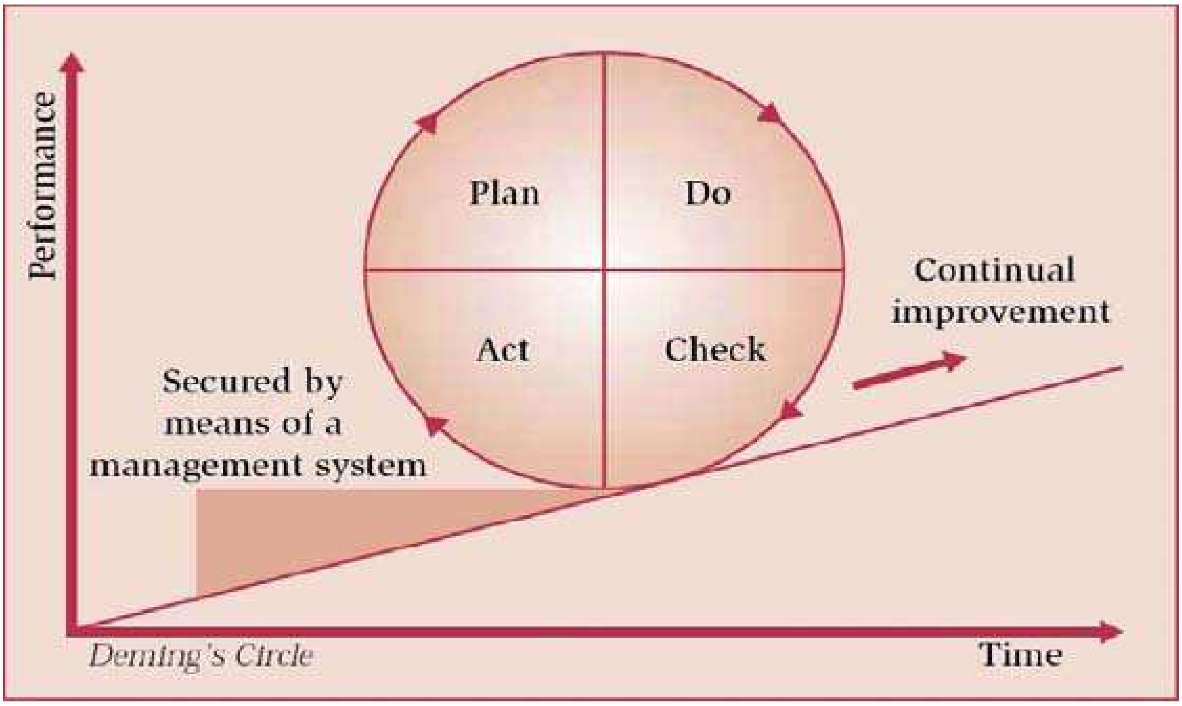
The objective of energy management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

- to minimize energy costs / waste without affecting production & quality
- to minimize environmental effects.

Energy management is effectuating organizational, technical, and behavioral actions in an economically sound manner in order to minimize the consumption of energy, including energy for production, and to minimize the consumption of basic and added materials.

According to Lackner and Holanek (2007, p.9) energy management means structural attention for energy with the objective of continually reducing energy consumption and maintaining the achieved improvements. It ensures that a company or an organization continually passes through the cycle of making policy, planning actions, implementing actions, and checking results, based on which new policy is made. This cycle makes continual improvement possible, as reflected in Deming's Circle.

Figure 2.1: Deming's circle



Source: Lackner and Holanek (2007, p. 46).

The implementation of an energy management system is not an objective in itself. What matters the results of the system: anchoring attention for energy in daily practice is. Whether an energy management system works is dependent on the willingness of the (relevant) organization to manage energy consumption and energy costs. The willingness in their deeds whatever their main reasons are: controlling costs, environmental considerations, legal requirements, social agreements, or image.

Organizations seeing the financial returns from superior energy management continuously strive to improve their energy performance. Their success is based on regularly assessing energy performance and implementing steps to increase energy efficiency. No matter the size or type of organization, the common element of successful energy management iscommitment. Organizations make a commitment to allocate staff and funding to achieve continuous improvement. Changing how energy is managed by implementing an organization-wide energy management program is one of the most successful and cost-effective ways to bring about energy efficiency improvements (McKane et al, 2007, p. 35).

2.1.3 Basic principles of energy management

Energy productivity is an important opportunity for the company. It represents a real chance for creative management to reduce that component of the product cost that has raised most.
To take advantage of these opportunities there should be clear intent of the top executive. Once the commitment is understood, managers at all levels of the organization can and do respond seriously to the opportunities at hand. Without that leadership, the best design energy management programs produce little result.

To expand the effectiveness of the existing energy management programs or provides the starting point of new efforts. The following basic principles may be followed (Turner et al, 2007, p. 5-7):

- The first principle is to control the costs of energy function or service provided but not the Btu of energy. Energy is just a means of providing some service or benefit. Energy is not consumed directly; it is always converted into some useful function. It is useful to break down functions provided so that opportunities for matching the source to the work requirement can be utilized. In addition to energy costs, it is useful to measure the depreciation, maintenance, labor, and operating costs involved in providing the conversion equipment necessary to deliver required services. The total cost of functions that must be managed and controlled, not the Btu of energy.

- A second principle of the energy management is to control energy function as a product cost, not as part of the manufacturing or general overhead. Many companies lump up all energy costs into one general or manufacturing overhead account without identifying those products with the highest energy function cost. In most cases, energy functions must become part of the standard cost system so that each function can be assessed as to its specific impact on the product cost. The minimum theoretical energy expenditure to produce a given product can usually be determined enrooted to establishing a standard energy cost for that product. As in all production cost functions, the minimum standard is often difficult to meet, but it can serve as an indicator of the size of opportunity.

  In comparing actual values with minimum values, four possible approaches can be taken to reduce the variance, usually in this order:

  - an hourly or daily control system can be installed to keep the function cost at the desired level;
  - fuel requirement can be substituted to a cheaper and more available form;

    - a change can be made to the process methodology to reduce the need for the function;
    - new equipment can be installed to reduce the cost of the function.

  The starting point for reducing costs should be in achieving the minimum cost possible with the present equipment and processes. Installing management control systems can indicate what the lowest possible energy use is in a well-controlled situation. It is only at the point when a change in process or equipment configuration should be considered. An equipment change prior to actually minimizing the expenditure under the present systems may lead to increase in capacity of new equipment or replacing equipment for unnecessary functions.

- The third principle is to control and meter only the main energy functions- the roughly 20% that makes up 80% of the costs. As Peter Ducker pointed out, a few functions usually account for a majority of the costs. It is important to focus control on those that represent the meaningful costs and aggregate the remaining item in general category. Many manufacturing plant have only one meter in the main. Sub metering the main functions can provide the information not only to measure but also to control the costs in a short time interval. The concept of metering and sub metering is usually incidental to the potential for realizing significant cost improvements in the main energy functions of a production system.

- The fourth principle is to put the major effort of an energy management program into installing controls and achieving results. Each step in saving energy needs to be monitored frequently enough by the manager or first-line supervisor to see noticeable changes. Logging of important usage or behavioral observations are usually necessary before any particular savings result can be realized. Therefore, it is critical that an energy manager or committee have the authority from the chief executive to install controls, not just advice line management.

2.2 Need of energy management

Business, industry, and government organizations have all been under tremendous economic and environmental pressures. Being economically competitive in the global market place and meeting increasing environment standards to reduce air and water pollution have been the major driving factors in most of the recent operational cost and capital cost investment decisions for all organizations. Energy management has been an important tool to help the organization to meet these critical objectives for the short-term survival and long-term success.

Energy management in the form of implementing new energy efficient technologies, new material and new manufacturing processes and the use of new technologies in equipment and material for business and industry is also helping companies to improve their productivity and increase their product or service quality. Often the energy savings is not the main driving factors when companies decide to purchase new equipment, use new processes, and use new high-tech materials. However, the combination of increased productivity, increased quality, reduced environmental emissions, and reduced energy costs provides a powerful incentive for companies and organizations to implement these new technologies.

Opportunities to improve industrial energy efficiency are found throughout the industrial sector (de Beer et al., 2001; ECCP, 2001; IPCC, 2001). Assessments of cost-effective efficiency improvement opportunities in energy-intensive industries in the US, such as steel, cement, and paper manufacturing, found cost-effective savings of 16% to 18% (Martin et al., 1999, 2000a; Worrell, et al., 2001); even greater savings can often be realized in developing countries where old, inefficient technologies have continued to be used to meet growing material demands (Price et al., 1999; Price et al., 2002; Schumacher and Sathaye,1999; WEC, 2004). An estimate of the 2010 global technical potential for energy efficiency improvement in the steel industry with existing technologies identified savings of 24% in 2010 and 29% in 2020 using advanced technologies such as smelt reduction and near net shape casting (de Beer et al., 2000).

If we consider the growth forecasts for the newly industrialized countries, it becomes clear that we shall increasingly have to focus on reducing consumption of energy. The problem of the finite nature of our energy reserves, the subsequent upward price spiral, and the fight to get a share of dwindling resources represent only one side of the coin. The other side is the risk to our environments caused by the building up of carbon dioxide in earth's atmosphere released through the burning of fossil fuels (Richarz et al, 2007).

According to Turner et al (2007), the problem that organizations face from both their individual and national perspective includes:

- Meeting more stringent environment quality standards, primarily related to reducing global warming and acid rain. The main challenge to the world at present is the climate change and global warming. The primary ingredient, which results in global warming, is green house gases, viz. carbon dioxide, sulphur dioxide. Commercial and industrial energy accounts for substantial amount of carbon dioxide and sulphur-dioxide released from the burning of fossil fuels. Thus, energy management, by reducing the combustion of fossil fuel can dramatically reduce the amount of carbon dioxide in the atmosphere and help reduce global warming. Less energy consumption means less thermal pollution and less cooling water discharge. Reduced cooling requirements or most efficient satisfaction of those needs means less CFC usage and reduced ozone depletion in the stratosphere. The bottom line is that energy management helps in improve environmental quality.

- Becoming or continuing to be economically competitive in the global market place, which requires reducing the cost of production or services, reducing industrial energy intensiveness and meeting customer service needs for quality and delivery time. Significant energy and money savings are possible through energy management.

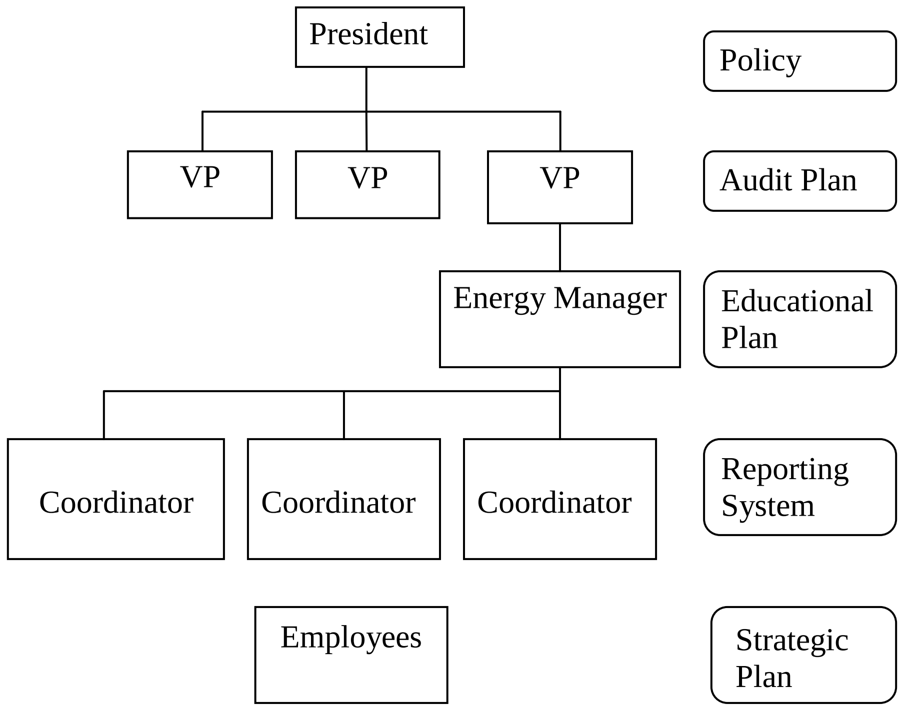
2.3 Components of the energy management program

The most important single ingredient for successful implementation and operation of energy management program is commitment by the top management to the program. Without this commitment, the program will likely fail to meet its objectives. The components of a comprehensive energy management program are discussed below:

2.3.1 Organization structure

Typical generic organization chart for energy management as suggested by Mashuburn (2007, p. 10) is shown below .The organizational chart for energy management must be adopted to fit into an existing structure for each organization depending upon the how large and small. Instead of president, it may be chief executive, and vice-president (VP) block may be general manager, but the fundamental principle is the same. The main feature of the organization chart is the location of the energy manager or energy management coordinator. This position should be high enough in the organizational structure to have access to key players in the management and to have knowledge of current events within the company.

Figure 2.2: Organizational chart for energy management



Source: Mashbarn (2007, p. 10).

2.3.1.1 Energy manager

To develop and maintain vitality for the energy management program, a company must designate a single person who has responsibility for coordinating the program. The energy manager should be strong, dynamic, goal oriented and good manager. Energy manager should be able to develop a working organizational structure, as managing the program by involving everyone at the facility is much more productive and permanent. The Energy manager's key duties often include (Tripp, 1998; Guide lines for energy management, n.d.; Energy manager training, n.d.):

- coordinating and directing the overall energy program
- acting as the point of contact for senior management
- increasing the visibility of energy management within the organization
- assessing the potential value of improved energy management
- creating and leading the Energy Team
- securing sufficient resources to implement strategic energy management
- assuring accountability and commitment from core parts of the organization
- identifying opportunities for improvement and ensuring implementation
- measuring, tracking, evaluating, and communicating results
- obtaining recognition for achievements.

2.3.1.2 Energy team

Energy team is the core of the energy management program. Team should comprise of representatives of various groups such as accounting, purchasing, from facilities, maintenance and from all other departments. As skill of several engineering disciplines may be necessary to accomplish a full-scale study of the plant, it is necessary to have an energy management committee comprising of members having different skill. As per Capehart et al. (2003, p. 15) two sub-committees that are often desirable are the technical and steering sub-committees.

The technical committee is usually composed of several persons with strong technical background in their discipline. Their responsibility is to provide technical assistance to the coordinator or energy manager and plant level people. While the energy manager may be a full time position, the technical committee is likely to operate part time. The steering committee has an entirely different purpose from the technical committee. It helps guide the activities of the energy management program and aid in communications through all organizational levels. The steering committee also helps ensure that all plant personnel are aware of the program. The steering committee members are usually chosen so that all major areas of the company are represented. The members should be selected because of their widespread interests and a sincere desire to aid in solving the energy problems.

Team members should be selected to supplement specialized skills lacking in the energy manager. Therefore, total skills needed for the team, including the energy manager may be defined as follows:

- have enough technical knowledge within the group to either understand the technology used by the organization, or be trainable in that technology
- have knowledge of potential new technology that may be applicable to the program
- have planning skills that will help establish the organizational structure, plan energy surveys, determine educational needs, and develop a strategic energy management plan
- understand the economic evaluation system used by the organization, particularly payback and life cycle cost analysis
- have good communication and motivational skills since energy management involves everyone within the organization.

The strengths of each team member should be evaluated in the light of the above desired skills and their assignments made accordingly.

2.3.1.3 Employees

Employees are the greatest untapped resource in an energy management program. A structured method of soliciting their ideas for more efficient use of energy will prove to be the most productive effort of the energy management program. Too many times employee's involvement is limited to posters that say " Save Energy." Employees in manufacturing plants generally know more about the equipment than any one else in the facility because they operate it. They know how to run more efficiently, but because there is no mechanism in place for them to have an input, their ideas go unsolicited.

2.3.2 Energy policy

As stated by Energy Star energy policy provides the foundation for successful energy management. It formalizes senior management's support and articulates the organization's commitment to energy efficiency for employees, shareholders, the community and other stakeholders.

To undertake effective energy management program in the facility, it is very much essential to have a well-written energy policy, which has been authorized by the management. It provides the energy manager with the authority to be involved in business planning, new facility location and planning, the selection of production equipment, purchase of measuring equipment, energy reporting, and training. To be effective, the energy policy should be short and precise. An energy policy should contain following item as a minimum.

- State an objective - Have a clear, measurable objective that reflects the organization's commitment, culture, and priorities. Objective contain the standard motherhood and flag statements about energy, but the most important is that the organization will incorporate energy efficiency in facilities and new equipment, with emphasis on life cycle cost analysis rather than lowest initial cost.

- Establish accountability - Institute a chain-of-command, define roles in the organization, and provide the authority for personnel to implement the energy management plan. This should establish the organizational structure and the authority for the energy manager, coordinators, and any committees or task groups.

- Ensure continuous improvement - Include provisions for evaluating and updating the policy to reflect changing needs and priorities.

- Promote goals - provide a context for setting performance goals by linking energy goals to overall financial and environmental goals of the organization.

- Reporting- Without authority from the top management, it is often difficult for the energy manager to require others within the organization to comply with reporting requirements, necessary to properly manage energy. The energy policy is the place to establish this. It also provides a legitimate reason for requesting funds for instrumentation to measure energy usage.

- Training-If training requirement are established in the policy, it is easier to include this in the budgets. It should include training at all levels within the organization.

2.3.3 Audit planning

Audit planning should be conducted prior to the actual audits. The planning should include types of audit to be performed, team makeup and dates. By making the audit specific, rather general in nature, much more energy can be saved. Types of the audit that might be considered are tuning-operation-maintenance, compressed air, motor, lighting, steam system, water, controls, HVAC, employee suggestion.

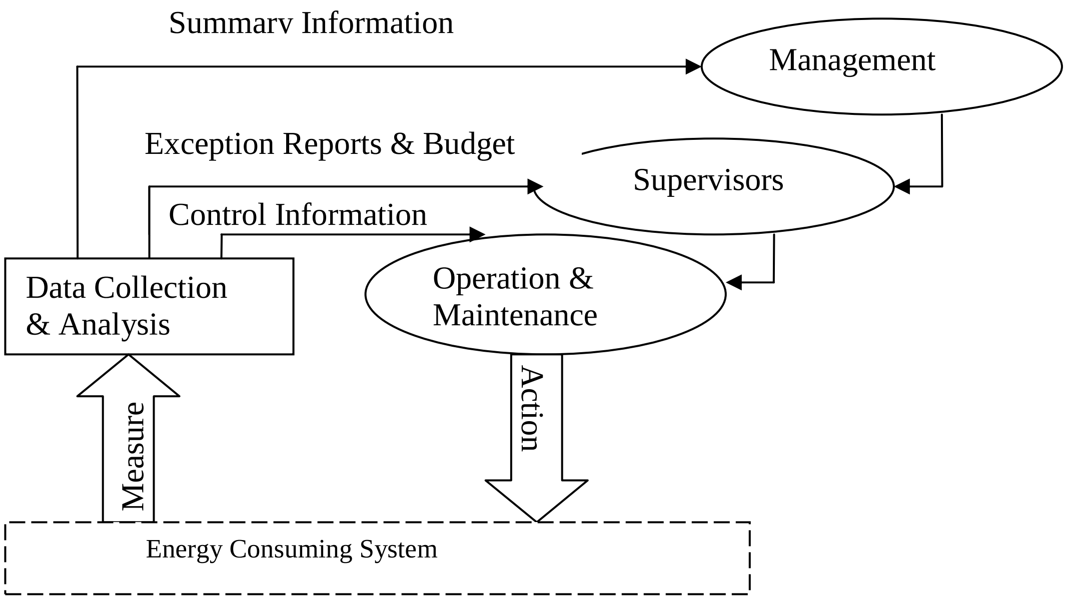
2.3.4 Reporting and monitoring

According to Tripp and Dixon (2003) energy master plan needs to ensure that a reporting mechanism exists to put the right information in the right hands at the right time. The objective of an energy reporting system is to measure energy consumption and compare it either to company goals or to some standard of energy consumption. Ideally, this should be done for each operation or production cost center in plant. Systems that should be metered include power, steam, and compressed air and chilled and hot water.

The reporting scheme needs to be reviewed periodically to ensure that only necessary material being generated, that all needed data are available, and that the system is efficient and effective.

Figure 2.3 below summarizes the information flow cycles for operational through management purposes, and demonstrates the principle that the level of detail of performance information needed by the various stakeholders in the organizations depends on their level and the immediacy of their impact on performance.

Figure 2.3: Energy information flow in an organization



Source: Tripp and Dixon (2003, p. 8).

2.3.5 Educational planning

A major part of the energy manager's job is to provide some energy education to persons with in the organization. The energy management program will operate much more effectively if management understands the complexities of energy, and particularly the potential for economic benefit, the coordinators will be more effective if they are able to prioritize energy conservation measures and aware of latest technology, the quality and quantity of employee suggestions will improve significantly with training. Educational training should be considered for three different group management, the energy team, and employees. It is difficult to gain much of management’s time, so subtle way must be developed to get them. The training can be broken down as shown in the table (See Table 2.1, p. 18).

Table 2.1: Educational planning for energy management

Personnel involved	Types of necessary training	Source of required training
1.Technical committee	1.Sensitivity to energy management 2.Technology development	1.In house with outside help 2. Professional societies, universities, consulting groups, journals.
2.Steering committee	1.Sensitivity to energy management 2.Other industries' experience	1.In house with outside help 2. Trade journals, energy sharing groups, consultants.
3.Plant wide	1.Sensitivity to Energy management 2.What is expected, goals to be obtained etc.	1.In house 1.In house

Source: Guide to energy management (2007, p. 18).

2.3.6 Cost allocation

One of the most difficult problems for the energy manager is to try to reduce energy cost for a facility when the energy costs are accounted for as part of the general overhead. In that case, the individual manager and supervisors do not consider themselves responsible for controlling the energy costs. This is because they do not see any direct benefit from reducing costs that are part of the total company overhead. The best solution of this problem is for top management to allocate energy costs down to "cost centers" in the company or facility. Once energy costs are charged to production centers in the same way that materials and labor are charged, the managers have a direct incentive to control those energy costs because this will improve the overall cost effectiveness of the production center.

2.4 Strategic planning

2.4.1 Strategy

Strategy focuses on how to compete in an industry and how to achieve competitive advantage by formulating plans and initiating decisions. The more accurate the firm can scan the environment and predict the future for opportunities and threats, the better it can formulate its strategies to fulfill their mission and derive above average returns.

Strategic competitiveness is achieved when a firm successfully formulates and implements a value creating strategy. When a firm implements a value creating strategy that current and potential competitors are not simultaneously, implementing and when other companies are unable to duplicate the benefits of its strategy, this firm has achieved sustained competitive advantage. A firm is assured of sustained competitive advantage only after others' efforts to duplicate its strategy have ceased because they have failed.

Chandeler (1962, p. 13) defined that strategy as "the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals".

According to Jauch and Glueck (1988, p. 11), "a strategy is a unified, comprehensive and integrated plan that relates the strategic advantages of the firm to the challenges of the environment. It is designed to ensure that the basic objectives of the enterprise are achieved through proper execution by the organization."

A strategy is the means used to achieve the ends (i.e. objective). A strategy is a plan that is unified, comprehensive, and integrated. It ties all major aspects of the enterprise together and all the parts of the plan are compatible to each other.

Strategic management allows firms to anticipate changing conditions and provides clear objectives and direction for employees. Business involves a great deal of risk taking and strategic management attempts to provide data so that reasonable and informed risks can be made. Effective strategies should encompass at a minimum certain critical factors and structural elements, like (Drucker, 1974):

- Clear, decisive objectives**:** Are all efforts directed toward clearly understood, decisive, and attainable overall goals? Specific goals may change in the heat of competition, but the overriding goals of the strategy must remain clear enough to provide continuity and cohesion for technical choices during the time horizon of the strategy.

- Maintaining the initiative**:** Does the strategy preserve freedom of action and enhance commitment? Does it set the pace and determine the course of events rather than reacting to them?

- Concentration: Does the strategy concentrate superior power at the place and the time likely to be decisive? Has the strategy defined precisely what will make the enterprise superior in power-that is best in critical dimensions-in relation to its competitors?

- Flexibility**:** Has the strategy purposely built in resource buffers and dimensions for flexibility and maneuver? Reserved capabilities, planned maneuverability, and repositioning allow one to use minimum resources while keeping competitors at a relative disadvantage.

- Coordinated and committed leadership**:** Does the strategy provide responsible committed leadership for each of its major goals? Successful strategies require commitment, not just acceptance.

- Surprise: Has the strategy made use of speed, secrecy, and intelligence to attack exposed or unprepared competitors at unexpected times? With surprise and correct timing, success can be achieved out of all proportion to the energy exerted.

As per Porter (1980), the underlying principles of strategy are:

- A good strategy is concerned with the structural evolution of the industry and with the firm's position within the industry
- Leading companies will be those that don't just optimize within an industry, but redefine their industry
- A good strategy makes the company different, giving the company a unique position involving delivery of a particular mix of value to an array of customers. Beyond being different, the firm's got to be different in ways that involve tradeoffs between what its competitors do and this firm does.

2.4.2 Strategic energy planning

As discussed by Bedell and Short (2008), Strategic Energy Planning (SEP) is an integrated comprehensive process, which will result in long-term success for those companies committed to operational sustainability in their facilities. Strategic planning for the energy management program constitutes developing objectives, programs, and action items.

Successful energy management within organizations is usually found to be an integral part of the culture of those organizations and the plan itself may well be included in the organization's overall strategic plan. A written plan of action which is integrated into an agency's business strategy or that is consistent with an agency's mission statement is superior to an undocumented set of related actions taken by an organization.

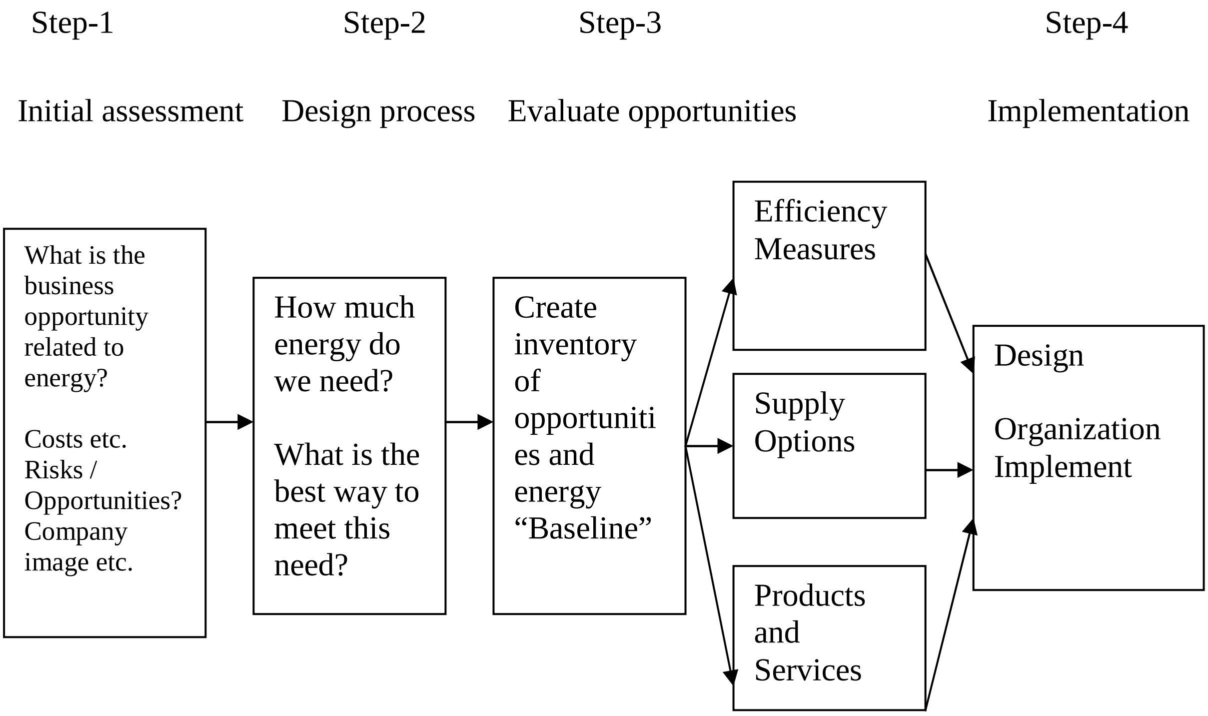
The written plan identifies specific objectives or performance goals, courses of action to be taken, and states how performance will be measured. A written plan that is endorsed by top administrators in an organization has status. The endorsement serves as a directive from top management on goals that it is assigning to the organization. By approving the plan, management has quantified its expectations, established initiatives by which its expectations will be achieved, endorsed the use of resources for achieving those objectives, and has indicated how those efforts will be measured to be deemed successful. The written plan should consist of at least three primary parts:

- specific measurable goals or objectives to be achieved in some delineated time frame;
- a listing of the individual initiatives aimed at achieving those objectives;
- a strategy for measuring the affects of those initiatives, and a plan for how those initiatives will be maintained over time. The maintenance aspect is important since it may not be intuitive to some that additional operational and labor costs above

invested costs may be required to maintain many energy management cost savings initiatives.

Bennett and Whiting (2005) has suggested following a road map developed by the Conference board for energy planning and management for businesses. It is intended to guide companies in identifying energy related business opportunities and developing strategic framework for realizing them. There are four steps in the overall process, which is shown in the figure below.

Figure 2.4: Energy planning and management " Road map"



Source: Bennett and Whiting (2005, p. 3).

The four steps as suggested are as follows:

- Initial assessment: It involves a thorough, organization-wide assessment of the importance of energy to the company in relation to its overall needs, risks, goals, image and reputation, and of potential business opportunities through energy-related products or services.

- Design the process: The design and planning process begins with an assessment of a company's actual energy needs versus "business as usual" practices and an investigation into the most promising solutions for meeting those needs. It is important that process design and planning consider all factors that could inhibit success, from corporate culture to appropriate scale to resources, funding, and organization.

- Evaluate opportunities: This step is the “nuts and bolts” of the energy strategy and management planning process because it is where real opportunities can be realized. It is where the “real work gets done,” but because of its potential size and complexity, especially in larger, diversified and energy intensive businesses, if not well mapped out and systematically approached, significant opportunities maybe missed, or momentum may be lost that will be difficult to regain. Opportunities fall into three categories:

    - energy efficiency reduces the amount of energy used, reducing both cost and environmental impact;
    - energy supply management can help to control costs and assure reliability;
    - energy related products and services could help existing products to be more competitive in the marketplace or create new market.

  Factors influencing the opportunities are dynamic; a strategic approach to energy planning and management must be dynamic and iterative rather than static. Only in this way, will the opportunities be continuously identified and realized.

- Implement: This process step involves determining and setting in place an organizational structure that will ensure that the program is integrated into overall company management culture and that the new energy management goal achieved. Regardless of the framework decided upon, certain management principles and tools must be in place to achieve significant results. These include:

    - Leadership at the very top of the company with a clear commitment to results;
    - Clearly stated goals and measurable objectives at appropriate levels;
    - Clear accountability for results, whether in a single or multiple executives;
    - Sufficient resources to enable achievement of the objectives and goals;
    - Periodic review and updating of goals, objectives and resource commitments;
    - Recognition of progress and reward for achievements.

2.5 Starting energy management program

Several items contribute to the successful start of energy management program. They include:

- visibility of the program startup,
- demonstration of management commitment to the program
- selection of a good initial energy management project.

2.5.1 Startup

To be successful, an energy management program must have the backing of the people involved. To obtain this support is not an easy task, so careful planning is necessary. The people must:

- understand why the program exists and what its goals are;
- see how the program will effect their job and income;
- know that the program has full management support; and
- know what is expected from them.

Therefore, management and energy manager must communicate this information to the employees. The company must take advantage of all existing communications channels to reach the employees taking into consideration the above points.

2.5.2 Demonstration of management commitment

To be a successful, commitment of management to the energy management program is very much essential, and this commitment must be obvious to all employees if the program is to reach its full potential. Management participation in the program start-up demonstrates this commitment, but it should also be emphasized in other ways. Management may demonstrate this by following ways:

- Reward participating individual: The management should formulate a reward mechanism to encourage people at all levels. When the employee has made a suggestion that led to large energy savings, his activities should be recognized through monetary reward, publicity or by both. Public recognition can be given in the company news letter, or bulletin boards, or in plant departmental meetings
- Management should reinforce its commitment periodically to the employees by demonstrating current results of the program and the plans for the future. It should report on outstanding suggestions from the employees
- If an energy management project is cost effective then management should fund it. The energy management projects should be treated as the same priority like other capital budget projects.

2.5.3 Early project selection

The energy management program is a treacherous footing in the beginning. The initial energy management project should be selected in such a way that, the project has a rapid pay back, a high probability of success, and few negative consequences.

To have a greater degree of success of the program, the energy management team may select projects initially like improving lighting system, repairing of steam leaks, and insulation of hot surfaces, whose results are quite visible. If the energy management project fails at the first instance it, create negative impression of the employees towards the program.

2.6 Setting up and running an effective energy management program

According to Parish (2007) energy should be viewed as any other valuable raw material, resource required to run a business – not as mere overhead and part of business maintenance. Energy has costs and environmental impacts. They need to be managed well in order to increase the business' profitability and competitiveness and to mitigate the seriousness of these impacts. All organizations can save energy by applying the same sound management principles and techniques they use elsewhere in the business for key resources such as raw materials and labor. These management practices must include full managerial accountability for energy use. The management of energy consumption and costs eliminates waste and brings in ongoing, cumulative savings.

2.6.1 Strategy considerations

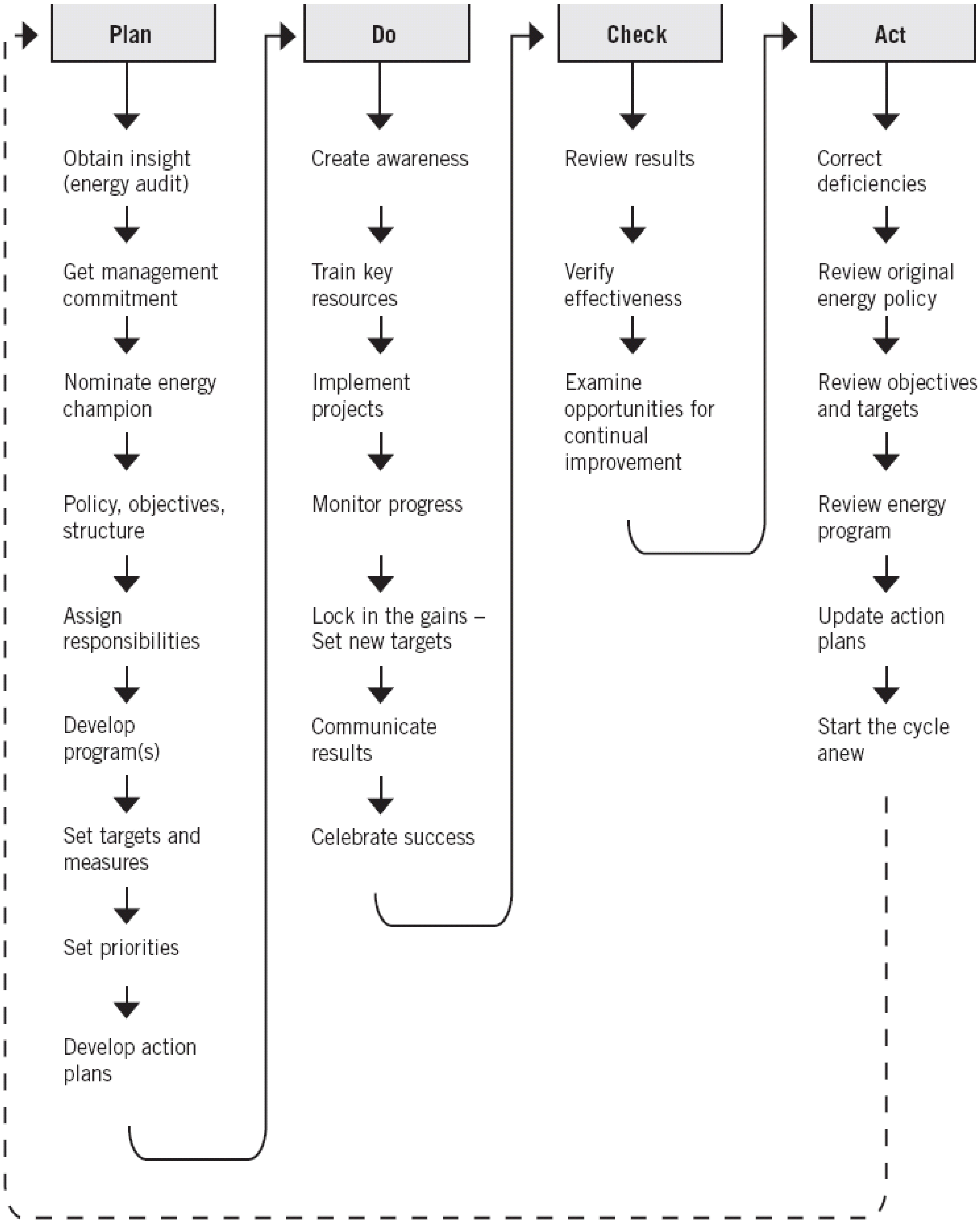
In essence, the strategic goal of most corporations is to gain a competitive advantage by seizing external and internal opportunities to improve the profitability of their operations, products and sales and their marketplace position. Developing a successful corporate strategy requires taking into account all of the influences on the organization's operation and integrating the various management functions into an efficiently working whole. Energy management should be one of these functions.

In the process, an organization may wish to first conduct a review of its strengths, weaknesses, opportunities and threats (SWOT analysis) that would also include various legal and environmental considerations (such as emissions, effluent, etc.). Inevitably, this analysis would identify future threats to profitability, and ways to reduce costs should be sought. Energy efficiency improvement programs should, therefore, become an integral part of the corporate strategy to counter such threats. They will help to improve profit margins through energy savings. Applying good energy management practices is just as important to achieving these savings as the appropriate process technology. They would become a part of the organization's overall environmental management system. This would ensure that energy issues would be raised at the corporate level and receive proper attention. The integration of energy into the overall management system should involve evaluation of energy implications in every management decision in the same way as economic, operational, quality and other aspects are considered.

2.6.2 Defining the program

Setting up an effective energy management program follows proven principles of establishing any management system. These principles fit any size and type of organization. As defined by Deming, the process should have four steps: These steps, broken down, require several essential activities are shown in the Figure 2.5 below.

Figure 2.5: Energy management plan at a glance



Source: CIPEC (2002, p. 12).

2.6.3 Energy management program – how to implement it

CIPEC (2002) has adopted a sequential procedure for implementing energy management program as follows:

- Obtain insight: The first step in implementing an energy management program is the energy audit. It consists of documentary research, surveys (including interviews and observations) and analysis to determine where and how energy is used. The energy audit is the cornerstone of the energy management program. The energy audit is necessary in order to identify opportunities for energy management and savings. It establishes "ground zero’’ the base from which the progress and success of energy management can be measured.

- Get management commitment: Energy management must be a matter of concern to everybody in the company before it cans succeed. Without strong, sustained, and visible support of the company’s top management, the energy management program is doomed to failure. Employees will apply their best efforts to the program only when they see that their supervisors are fully committed. Hence, it is crucial that top management rally to the cause and provide full support and enthusiastic participation.

- Nominate an energy champion: A senior manager in the role of energy management champion should head the energy management structure. The person will give the program enough clout and stature to indicate to the entire workforce that energy management is a commitment that everyone must take seriously. The champion should demonstrate a high level of enthusiasm and deep conviction about the benefits of the energy efficiency program.

- Set energy policy, objectives, and structure: The launch of the energy management program should start with a strong policy statement from the chief executive to the employees, followed up immediately by a presentation that explains the benefits of efficient energy use. The energy policy should be developed in step with the company’s strategic goals and in agreement with other policies (quality, production, environment, etc.) and the company’s vision and mission statements.

- Assign responsibilities: The champion chairs the Energy Management Committee (EMC) and takes overall personal responsibility for the implementation and success of the program and accountability for its effectiveness. Specific responsibilities and accountabilities for the energy management program may be assigned to area managers.

- Develop program(s) for energy efficiency management: A successful approach to developing an energy efficiency improvement program would include the following items:

    - a long-term savings plan;
    - a medium-term plan for the entire facility;
    - a first-year detailed project plan; and
    - action to improve energy management, including the implementation of an energy monitoring system.

The energy management champion should share with the EMC members all the available information about energy use and challenge them to explore ways to conserve energy in their respective areas or departments.

- Set targets and measures: Targets should be measurable and verifiable. To ensure that they are realistic, apply standards that indicate how much energy should be used for a particular application. Measure current performance against industry standards or calculated practical and theoretical energy requirements.

- Set priorities: Start with small, easily and quickly achievable targets. That will be a great source of motivation to employees – seeing that it can be done and that progress is being made will lead them to feel that they are successful. As well, EMC members will gain experience and confidence before tackling more complex or longer-horizon targets.

- Develop action plans: Be specific – an action plan is a project management and control tool. It should contain identification of personnel and their responsibilities, the specific tasks, their area and timing. It should also indicate specified resource requirements (money, people, training, etc.) and timelines for individual projects and their stages. Several project management software packages are in the market to facilitate the creation of Gantt charts, which are used to monitor and control project fulfillment, costs, and other data.

- Create awareness: Energy management stars with building awareness through meetings, newsletters and posters, employee learn what kinds of energy come into there facility, how much they use and what it costs. " Awareness is first, you cannot look ways to improve if you do not understand the energy you are already using. In addition, it does not make sense to spend on capital improvements if you are not efficiently operating the equipment you already have" (Schultz and Bridger, 2004). The entire work force should be involved in the energy improvement efforts. Therefore, every one should be aware of the importance of reducing energy consumption in bringing about savings, as well as of the broader environmental benefits of energy efficiency improvements -how the reductions in energy use translate into a decrease of CO2 emissions. Creating awareness about the importance of saving energy will help substantially in the implementation of virtually any cost energy-saving measures through better housekeeping.

- Train key resources: Members of the EMC, line managers and others who will be involved in the energy management program - and have a greater influence upon energy consumption than others – should receive appropriate training.

- Implement projects: The implementation of energy-saving projects should involve a coordinated, coherent set of projects linked together for the energy efficiency improvement program to be most effective. If several energy projects are contemplated, the interactions between them must also be considered.

Follow up on activities of individuals charged with specific responsibilities and be mindful of the implementation schedule. The energy management champion should meet with the committee regularly to review progress, update project lists, evaluate established goals, and set new goals as required. To sustain interest, the EMC should run a program of activities and communications, and the champion should make periodic progress reports to management, reviewing the program and re-establishing support for it with each report.

- Monitor progress: By continuously monitoring the energy streams entering the facility and their usage, the EMC can gather much information that will help it assess progress of its program and plan future projects. Energy-use monitoring produces data for activities such as the following:

    - determining whether progress is being made;
    - managing energy use on a day-to-day basis to make prompt corrections of process conditions that have caused sudden excessive consumption;
    - determining trends in energy usage and using that information in the budgeting process;
    - calculating the return on investment (i.e. the cost savings achieved from data gathered by the energy monitoring system);
    - providing positive reinforcement that helps employees to willingly adopt the new energy-saving practices;
    - comparing the results of an implemented energy-saving measure to the projections in order to identify problems with the project's performance and improve techniques for estimating costs and benefits of energy efficiency improvements for future projects;
    - tracking the performance of projects in which suppliers made performance guarantees;
    - reporting energy improvements accurately to senior management, thus ensuring management commitment;
    - setting future energy use reduction targets and monitoring progress toward new goals; and
    - selecting areas of the facility for a future detailed energy audit.

In a large facility with many different functions, energy monitoring is done with metering equipment installed at strategic points to measure the flow of energy sources such as steam, compressed air, or electricity – to each major user. Energy performance is then gauged by calculating the amount of energy consumed per unit of production. Calculating energy performance helps managers identify wasteful areas of their facility and lets managers take responsibility for energy use in their areas.

When monitoring shows that energy consumption is declining as improvements are being made, attention can be turned to the next area of concern.

- Lock in the gains – set new targets: Without vigilant attention to energy management, the gains could fade away and the effort could disintegrate. To make the new energy-saving measures stick, pay sustained attention to the implemented project until the measure has become a well-entrenched routine.

  Energy management is an issue of technology as well as people. If practices and procedures have been changed as the result of the project, take the time and effort to document it in a procedure or work instruction. That will ensure the future consistency of the practice, as well as serve as a training and audit tool.

  Once a target has been met on a sustained basis over a period of several weeks, it is time to review it. It can become the new standard, and a new, progressive target can be set. Target setting helps to involve the entire workforce in energy projects by giving them goals to achieve. By setting targets in a step-wise, improving fashion, managers will learn to treat energy as a resource that must be managed with attention equal to that for other process inputs, such as labor and raw materials.

- Communicate the results: This extremely important step needs to be well executed in order to foster the sense that everybody is a part of the energy management effort. Regular reports taken from the monitored data encourage staff by showing them that they are progressing toward their goals. The emphasis should be on simplified graphical, visual representation of the results – use charts, diagrams or “thermometers” of fulfillment posted prominently on bulletin boards where people can see them.

- Celebrate the success: This is often an overlooked yet very important segment of a program. People crave and value recognition. A myriad of ways can be employed to recognize the achievement and highlight the contribution of teams (rather than the contribution of individuals, which can be divisive!). Celebrating success is a motivational tool that also brings psychological closure to a project. The achievement of a target should be celebrated as a milestone on the way to continual improvement of energy efficiency in the plant.

- Review results: Energy management updates should be a permanent agenda item of regular operations management review meetings, just as quality, production, financial and environmental matters are. Results of the implemented project are reviewed, adjustments are made, conflicts are resolved, and financial considerations are taken into account.

- Verify effectiveness: Has the project lived up to the expectations? Is the implemented energy efficiency improvement effective? Is it being maintained? To support the credibility of the energy management effort, the effectiveness of measures taken must be verified, so adjustments could be made and the future project managed better.

- Examine opportunities for continual improvements: Often one project opens the door to another idea. The energy efficiency improvement program is an ongoing effort. The EMC and all employees should be encouraged to examine and re-examine other opportunities for further gains as a matter of course. That is the essence of continual improvement, which should be promoted in the interest of any organization.

- Correct deficiencies: Information gained from monitoring data, from the input from EMC and others, from the review of results and from the verification of the project's effectiveness may indicate that a corrective action is required. The energy management champion is responsible for arranging this action with the EMC team and the personnel from the respective area. The root cause of the deficiency will be determined, and the required corrective action will be initiated. Remember to document it, as necessary. Future energy efficiency projects will benefit from the lessons learned.

- Review original energy policy, objectives and targets, energy efficiency improvement program and action plans: These steps ensure the continued relevancy and currency of the energy policy. Objectives and targets support the policy. As they change in time, they must be reviewed to ensure that priorities are maintained in view of present conditions. This review should take place annually or half yearly.

The energy efficiency improvement program and action plans are "living" documents. Frequent updating and revisions are necessary as old projects are implemented and new ones initiated and as business, conditions change.

2.7 Energy management standards

The purpose of an energy management standard is to provide guidance for industrial facilities to integrate energy efficiency into their management practices, including fine-tuning production processes and improving the energy efficiency of industrial systems.

An energy management standard requires a facility to develop an energy management plan. In companies without a plan in place, opportunities for improvement may be known but may not be promoted or implemented because of organizational barriers. As stated by McKane et al (2007, pp. 38-39) features of an energy management standard include:

- a strategic plan that requires measurement, management, and documentation for continuous improvement for energy efficiency;

- a cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
- policies and procedures to address all aspects of energy purchase, use, and disposal;
- projects to demonstrate continuous improvement in energy efficiency;
- creation of an energy manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
- identification of key performance indicators, unique to the company, that are tracked to measure progress; and
- periodic reporting of progress to management based on these measurements.

3. ENERGY AUDIT

3.1 Concept of energy audit

Energy audits may be considered as the first step towards understanding how energy is being used in a given facility. Energy audit is usually one of the first steps in an energy management program. It shows how efficiently energy is being used and highlights opportunities for energy cost savings. It can also show ways to improve productivity. Energy audits take a thorough look at particular facilities, processes, or technologies.

Energy audit means accounting precisely for energy purchases and energy uses, for the various functions and processes carried out in an organization. Such an audit is carried out in conjunction with an overall energy efficiency program and bearing in mind the fundamental links between energy use and environmental pollution.

An initial energy audit need not be very sophisticated or accurate. The aim should be to obtain an overall picture of energy use and to be able to draw up an approximate energy balance for the organization. If appropriate, further desegregation of energy use can proceed once the initial audit has been carried out, leading to a full-scale energy analysis. An energy audit is particularly concerned with the question “can energy be used more efficiently to prevent waste?” It then proceeds to identify where improvements can be made and what those improvements are (Barratt, 1996, p. 617).

The energy audit is one of the first tasks to be performed in the accomplishment of an effective energy cost control program. An energy audit consists of a detailed examination of how a facility uses energy, what the facility pays for that energy and finally recommended program for changes in operating practices or energy-consuming equipment that will cost-effectively save on energy bills. The energy audit is sometimes called an energy survey or an energy analysis (Capehart et al, 2007, p. 23).

Energy audits and the ensuing cost and energy saving opportunities identified in audits are best implemented in the context of an energy management program that operates, and is formally recognized, as an integral part of the ongoing management activities of the entity for which it applies. For this reason, one important function of an energy audit is to evaluate the energy management program and suggest ways in which it could be improved.

As per EECA (2007) energy audit should provide much of the essential information to progress an energy management program and action. It should summaries key energy use and cost indices, provide a breakdown of where energy is used, and give a table of recommended actions. An energy audit will also assist with preparing an action plan.

The energy audit aspects of the energy management process include determining the level of detail (high, mid-range and detailed) that an energy auditor will appraise when an audit is carried out, as well as the extent of any recommendations arising from the audit process. Table shows the outcomes of each level of detail of energy audits (Levels 1, 2 and 3 identified in the Energy Audit Standard, EEA, New Zealand) and the differences that distinguish between these levels.

Table 3.1: Characteristics of energy audits in ongoing energy management

Audit Level	**Description**
High- Level 1	A high level audit allows the overall energy consumption of the site to be evaluated, to determine whether energy use is reasonable or excessive. The information gathered by the energy auditor needs to be sufficient to enable site energy use to be compared with recognized benchmarks. Accuracy of costs and potential savings would generally be within ±40%.
Mid-Range-Level 2	A moderate level audit includes the analysis of energy inputs involved in a high-level audit, and investigates what the energy is used for. It also identifies specific areas where savings may be made, recommends measures to be taken, and provides a statement of costs and potential savings. Accuracy of costs and savings would generally be within ±20%.
Detailed-Level 3	A detailed audit provides a more detailed analysis than a mid-range level audit. It may cover a whole site or may concentrate on an individual item. The energy auditor may employ a specialist to carry out specific parts of the audit and may need to install data logging equipment. Accuracy of costs and savings would generally be within ±10%.

Source: Energy-audit manual, EECA, 2007.

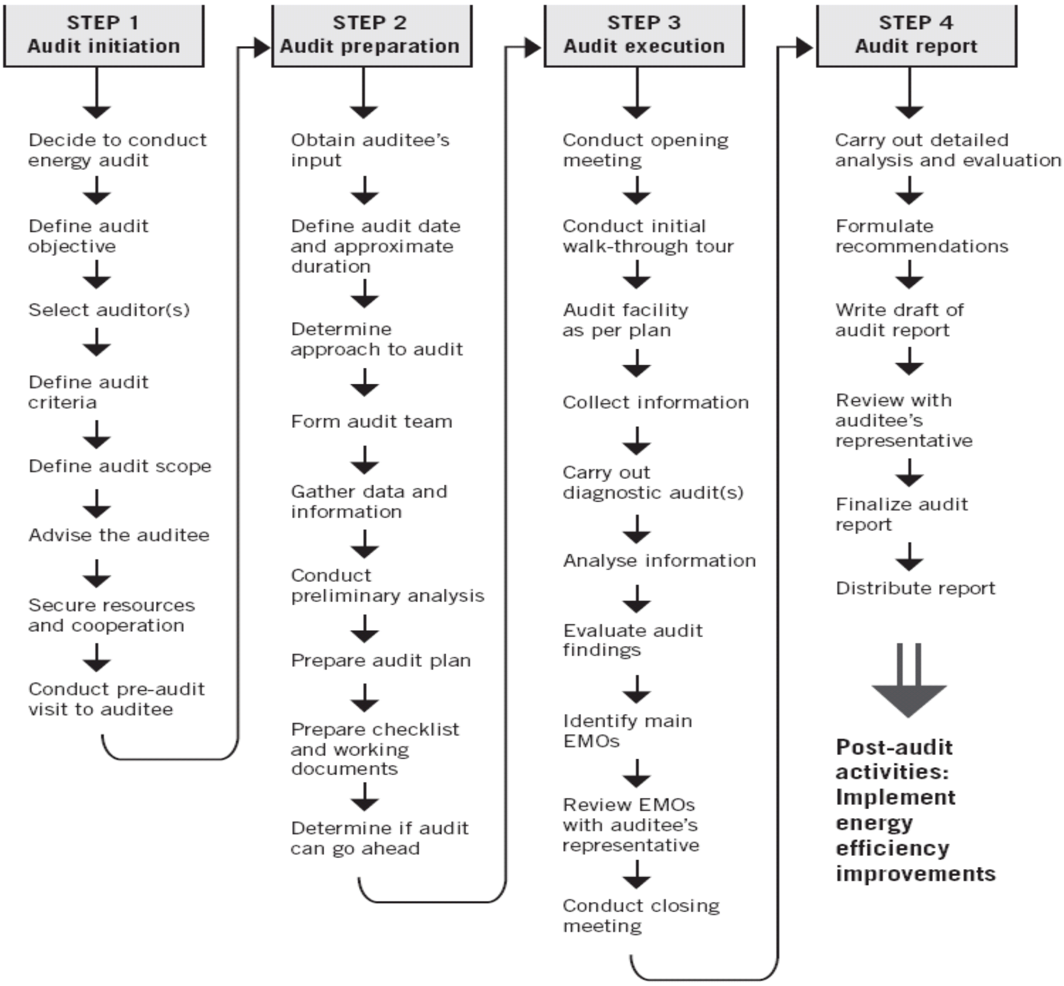
In general, in energy audit, the focus, and the techniques used are intended to get the picture of energy balance in a facility the inputs, uses, and losses. More focused and detailed audits (diagnostic audits) may be carried out to verify the conclusions of general audit or to get a detailed analysis of energy use and losses in a specific process or facility.

As suggested by CIPEC (2002) general energy audit comprise of four main stages:

- initiating the audit,
- preparing the audit,
- executing the audit,
- reporting the audit results.

These four steps have several sub-steps with associated activities and are shown in a graphical representation on Figure 3.1. The steps shown on the diagram apply to a formal energy audit in a large, complex facility.

Figure 3.1: Steps of energy auditing



Source: CIPEC, (2002, p. 25).

Once a commercial or industrial facility has designated its energy manager and given that person the support and authority necessary to develop adequate energy management program, the first step of the energy management program is to conduct an energy audit. The energy audit examines the ways the energy is currently used in that facility and identifies some alternatives for reducing energy costs. The goals of the audit are (Capehart et al, 2003):

- to clearly identify the types and costs of energy use,

- to understand how that energy being used-and possibly wasted,
- to identify and analyze alternatives such as improved operational technique and or new equipment that could substantially reduce energy costs, and
- to perform an economic analysis on those alternatives and determine which ones is cost- effective for the business or industry involved.

3.2 Energy audit: types and methodology

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management program.

As per the Energy Conservation Act, 2001, India, energy audit is defined as “the verification, monitoring, and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption”.

3.2.1 Need for energy audit

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labor and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. Energy audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The energy audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programs which are vital for production and utility activities. Such an audit program will help to keep focus on variations, which occur in the energy costs, availability, and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc. In general, Energy audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified period. The primary objective of energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy audit provides a “bench-mark” for managing energy in the organization and provides the basis for planning a more effective use of energy throughout the organization.

3.2.2 Type of energy audit

The type of energy audit to be performed depends on:

- function and type of industry,
- depth to which final audit is needed, and
- potential and magnitude of cost reduction desired.

Thus, energy audit can be classified into the following two types:

- preliminary audit,
- detailed audit.

3.2.3 Preliminary energy audit methodology

Preliminary energy audit is a relatively quick exercise to:

- establish energy consumption in the organization
- estimate the scope for saving
- identify the most likely (and the easiest areas for attention
- identify immediate (especially no-/low-cost) improvements/ savings
- set a ‘reference point’
- identify areas for more detailed study/measurement
- preliminary energy audit uses existing, or easily obtained data.

3.2.4 Detailed energy audit methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.

In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges. Detailed energy auditing is carried out in three phases:

- phase I - pre audit phase
- phase II - audit phase
- phase III - post audit phase.

A guide for conducting energy audit at a glance: Industry-to-industry, the methodology of energy audits needs to be flexible. A comprehensive ten-step methodology for conduct of energy audit as adopted by BEE at field level is presented in Table 3.2.

Table 3.2: Methodology for detailed energy audit

Step no	**Plan of action**	**Purpose/results**
	Phase -1 Pre audit phase	
Step-1	• Plan and organize • Walk through audit • Informal interview with energy manager, production manager, plant manager etc.	• Resource planning, establish and organize an energy audit team • Organize instruments and time frame • Macro data collection (suitable to type of industry) • Familiarization of process/plant activities • First hand observation and assessment of current level operation and practices
Step-2	• Conduct of brief meeting /awareness program with all divisional heads and persons concerned.	• Building up cooperation • Issue questionnaire for each department • Orientation and awareness creation
	Phase-II-Audit phase	
Step-3	• Primary data gathering, process flow diagram, and energy utility diagram	• Historic data analysis, Baseline data collection • Preparation of process flow charts • All service utilities system diagram. Example: Single line power distribution diagram, water, compressed air, and steam distribution. • Design, operating data and schedule of operation • Annual energy bill and energy consumption pattern from manual, logbook, nameplate, interview etc.

To be continued …….

Continued from previous page

Table 3.2: Methodology for detailed energy audit

Step no	Plan of action	Purpose/results
Step-4	• Conduct survey and monitoring	• Measurements: • Motor survey, insulation, and lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.
Step-5	• Conduct of detailed trials/experiments for selected energy guzzlers	• Trial/experiments: • 24 hours power monitoring (PF, kWh etc.) • Load variations trends in pumps, fan, compressors etc. • Boiler/efficiency trial for (4-8 hours) • Furnace efficiency trials • Equipments performance • experiments etc
Step-6	• Analysis of energy use	• Energy and material balance
Step-7	• Identification and development of energy conservation opportunities	• Identification and consolidation energy conservation measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by the unit personal • Review the previous ideas suggested by the energy audit if any • Use brain storming and value analysis techniques • Contact vendors for new/efficient technology

To be continued…..

Continued from previous page

Table 3.2: Methodology for detailed energy audit

Step no	**Plan of action**	**Purpose/results**
Step-8	• Cost benefit analysis	• Assess technical feasibility, economic viability • Select the most promising projects • Priorities by low, medium, long term measures
Step-9	• Reporting and presentation to the top management	• Documentation, report presentation to the top management
	Phase-III- Post audit phase	
Step-10	• Implementation and follow-up	Assist and implementation energy conservation recommendation measures and monitor the performance • Action plan, schedule for implementation • Follow-up and periodic review

Source: BEE (2004, p. 60-61).

Phase I –Pre audit phase activities**:** A structured methodology to carry out an energy audit is necessary for efficient working. A familiarization visit to the facility before proceeding with other audit preparations serves several purposes: personal contacts and lines of communication are established; a clearer picture of the facility and the scope emerges; issues may be clarified; resources may be identified and secured; and adjustments to the planned audit scope, date and duration may be made.

The main activities, which can be carried out in this visit, are to (BEE, 2004; CIPEC, 2002):

- finalize energy audit team,

- identify the main energy consuming areas/plant items to be surveyed during the audit,
- identify any existing instrumentation/ additional metering required,
- decide whether any meters will have to be installed prior to the audit,
- identify the instrumentation required for carrying out the audit,
- plan with time frame,
- collect macro data on plant energy resources, major energy consuming centers,
- create awareness through meetings/ program.

Phase II- Detailed energy audit activities: Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. In detailed audit detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried out.

The audit report will include a description of energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected payback on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes (BEE, 2004; Capehart et al, 2003):

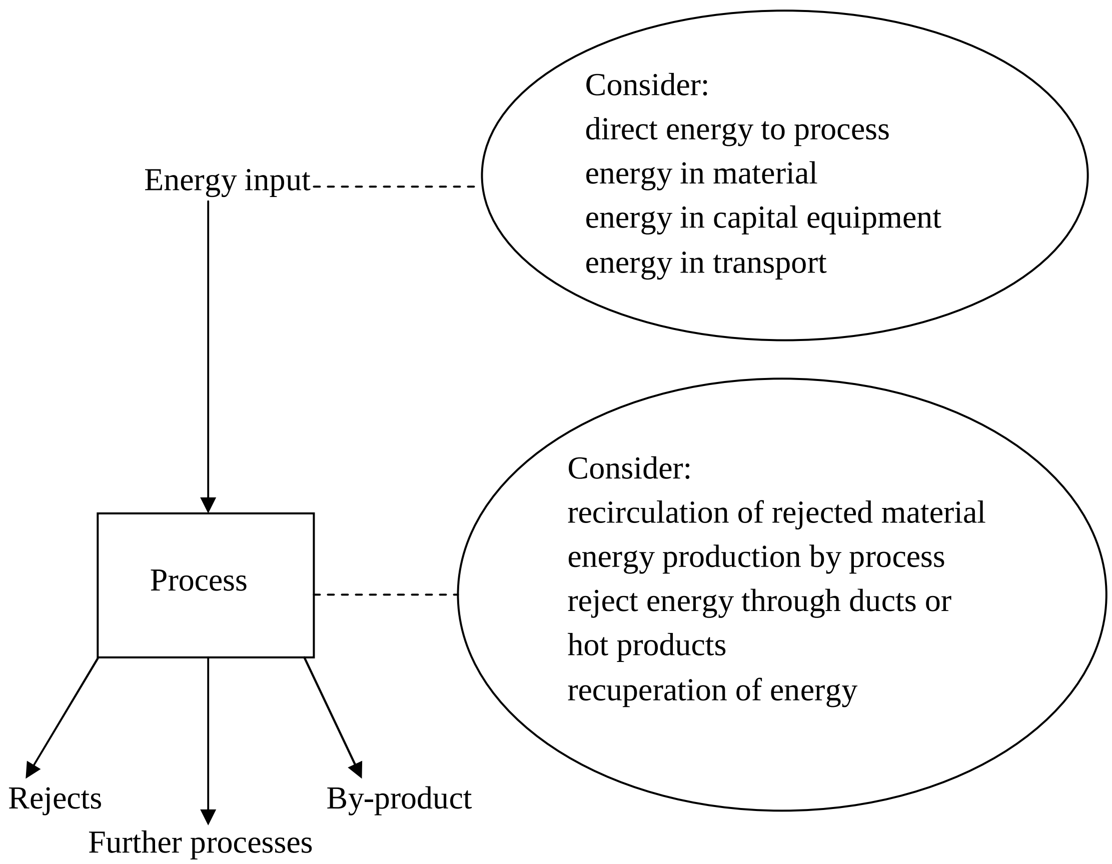
1. energy consumption by type of energy, by department, by major items of process equipment, by end-use;
2. material balance data (raw materials, intermediate and final products, recycled material, use of scrap or waste products, production of by-products for re-use in other industries, etc.);
3. energy cost and tariff data;
4. process and material flow diagrams;
5. generation and distribution of site services (e.g. compressed air, steam);
6. sources of energy supply (e.g. electricity from the grid or self-generation);
7. potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation);
8. energy management procedures and energy awareness training programs within the establishments.

Existing baseline information and reports are useful to get consumption pattern, production cost and productivity levels in terms of product per raw material inputs. The audit team should collect the following baseline data:

- technology, processes used and equipment details;
- capacity utilization;
- amount & type of input materials used;
- water consumption;
- fuel consumption;
- Steam consumption;
- electricity consumption;
- other inputs such as compressed air, cooling water etc.

While analyzing a process identification of waste streams and obvious energy wastage are to be found out. An overview of unit operations, important process steps, areas of material and energy use and sources of waste generation should be gathered and should be represented in a flowchart. Existing drawings, records, and shop floor walk through will help in making this flow chart. Simultaneously the team should identify the various inputs & output streams at each process step.

Figure 3. 2: A typical flow diagram of process



Source: Barratt (1997, p. 618).

Identification of energy conservation opportunities: Capehart et al (2003) suggested that as the audit is being conducted, the audit team should take notes on potential energy conservation opportunities or energy management opportunities that are evident. Generally, the greatest effort should be devoted to analyzing and implementing the energy conservation opportunities, which show the greatest saving, and least effort to those with the smallest saving potential. Therefore, the largest energy and cost activities should be examined carefully to see where savings could be achieved. Identifying EMOs require s a good knowledge of the available energy efficiency technologies that can accomplish the same with less energy and less cost.

While every industrial facility is different, there are several energy efficiency opportunities, which typically provide high returns. Typical energy efficiency opportunities are: steam system upgrades; heat recovery; compressed air system upgrades; lighting; motor and drive system upgrades; energy efficiency in buildings; production of energy from waste; cogeneration; modernization; water system upgrades and re-use etc.

Technical and economic feasibility: After identification of energy conservation opportunities, both technical and economic feasibility are to be established. The technical feasibility depends on technology availability, space, skilled work force, reliability, service etc; the impact of energy efficiency measure on safety, quality, production, or process; the maintenance requirement and spares availability.

Acceptance of energy conservation opportunities by the management depends on the economic viability and often it becomes the key parameter. The economic analysis can be conducted by using a variety of methods. Example: Pay back method, internal rate of return method, net present value method etc. For low investment short duration measures, which have attractive economic viability, simplest of the methods, payback is usually sufficient.

Classification of energy conservation measures: Based on energy audit and analyses of the plant, a number of potential energy saving projects may be identified. These may be classified into three categories:

- Low cost –high return;
- Medium cost- medium return;
- High cost –high return.

Normally low cost- high return projects receive priority. Other project have to be analyzed, engineered, and budgeted for implementation in phase manner. Projects relating to energy cascading and processes changes usually involve high cost coupled with high return, and may require useful scrutiny before fund can be committed. These projects are generally complex and may require long lead times before they can be implemented. A general guideline for project priority has been tabulated as follows (See Table 3.3, p. 42).

Table 3.3: Project priority guideline

Priority	Economic feasibility	Technical feasibility	Risk feasibility
A-Good	Well defined and attractive	Existing technology adequate	No risks Highly feasible
B- May be	Well defined and only marginally acceptable	Existing technology may be updated, lack of conformation	Minor operating risk May be feasible
C-Held	Poorly defined and marginally unacceptable	Existing technology is inadequate	Doubtful
D-No	Clearly not attractive	Need major break through	Not feasible

Source: BEE (2004, p. 66).

3.3 Energy audit report

The next step in the energy audit process is to prepare a report, which details the results of the energy analyses and provides energy cost saving recommendations. After successfully carried out energy audit energy manager/energy auditor should report to the top management or effective communication and implementation. An industrial audit is more likely to have a detailed explanation of the ECOs and cost benefit analyses.

The report should begin with an executive summary that provides the owners/managers of the audited facility with brief synopsis of the total savings available and the highlights of each EMO. The report should then describe the facility that has been audited, and provide information on the operation of the facility that relates to its energy costs. The energy bill should be presented, with tables and plots showing the cost and consumption. Following the energy cost analysis, the recommended ECOs should be presented, along with the calculations for the costs and benefits, and the cost-effectiveness criterion.

Regardless of the audience for the audit report, it should be written in a clear, concise, and easy-to understand format and style. An executive summary should be tailored to non-technical personnel, and technical jargon should be minimized. The reader who understands the report is more likely to implement recommended ECOs (Capehart et al, 2003).

3.4 Benchmarking and energy performance

A successful program in energy management begins with a strong commitment to continuous improvement of energy efficiency. As a first step, once the organizational structure has been established is to assess the major energy uses in the facility to develop a baseline of energy use and set goals for improvement. The selection of key performance indicators and goals help to shape the development and implementation of an action plan. An important aspect for ensuring the successes of the action plan is involving personnel throughout the organization. Personnel at all levels should be aware of energy use and goals for efficiency. Staff needs to be trained in both skills and general approaches to energy efficiency in day-to-day practices. In addition, performance results should be regularly evaluated and communicated to all personnel, recognizing high achievement. The use of energy monitoring and process control systems can play an important role in energy management and in reducing energy use. These may include sub-metering, monitoring, and control systems. They can reduce the time required to perform complex tasks, often improve product and data quality and consistency, and optimize process operations (Worrell et al, 2004).

Energy benchmarking involves the development of quantitative and qualitative indicators through the collection and analysis of energy-related data and energy management practices. Benchmarking in simplistic terms is the process of comparing the performance of a given process with that of the best possible process and tries to improve the standard of the process to improve quality of the system, product, services (Price et al., 2008) etc. It allows organizations to develop plans on how to adopt such best practices, usually with the aim of increasing some aspects of performance. Benchmarking may be a one-off event, but is often treated as a continuous process in which organizations continually seek to challenge their practices. Benchmarking is a method, which should be used on a continual basis as best practices are always evolving.

The Lawrence Berkeley National Laboratory has developed an excel-based spreadsheet tool called BEST: Benchmarking and energy saving tool for use by industry to benchmark a plant’s energy intensity to “best practice” and to identify energy efficiency improvement options (Price et al., 2003; Galitsky et al., 2005).

Benchmarking of energy consumption internally (historical / trend analysis) and externally (across similar industries) are two powerful tools for performance assessment and logical evolution of avenues for improvement. Historical data well documented helps to bring out energy consumption and cost trends monthly, daily. Trend analysis of energy consumption, cost, relevant production features, specific energy consumption, help to understand effects of capacity utilization on energy use efficiency and costs on a broader scale.

External benchmarking relates to inter-unit comparison across a group of similar units. However, it would be important to ascertain similarities, as otherwise findings can be grossly misleading. Few comparative factors, which need to be looked into while benchmarking externally are (BEE, 2004):

- scale of operation
- vintage of technology
- raw material specifications and quality
- product specifications and quality.

Benchmarking energy performance permits:

- quantification of fixed and variable energy consumption trends vis-à-vis production levels,
- comparison of the industry energy performance with respect to various production levels (capacity utilization),
- identification of best practices (based on the external benchmarking data),
- scope and margin available for energy consumption and cost reduction,
- basis for monitoring and target setting exercises.

3.5 Matching energy usage to requirement

Mismatch between equipment capacity and user requirement often leads to inefficiencies due to part load operations, wastages etc. Worst case design, is a designer's characteristic, while optimization is the energy manager's mandate and many situations present themselves towards an exercise involving graceful matching of energy equipment capacity to end-use needs. Some examples of matching energy usage to requirement are as follows:

- eliminate throttling of a pump by impeller trimming, resizing pump, installing variable speed drives
- eliminate damper operations in fans by impeller trimming, installing variable speed drives, pulley diameter modification for belt drives, fan resizing for better efficiency
- moderation of chilled water temperature for process chilling needs
- recovery of energy lost in control valve pressure drops by back pressure/turbine adoption
- adoption of task lighting in place of less effective area lighting.

4. ENERGY ANALYSIS OF CPM

4.1 Introduction

The pulp and paper industry is one of India's oldest and core industrial sector. The socio-economic importance of paper has its own value to the country's development as it is directly related to the industrial and economic growth of the country. Although paper, have many uses its most important contribution to modern civilization is its use as a medium to record knowledge. Paper manufacturing is a highly capital, energy and water intensive industry. It is also a highly polluting process and requires substantial investments in pollution control equipment.

According to Mike (2007) energy, management is on the rise as a strategy for sustaining global competitiveness and is effective tool for gaining economic ground, is particularly important to energy intensive industries such as pulp and paper. However, the greatest potential comes when companies correlate continuous improvement with a strategic approach to energy management to create a deliberate process focused on increasing profitability, and achieving greater productivity and reliability.

With the increase in concern about global warming, and climate change, it has become imperative for the mills to become energy efficient by improving performance of equipments, modifying process or adapting to the new and clean technology. As such, energy management has become an essential part of an organization.

4.2 Energy management program in CPM

Pulp and paper industry is an energy intensive one. As per BEE, energy conservation potential of pulp and paper sector is 25%, which is highest among the energy intensive industries. Under ECA'2001 India, it is mandatory to have energy efficiency program in place to study about the energy requirement and consumption of various processes of the paper manufacturing and prepare energy norms. Accordingly, Energy Management Program (EMP) was introduced and energy management policy adopted at HPC in 2004-05 as follows.

Hindustan Paper Corporation Limited is committed to conservation of energy through:

- use of energy -efficient and environment friendly technologies
- optimal utilization of natural resources and undertaking a war on wastages
- continual review of the specific energy consumption norms for bench marking with the best in the industry
- carrying out regular energy audits internally and through external experts
- promoting awareness amongst the employees and other stakeholders.

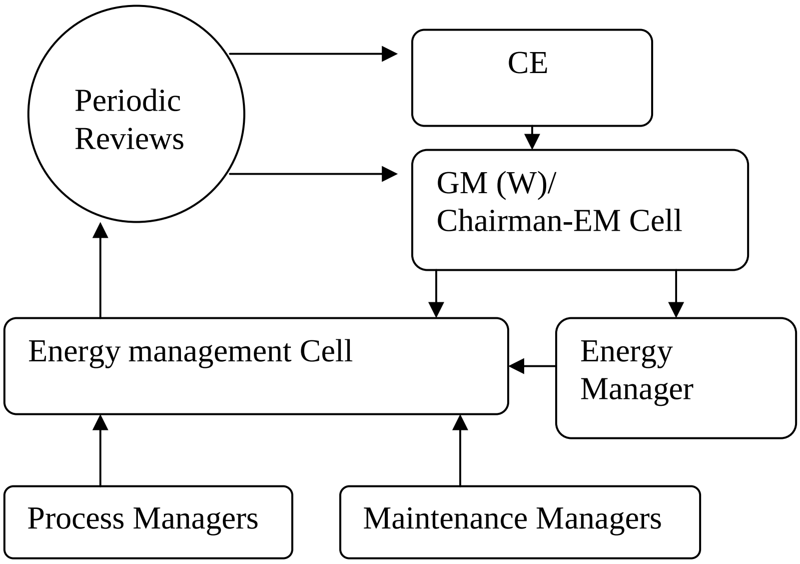
It is stated in the mission statement of the corporation that " To explore and implement technological up gradation of existing equipment for improved quality and increasing productivity and for greater cost effectiveness. To preserve the ecological balance and explore eco-friendly production process to strike a harmonious relationship between nature and industry."

There is a well-defined EMP and it has been placed in the mission statement of the corporation. Thus, it can be concluded that the top management is committed to the energy management program. However, there is no specific measurable written objective for energy management program.

Accordingly, management has created Energy Management Cell (EMC) and appointed Energy manger (EM) and coordinators representing from all functional areas. Objective of energy management cell is to monitor, analyze, and improve various processes. Energy manager monitors the trend of consumption on daily basis, identifies the scope for energy conservation, and takes necessary action for timely implementation. The Chief Executive (CE) reviews the daily energy consumption figures against the set norms and suggests concerned HODs and Managers for necessary corrective measures in case of deviations. Various activities of energy management program are reviewed at operational, managerial and apex level periodically.

Awareness among employees are created through banners, posters etc. Both in-house and external training program are carried out for employees to impart knowledge of energy management and its effects to the company in particular and to the environment in general. The energy management structure of Cachar paper Mill is shown in the figure below.

Figure 4.1: Energy management structure

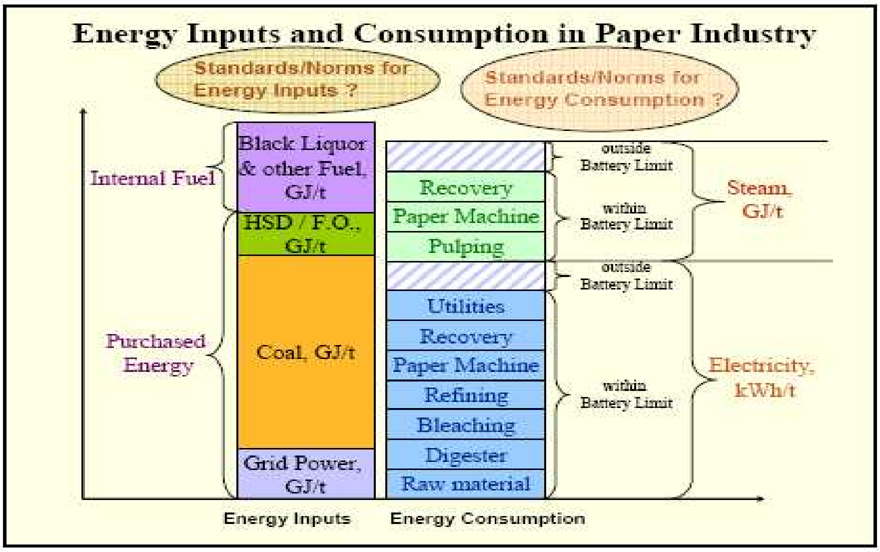


4.3 Specific energy consumption for pulp and paper sector

4.3.1 Source of energy and consumption

The paper industry is highly energy intensive. This industry is ranked sixth largest energy consumer in the country. Coal and the electricity are the main source of energy for the industry. Other fuels such as low sulfur heavy stock (LSHS), furnace oil, are also used to fire boilers. All large and medium sized plants are also using recovery boilers to generate steam from black liquor, which can provide up to 30% of the total energy requirement. The Figure 4.2 shows the input and consumption of energy from various sources and in various processes respectively (See Figure 4.2, p. 47).

Figure 4.2: Energy input and consumption in paper industry



Source: CPPRI, 2008.

The share of energy consumption as percentage of manufacturing cost in Indian paper mill ranges in 15-20%. The steam and electricity consumption per ton of paper is 11 - 15 tone and 1,500 – 1,700 kWh respectively in Indian large mills, which is roughly twice the norms, compared to North American and Scandinavian mills. It shows that there is immense potential of energy savings in this sector.

4.3.2 Specific energy consumption norms

Under the Energy Conservation Act 2001, energy intensive industries have been identified and specified as designated consumers of energy and to establish and prescribe energy consumption norms for designated customers. As per the act any pulp and paper mill having energy consumption equal to or more than 30, 000 metric tone of oil equivalent (MTOE) per year are designated customer.

Since pulp and paper industry in India is a conglomerate of old and new plants having diversified technology, using varying raw material and fuel characteristics in different geographical regions producing variety of products, their energy consumption varies widely depending on large number of factors. So based on the raw material and products mills have been categorized in to different group as:

1. Wood and bamboo based mills producing: bleached and unbleached varieties; newsprint; rayon grade pulp; and specialty like tissue paper etc.
2. Agricultural residue based mills.
3. Recycled fiber and market pulp based mills.

4. Market pulp based mills.

Both the mills of HPC viz: CPM and NPM are utilizing wood and bamboo as raw material. Therefore, criteria for wood and bamboo based mills is considered for discussion. Based on its product mix and raw material mix, wood and bamboo based mills are further categorized into five groups by BEE as:

1. Writing Printing Paper (WPP) grade paper mills.
2. WPP and Packaging grade paper mills.
3. Mills using wood, non-wood and re-cycle able fiber (RCF) producing WPP, packaging paper, and newsprint.
4. Newsprint mill.
5. Rayon grade mill.

Designated customers of wood/bamboo based mills, category wise as per ECA-2001are shown in the table below.

Table 4.1: Designated customer under ECA-2001

Group-1 WPP Grade Mills 1. JK Paper Ltd. CPM(JKCPM) 2. JK Paper Ltd. Rayagada (JKR) 3. BILT, Ballarshah (BILT-1) 4. BILT, Sewa (BILT-2) 5. BILT, Yamunanagar(BILT-3) 6. HPC, Cachar Paper Mill (CPM) 7. HPC, Nagaon paper Mill (NPM) 8. Orient Paper Mills Ltd (OPM) **Group-2 WPP & Packaging Paper Mills** 1. West coast paper Mills Ltd (WCPM) 2. Star Paper Mill (SPM) 3. APPM 4. Sirpur Paper Mills (SiPM)	**Group-3 WPP with mixed raw material** 1. ITC, Bhadrachalam (ITC) 2. SPB Ltd (SPB) 3. Century Paper Mill (CP) 4. Mysore paper Mills (MPM) 5. TNPL **Group-4 Newsprint Mills** 1. Hindustan Newsprint Ltd (HNL) **Group-5 Rayon grade mills** **1.** BILT Kamlapuram (BILT-4)

Source: BEE, 2007.

Based on the products and analysis of energy consumption data of the individual mills for 2003-04,2004-05, 2005-06 and weighted average of these have been considered as base line for the mills to reduce energy consumption.

The norms proposed for the mills are:

1) The energy input in GJ/t
2) Steam and electricity consumption
    a) Within battery limit

b) Outside battery limit.

The norms for steam and electrical energy consumption in various processes have been split into two parts. First part including the major pulping and paper making operations, is quite similar for mills within a group and can be compared with one another. The processes included in first part are raw material preparation, pulping, bleaching, stock preparation, paper machine, chemical recovery, boiler house, water systems, effluent treatment plant etc. and are designated as "Within Battery Limit". The other part including auxiliaries such as turbines, water intake, effluent discharge, and chemical plants such as oxygen, chlorine dioxide, chloro alkali plant etc., are included in the "Outside Battery Limit". Tables below show the norms of the different paper mills.

Table 4.2: Specific consumption of wood based group- 1: WPP mills

Name of the mill	**Energy GJ/t paper**			**Electricity kWh/t paper**			**Steam consumption t / t paper**		
	Purchased	Internal	Total	Within battery	Outside battery	Total	Within battery	Outside battery	Total
JKCPM	24.9	22.5	47.4	1,188	83	1,272	8.2	2.7	10.9
JKR	24.6	25.8	50.4	1,339	79	1,418	9.3	2.7	12.0
BILT-1	40.0	20.8	60.8	1,253	471	1,725	10.0	6.8	16.8
NPM	42.3	18.7	61.0	1,474	545	2,020	9.4	6.7	16.1
BILT-2	41.2	23.2	64.4	1,529	186	1,715	10.8	4.2	15.0
CPM	47.6	21.7	69.3	1,501	571	2,072	10.4	5.8	16.2
BILT-3	51.8	18.5	70.3	1,383	311	1,695	9.9	5.8	15.7
OPM	46.5	23.8	70.3	1,486	255	1,740	9.3	3.2	12.5

Source: BEE, 2007.

Table 4.3: Specific norms of wood/bamboo based group-2: WPP and packaging paper mills

Name of the mill	**Energy GJ/t paper**			**Electricity kWh/t paper**			**Steam consumption t / t paper**		
	Purchased	Internal	Total	Within battery	Outside battery	Total	Within battery	Outside battery	Total
WCPM	23.1	14.2	37.3	1,371	151	1,522	8.6	3.8	12.4
SPM	23.4	20.8	44.2	1,227	64	1,291	8.6	0.0	8.6
APPM	33.0	25.1	58.1	1,442	123	1,565	8.9	3.3	12.2
Si.PM	54.9	21.9	76.8	1,504	527	2,031	13.1	0.4	13.5

Source: BEE, 2007.

Table 4.4: Specific norms of wood/bamboo based group-3: WPP with mixed raw materials

Name of the mill	**Energy GJ/t paper**			**Electricity kWh/t paper**			**Steam consumption t / t paper**		
	Purchased	Internal	Total	Within battery	Outside battery	Total	Within battery	Outside battery	Total
ITC-1	23.8	14.7	38.5	1,117	85	1,202	6.7	0.0	6.7
SPB	21.0	14.2	35.2	1,382	59	1,441	7.5	2.1	9.6
Century	21.8	23.5	45.3	1,199	125	1,324	9.2	1.2	10.4
MPM	80.5	8.9	89.4	2,057	195	2,252	6.1	7.0	13.2
TNPL	34.5	17.6	52.1	1,367	88	1,525	7.0	0.0	7.0

Source: BEE, 2007.

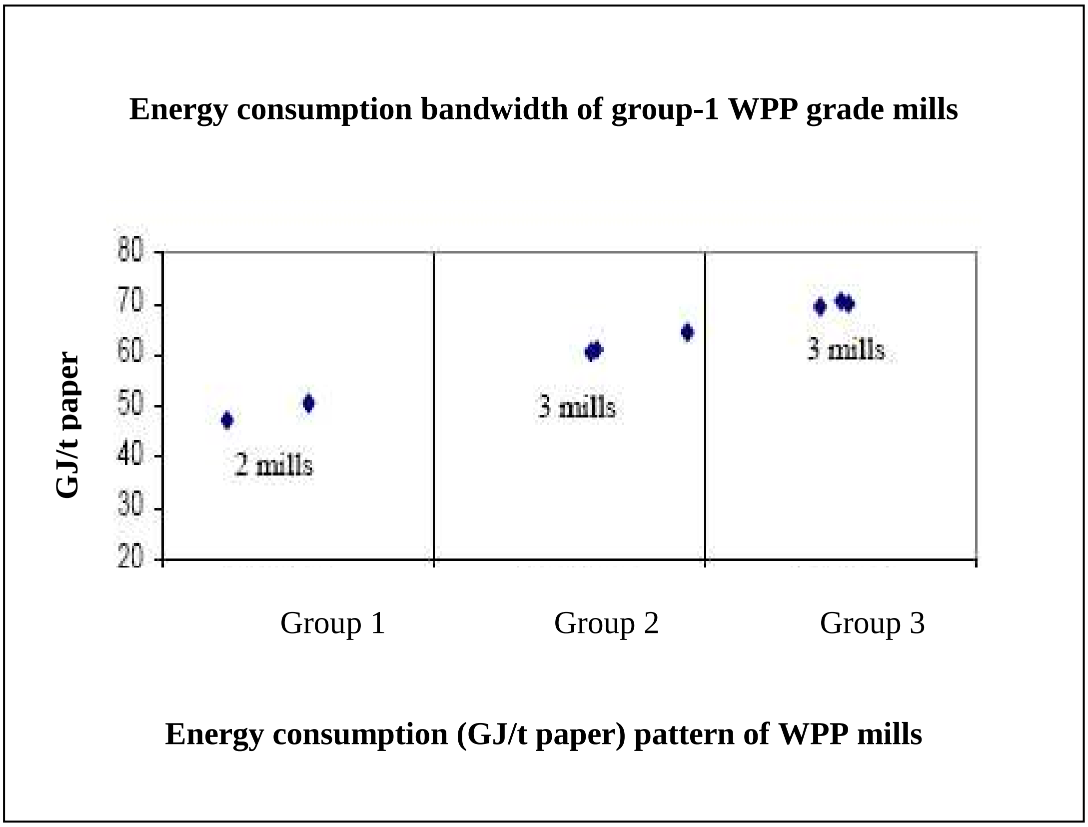
Table 4.5: Wood based group-4 and 5: News print mill and Rayon grade mill

Name of the mill	**Energy GJ/t paper**			**Electricity kWh/t paper**			**Steam consumption t / t paper**		
	Purchased	Internal	Total	Within battery	Outside battery	Total	Within battery	Outside battery	Total
HNL	30.0	4.1	34.1	1,693	114	1,807	5.2	2.6	7.8
BILT-4	19.3	34.1	53.4	1,052	130	1,182	12.1	1.2	13.3

Source: BEE, 2007.

To analyze the energy efficiency of designated mills, BEE has adopted the concept of energy bandwidth. Based on the specific consumption of energy, steam, electricity bandwidths are divided into various categories, from most energy efficient to least energy efficient. The most energy efficient mills are placed in first group; average mills are placed in second and below average mills are placed in third group. The mills in the first group of energy bandwidth are compared with the international levels. The average and below average mills are where most opportunities for improvements exists. Figure 4.3 shows position of group-1, WPP grade mills in the energy consumption bandwidth of paper industry (See Figure 4.3, p. 51).

Figure 4.3: Energy consumption bandwidth of specific energy group-1: WPP grade mills

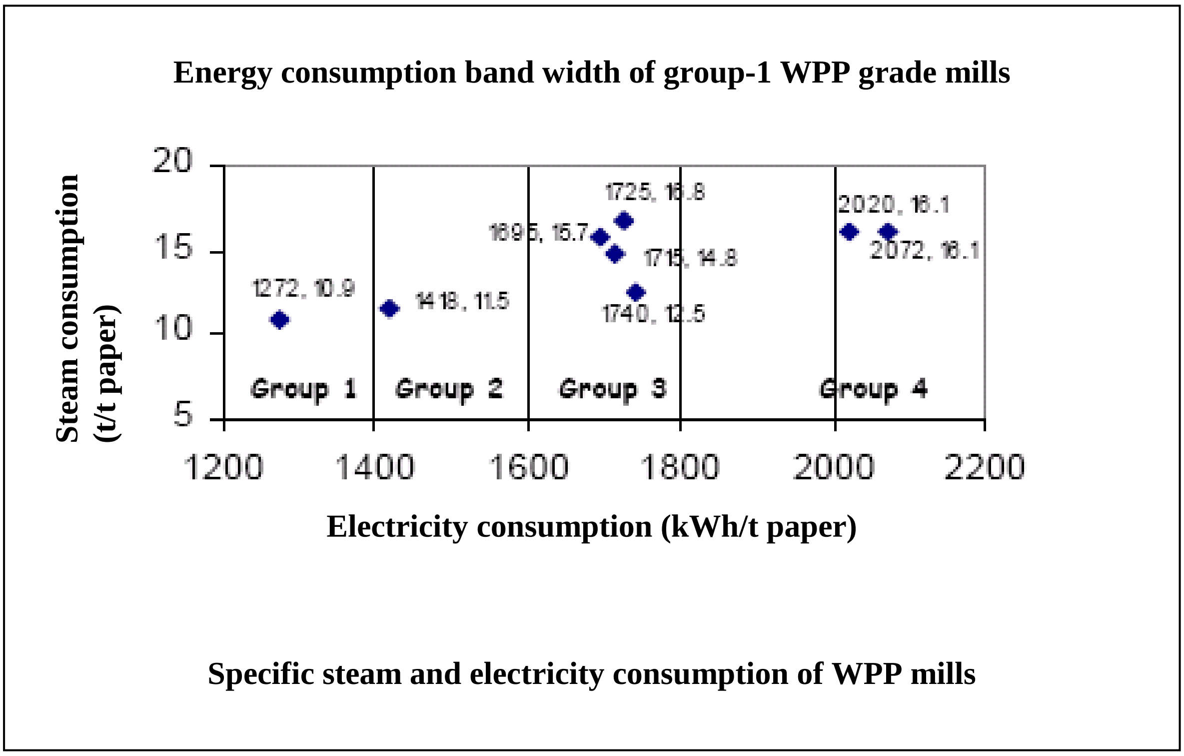


Source: CPPRI, 2007.

There are eight mills in this category. Based on energy consumption mills are positioned in different group of energy brand width. In the figure JKCPM and JKR are placed in group-1; BILT-1, NPM, BILT-2 are placed in group-2; CPM, BILT-3 and OPM are placed in group-3. The position of Cachar Paper Mill (CPM) in the energy brand width falls into group-3. Therefore, it may be pointed out that there exist lots of opportunities for energy conservations in Cachar Paper Mill, so as to position it into higher energy grade.

The figure 4.4 shows the position of different mills of WPP grade in energy bandwidth with respect to its specific steam and specific electricity consumption. The position of Cachar Paper Mill in the energy bandwidth is in fourth group. It is clear from the figure that energy consumption of the mill is much higher compared to the mills, which are positioned in group-1, group-2, and group-3 of energy bandwidth. Specific steam and electricity consumption of the mill in first group is 10.90 t/t and 1,272 kWh/t respectively, where as specific consumptions of steam and electricity of CPM is 16.1 t/t and 2,072 kWh/t. As per BEE, there exists lots of energy saving opportunities in the mills, which falls under group-3 and 4 of energy bandwidth. So in order to position it in the efficient energy group energy saving opportunities are to be identified and implemented (See Figure 4.4, p. 52).

Figure 4.4: Energy consumption bandwidth of specific steam and electricity consumption group-1: WPP grade mills



Source: BEE, 2007.

4.3.3 Comparison of specific energy, electricity, and steam consumption with international standards

Energy efficiency of a typical Indian mill is much lower compared to its counterparts in the developed countries owing to old technology base. Absence of modernization at an aggregate level has reflected in poor energy efficiencies vis-a-vis mills in developed countries. As per The Energy Research Institute (TERI), (2003) the average energy cost for Indian paper mills is around 20 - 30% of total production cost, as against 12-14% in the USA, Sweden, Finland and other major paper producing countries.

By adoption of new technologies, mills in developed countries have been able to reduce their consumption of fossil fuels. As per TERI (2003, p.248) Sweden, which has reduced the oil consumption in the industry by 70%, over the past decade (1980-90) tops the list, followed by Finland, Japan (34%) and UK (8%). The comparison of energy consumption in Indian and international mills is given in Table 4.6 (See Table 4.6 p. 53).

Table 4.6: Energy usage pattern: International and Indian paper mills per tone of paper

Bleached varieties	**Steam t/t paper**		**Steam index[1]**	**Electricity kWh/t paper**		**Electri-city index[2]**
	Internat-ional	**Indian**		**Internat-ional**	**Indian**	
Chip conveying	-	-	-	20	20	100.00
Digester	0.61	1.30	164.50	40	40	100.00
Washing and screening				30	110	104.76
Oxygen de-lignifications	0.18			75	-	
Bleaching	0.83	0.30	36.14	100	80	80.00
Paper machine	1.50	2.50	166.66	253	600	237.15
Soda recovery	1.50	2.60	173.33	55	125	227.27
Power plant	0.83	1.20	144.57	60	125	208.33
Kiln and re-causticising	-	-	-	25	-	
Hot water supply	-	-	-	32	50	156.25
Waste paper treatment	-	-	-	30	40	133.33
Misc, unaccounted losses	0.00	1.10		30	110	366.66
Total consumption	5.45	9.00	165.10	750	1300	173.33

Source: CPPRI, 2008.

Note: 1) Steam index = Usage of Indian/ Usage of International, 2) Electricity index = Usage of Indian/ Usage of International

The table above shows process wise average consumption of specific steam and electricity per tone of paper in international and Indian mills. It is evident from the table that processes like chip conveying, digester, washing and screening with oxygen de-lignifications consumes same amount of specific electricity in Indian as well as in international mills. However paper machine, soda recovery, power plant consumes much more electricity compared to the international average consumption. It is very clear from the table that there is significant amount of electricity losses in the Indian mills compared to the international average consumption. It is evident from the table that Indian mills consume 73.33% more electricity compared to the international mills. Therefore, it can be concluded that there are lots of energy conservation opportunities in Indian mills compared to the international mills.

The specific steam consumption of the international and Indian mills is 5.45 t/t paper and 9 t/t paper respectively. It is clear from the table that Indian mills consume 65.10% more steam compared to the international mills. It is evident from the table that an unaccounted steam loss is 1.1 t/t of paper in Indian mills. Steam consumption in paper machine, soda recovery, and power plant of Indian mills is much more higher compared to the international average consumption. Therefore, there exists many opportunities to reduce the electricity and steam consumption in Indian mills. With adoption of new technology, energy efficient processes and increasing energy efficiency of process and equipment, substantial amount of electricity and steam consumption can be reduced.

4.4 Energy analysis of the mill

4.4.1 Energy consumption scenario

The major source of energy used in Cachar Paper Mill is coal for generation of steam and power from steam turbines. Black liquor from the pulp mill is used as a fuel in recovery boiler to generate steam and furnace oil is used to supplement black liquor at the time of start up. The energy consumption scenario of the mill is shown in the table below. Various energy conservation schemes, both in house and suggested by external agencies have been taken on continuous basis, resulting in steady decline in the energy consumption over the years. The tables below show the trend of paper production and consumption trend of electricity, steam, and coal per tone of paper produced from 2002-03 to 2006-07.

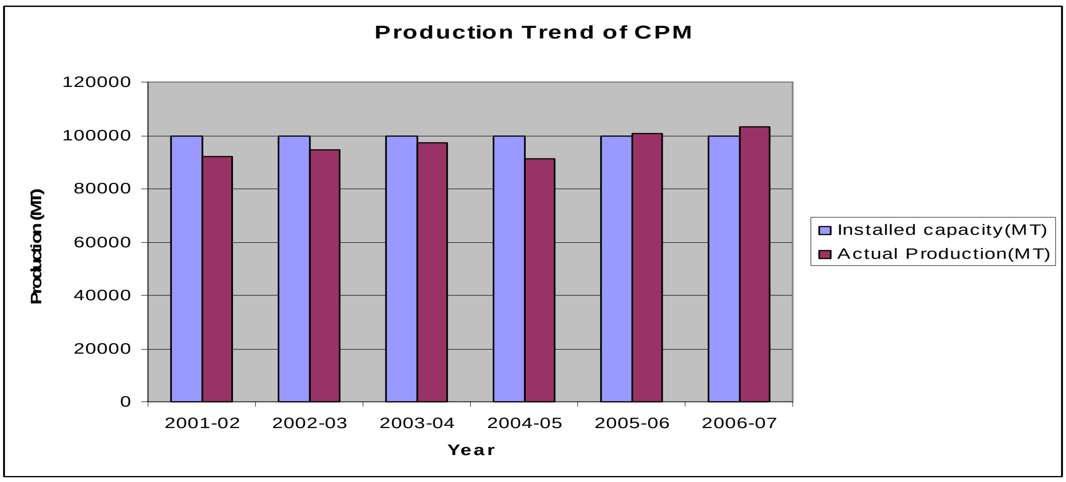
Table 4.7: Energy consumption scenario at CPM

Financial Year	Production t (tone)	Specific electricity consumption kWh/t paper	Specific steam consumption t/t paper	Specific coal consumption t/t paper
2002-03	94,702	1,576	11.11	1.96
2003-04	97,376	1,550	10.80	1.91
2004-05	91,012	1,527	10.60	1.84
2005-06	100,631	1,478	10.10	1.75
2006-07	103,155	1,507	9.80	1.94

Source: Internal data of CPM, 2007.

The Figure shows production trend of CPM from the year 2001-02 to2006-07. It is clear from the figure that there is an increasing trend of paper production.

Figure 4.5: Production trend of CPM

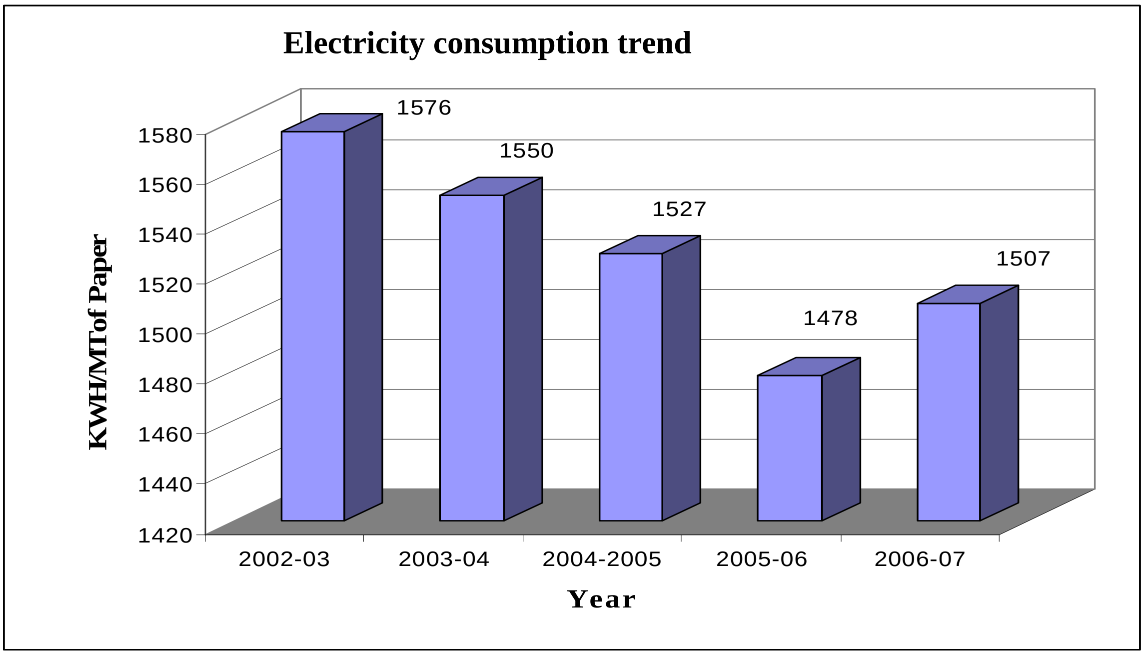


Source: Table 4.7.

The mill has achieved production of 100,631 tones and 103,155 tones of paper in the year 2005-06 and 2006-07 respectively against its capacity of 100, 000 tones per annum.

The electricity consumption trend of CPM per tone of paper is shown in the figure below.

Figure 4.6: Electricity consumption trends per tone of paper in CPM



Source: Table 4.7.

Electricity consumption trend of the mill shows a decreasing trend. It is because of implementation of various energy conservation measures taken up in the mill continuously. The specific electricity consumed is very close to the norms set by BEE for the mill. However, electricity consumption of CPM is higher than the norms of 1,300 kWh/t paper. Therefore, to improve the specific consumption there has to be continuous effort to find out opportunities and to implement those opportunities and optimization of the process. There exist lots of opportunities to reduce electricity consumption. Motors are at the core of almost every industrial process. They run many types of equipment, including pumps, fans, blowers, conveyors. Because of their extensive role in production, motors consume a large amount of electricity and can be an attractive target for energy efficiency investments.

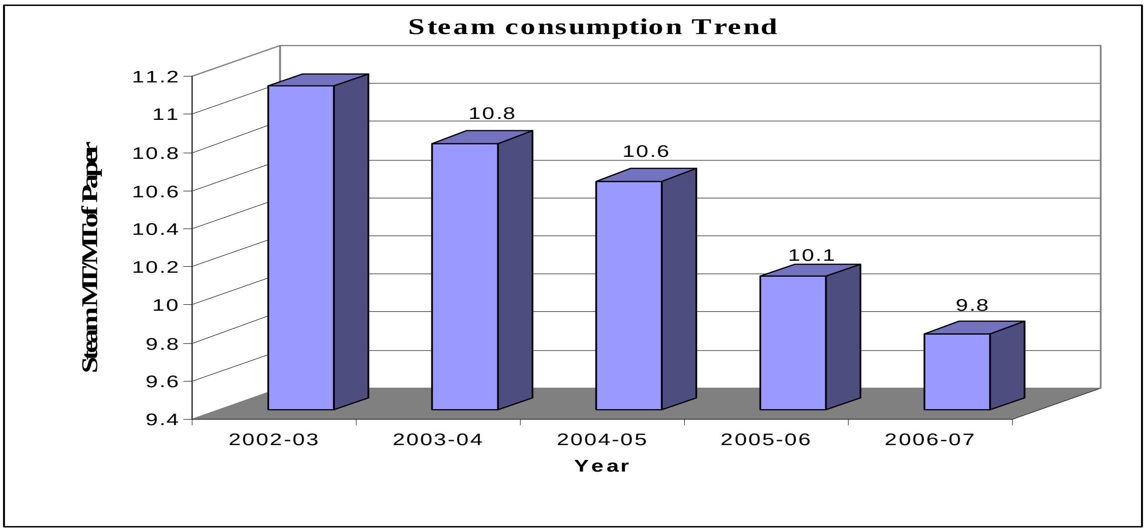
Improving motor and equipment efficiency can reduce significant amount of electricity. Properly matching motor size to load can reduce energy use. Motors are often oversized to ensure that they can handle greater than normal load if needed. Over sized motors results in increased initial as well as operating costs.

Installing motors with variable speed drives is another option. A variable speed drives (VFD) particularly applicable if the motor load fluctuates over time, and the motor has extended periods of light load operation. Variable speed drives are usually cost-effective as it matches the output to the load by varying the speed of the motor. This increases energy efficiency by limiting energy use during periods of low output. Fans, pumps, and speed-insensitive machinery are often the best candidates for variable speed drives. Variable speed drives can also improve product quality by allowing for greater control and they can reduce maintenance cost.

Steam consumption trend at CPM is shown in the Figure 4.13. There is a decreasing trend of specific steam consumption. Specific consumption of steam has decreased from 11.1 t/t of paper in 2002-03 to 9.8 t/t of paper in 2006-07. This is due to implementation of various energy conservation opportunities in the mill including good housekeeping. However, specific steam consumption of the CPM is higher than that of the norms specified by BEE for Indian mills of 9 t/t paper.

According to Schmidt (2007, p.125) many opportunities exist for energy savings in steam system operation, ranging from simple operating procedure modifications to retrofits requiring significant capital expenditures. Significant savings can be obtained by reducing steam and hot water load. Insulating steam and condensate pipes and installing or repairing steam traps are usually highly cost-effective energy measures. Therefore, energy management cell should closely monitor the system on regular basis and find out possible opportunities. So that by implementing those opportunities further reduction of steam can be attained.

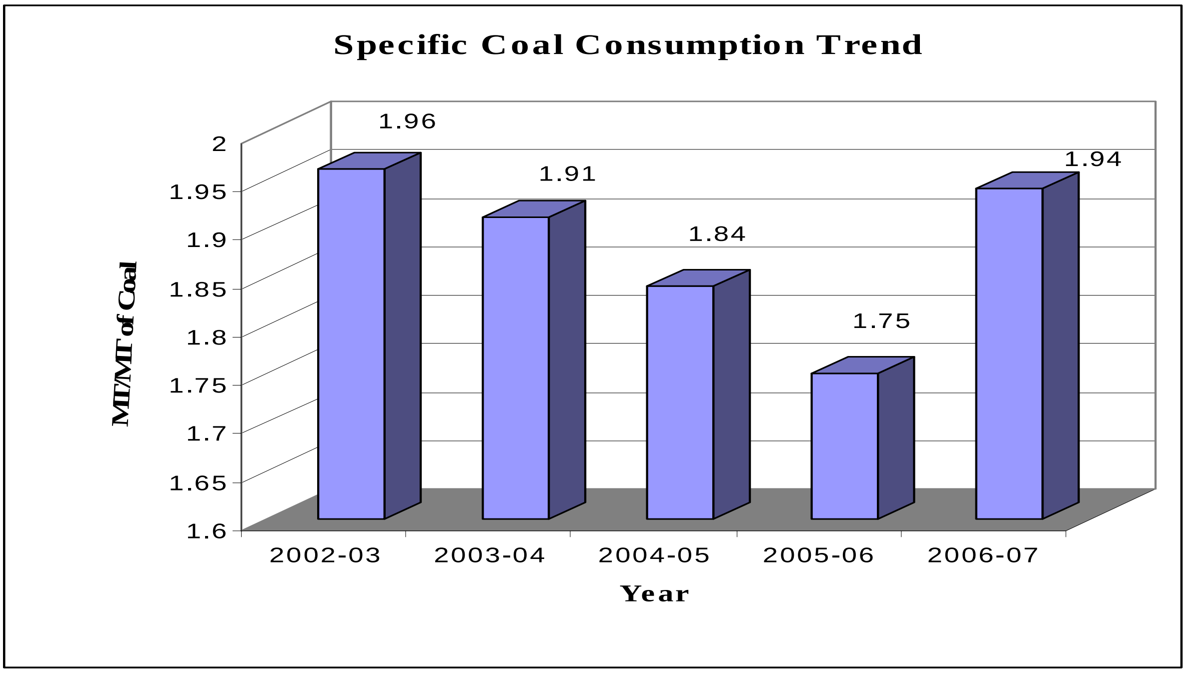
Figure 4.7: Steam consumption trend per tone of paper in CPM



Source: Table 4.7.

Coal consumption trend at CPM from the year 2002-03 to 2006-07 is shown in the Figure 4.8. It is clear from the figure that specific coal consumption per tone of paper has been decreasing from 1.96 t/t of paper in 2002-03 to 1.75 t / t of paper in 2005-06. However, the specific consumption of coal has gone up in the year 2006-07. With decrease in specific steam consumption in 2006-07, coal consumption should have been also decreased.

Figure 4.8: Specific coal consumption trend in CPM

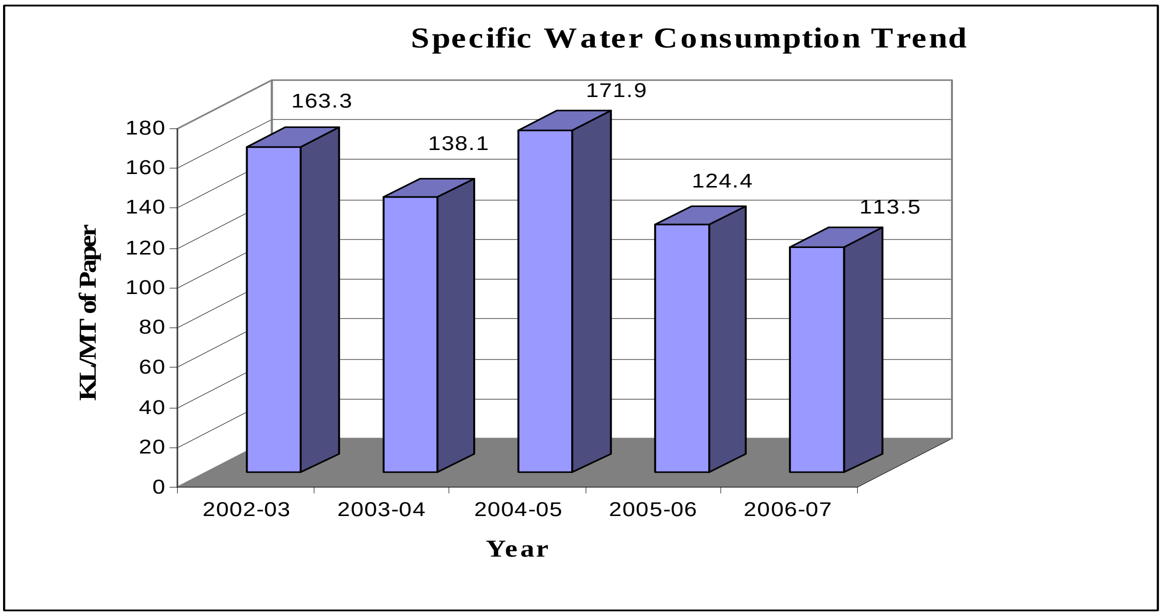


Source: Table 4.7.

Water consumption trend of the Cachar Paper Mill is shown in the Figure 4.9 (See Figure 4.9, p. 58). Mill has taken up lot of measures like re-use of paper machine back water in dilution of pulp in unbleached tower, vat dilution of DCW, make up of chip washing water by effluent water, collection of sealing and cooling water of pumps, compressor etc and using it, using of bleached filtrate for dilution of pulp. Moreover, awareness has been created amongst the employees regarding wastage of water and optimizing its use. With these measures and implementation of energy conservation opportunities on continuous basis it has been possible to reduce the consumption of water from 163.3 m^3/t of paper in 2002-03 to 113.5 m^3/t of paper in 2006-07, which is less than that of the norms set for the mill by BEE. However, the consumption is higher compared to the similar mills of developed countries and best practices of Indian mill. According to APIC Public eco-efficiency report, (2003) as referred by National Productivity Council (NPC) average water consumption in developed countries varies from 30-70 m^3/t of paper.

According to National Productivity Council (NPC) based on OECD report (2001), one of the reasons for higher water consumption in India compared to developed countries is the price of water. Water pricing in OECD countries and in USA are mostly based on average cost pricing or marginal cost pricing. However, along with water cost some of these countries have also introduced the “polluter pay's principle” for water pollution load discharged by companies. In comparison, the Indian industry pays a nominal amount.

Figure 4.9: Water consumption trend in CPM



Source: Internal data of CPM, 2008.

The trend of manufacturing cost and energy cost per tone of paper in Cachar Paper Mill is presented in the Table 4.8. It is evident from the table that there is an increasing trend of cost of production. It is due to increase in prices of raw material, cost of transportation, chemical and energy consistently.

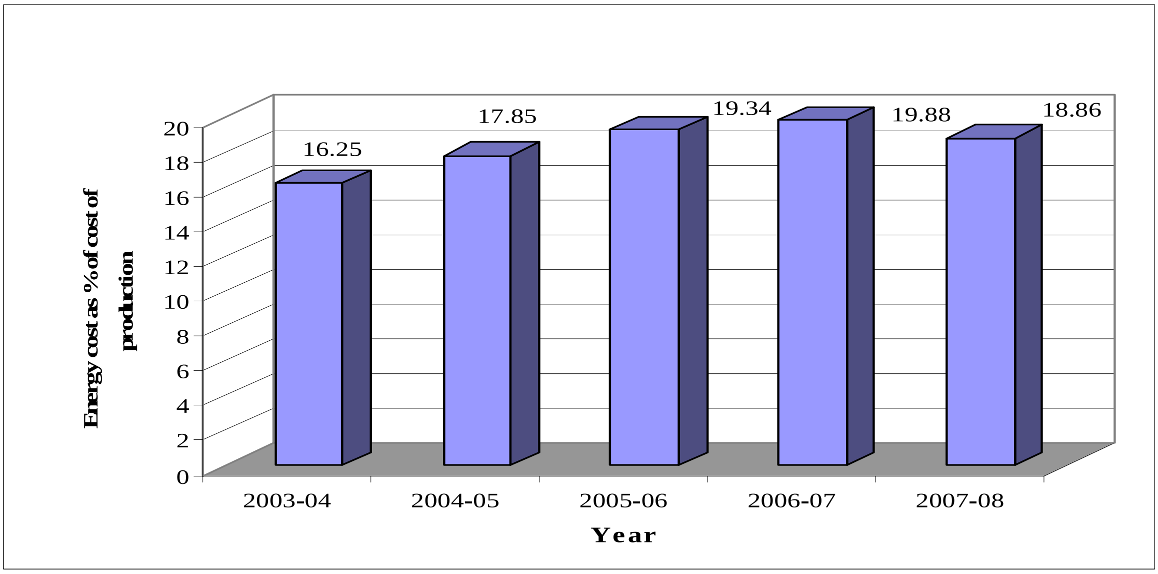
Table 4.8: Share of energy cost as part of manufacturing cost at CPM

Financial Year	**Cost of production INR/t of paper**	**Energy cost INR/t of paper**	**Energy cost as % of total cost**
2003-04	16,190.29	2,630.92	16.25
2004-05	18,212.06	3,250.06	17.85
2005-06	19,309.46	3,734.66	19.34
2006-07	19,630.31	3,903.37	19.88
2007-08	21,878.37	4,127.34	18.86

Source: Internal data of CPM, 2008.

The Figure 4.9 shows trend of energy cost as a share of cost of production at CPM :(See Figure 4.10, p. 59).

Figure 4.10: Energy cost as share of total cost in CPM



Source: Table 4.8.

It is clear from the Figure 4.10 that the share of energy cost to the manufacturing cost is raising, in spite of increase in production and decrease in specific consumption of coal per ton of paper, which is the main source of energy. It is due to the fact that, cost of the coal and furnace oil have been increasing each year at a rate of about 20 to 25% and 5% respectively (CPM internal source).

4.4.2 Benchmarking comparison

Benchmarking is fundamental to competitiveness analysis. It is undertaken to compare production costs, mill uptime, energy consumption or other critical parameters. Benchmarking is always conducted against mill of a similar type, producing essentially the same product. Gap analysis then reveals the differences with mills of the same age class and mills of newer, more modern design. Benchmarking is one of the first steps a mill should undertake. Benchmarking enables senior management to compare the relative performance of their mills with similar mills or with a model mill representing the current best practice. It provides the motivation for looking at energy conservation opportunities in mill operations.

Benchmarking is also useful in energy efficiency studies to provide direction in the search for energy conservation opportunities. However, for it to be effective, it is important that the section wise benchmarking be carried out, and by energy type, e.g. steam, electricity.

The specific energy consumption of CPM is 7.87 Gcal per tone of paper. It accounts towards 10.1 tone of steam required per ton of paper and 1,478 kWh per tone of paper. A comparison of present energy and water consumption with norms is shown in Table 4.9 (See Table 4.9, p. 60).

As the energy audit was carried out at CPM in 2006-07 by authorized external auditor of BEE, energy consumption data for the year 2005-06 was considered as a baseline data.

Table 4.9: Specific energy consumption of best practices in India and CPM

Specific consumption	**Writing and printing grade paper**		**Index (CPM/Norms)**
	Norms	**CPM (2005-06)**	
Energy (Gcal/ t paper)	7.00	7.87	112.42
Electricity (kWh/t paper)	1,300	1,478	113.70
Steam (t/t of paper)	9.00	10.10	112.22
Water (m^3/t of paper)	125	124	99.20

Source: CPPRI, 2007.

The table shows the specific consumption of energy, electricity, steam and water per ton of paper as specified by BEE and CPM in the year 2005-06. It is evident from the table that specific consumptions of energy, electricity, and steam in CPM are higher compared to the norms set by BEE. It is also evident from the table that CPM consumes about 12% more energy, electricity and steam compared to the norms specified by BEE. In order to improve the specific consumptions there has to be continuous effort to find out energy conservation opportunities and to implement those opportunities and optimization of the process.

The plant wise breakup of steam consumption for production of writing printing paper by the mill and its comparison with the Indian standards is shown in the table below.

Table: 4.10 Plant wise beak-up of specific steam consumption of Indian standards and CPM in Financial Year (FY): 2005-06

Sections	**Norms t/t paper**	**CPM t/t paper**	**Index CPM/Norms**
Pulp Mill	1.6	0.8	125.00
Bleach Plant		1.2	
Evaporators and Soda Recovery Plant	2.6	3.7	142.30
Paper Machine	2.5	1.6	64.00
Boilers	1.2	2.2	183.33
Others	1.1	0.7	63.63
Total	9.0	10.1	112.22

Source: CPPRI, 2007.

The specific steam consumption in pulp mill including bleaching, evaporators, soda recovery, and boilers are high compared to the norms given by BEE. Steam consumption can be reduced by adopting energy efficient processes, inculcating good house keeping, providing insulation, improving condensate recovery and installation of steam traps to provide proper condensate drainage etc. It is evident from the table that pulp mill including bleach plant, evaporator-recovery and boiler consumes 25%,42% and 83% more steam respectively than the norms. Thus, it can be concluded that there exist lots of energy conservation opportunities in evaporator-recovery and boiler.

The plant wise breakup of electricity consumption per tone of paper at CPM in2005-06 and the norms specified by BEE is shown in the table below.

Table 4.11: Plant wise break-up of specific power consumption of Indian standard and CPM in 2005-06

Sections	**Norms kWh/t paper**	**CPM (2005-06) kWh/t paper**	**Index CPM/Norms**
Chippers	20	27.4	137.00
Digesters, Washing & Screening	150	122.4	81.60
Bleach Plant	80	94.4	118.00
Stock Preparation	150	210.2	140.10
Paper Machine	450	493.1	109.50
Boilers	125	219.3	175.44
Recovery plant	125	136.5	109.20
Water system	50	74.3	148.60
Effluent Treatment	40	24.1	60.25
Others	110	76.2	69.27
Total	1,300	1,478.0	113.70

Source: CPPRI, 2007.

It is evident from the data in the table that chipper, bleach plant, stock preparation, paper machine, boilers, recovery, and water system consume more energy than the stated norms. It is evident from the table that boilers, water system and stock preparation consumes 75.44%, 48.6%, and 40% more electricity respectively compared to the norms specified by BEE. Therefore, it can be concluded that maximum opportunities for energy conservation exists in these sections. As electricity consumption of CPM is 13.70% more than the specified norms, thus there exist many opportunities to reduce the consumption of electricity. Improving motor and equipment efficiency, properly matching motor size, installation of variable frequency drive in motors, use of energy efficient motors, improving energy efficiency of processes etc can reduce significant amount of electricity.

Since CPM produces different grades of WPP in a wide range of gram per square meter, therefore it is the one of the most challenging tasks to benchmark energy cost due to the various diversity factors and due to significant difference in the delivered price of fuel due to location factor. The cost of production for utilities has been gradually rising in the last few years and the trend of variation in utility cost and total cost of production is shown the table.

Table 4.12: Cost of energy at CPM

Cost	Year 2003-04	Year 2004-05	Year 2005-06
Total cost of production(INR/t)	16,190.29	18,212.06	19,309.46
Cost of energy (INR/t)	2,630.92	3,250.06	3,734.66
Share of energy cost to total cost (%)	16.25	17.85	19.34

Source: Internal data of CPM, 2008.

4.5 Energy conservation opportunities

Based on the energy audit data, numbers of energy conservation opportunities were identified. In order to find out techno- feasibility of the energy saving proposals the utility (energy, water) consumption and cost parameters of 2005-06 were considered as baseline parameters. The plant wise benchmarking of energy consumption described above provides an impetus for discovering the best energy saving opportunities. The tables below show the consumption and cost of energy and water in CPM in 2005-06.

Table 4.13: Energy and water consumption per tone of paper at CPM in FY 2005-06

S.N.	Consumption	Unit	Quantity
1	Coal	t/t of paper	1.75
2	Steam	t/t of paper	10.10
3	Water	m^3/t of paper	124.00
4	Power	kWh/t of paper	1,478.00

Source: Internal data of CPM, 2008.

Table 4.14: Energy and water cost in CPM in FY 2005-06

S.N.	Item	Unit	Cost in INR
1	Steam	T	485.79
2	Water	m^3	2.00
3	Power (own generation)	kWh	1.91
4	Power (purchased)	kWh	4.57

Source: Internal data of CPM, 2008.

Acceptance of energy conservation opportunities by the management depends on the economic viability and often it becomes the key parameter. In order to find out viability of the opportunities the cost of energy, water and power shown in the Table 4.14 will be used. The economic criteria most frequently used to determine cost effectiveness are net present value, internal rate of return and payback. Payback will be used in determining viability as it tells the number of years it will take for a measure to pay for itself using the stream of savings. It is prevalent because it is very easy to calculate. The various energy conservation opportunities identified are as follows.

4.5.1 Use of flat belt in place of v-belt in chipper drives

During PEA, it was observed that multi grooves v-belt driven motors are in operation at chipper. The major disadvantage of v-belt is that it absorbs a great deal of useful power and adds running costs. These power losses are typically dissipated in the form of heat, which in turn has a deteriorating effect on the v-belt life. The explanation for the greater efficiency of flat belts over v-belts lies in the method of achieving pulley grip. The wedging action of v-belts involves an irreversible energy loss, as each belt is continuously wedged into the pulley groove and pulled out again. The loss is aggravated by misalignment and unmatched v-belts in a set. Further, loss of energy occurs in the flexing of solid rubber and in the shuffling of power between v-belts in a set. Another disadvantage with the v-belt drive system is the irregular wear of pulley grooves, which causes a set of v-belts to run on different pitch circle diameter.

Benefits of flat belt drive over v-belt drive are described as follows. Flat belts being much more flexible than the v-belts it requires less energy for travel around the pulleys and thus saves energy. It is suggested that all fans and motors should have flat belt drive system. The amount of energy saving can be 5-15% by switching over to flat belt. The proposal involves replacement of present v-belt pulleys with the flat belt pulleys in chippers.

Table 4.15: Operating data of chipper with potential energy saving at CPM

Equipment	Load KW	Operating hours in a year	Annual power consumption kWh	Annual power saving (5% of consumption) kWh	Annual saving in Indian Rupees (INR)[1]
Chipper-1	240	3,300	792,000	39,600	75,636
Chipper-4	240	3,300	792,000	39,600	75,636
Total savings				79,200	151,272

Source: Internal data of CPM, 2008.

Note: 1) The official exchange rate on 30 August 2008 of INR is EUR1= INR 64.54.

By converting existing v-belt drive to flat belt drive in both the chippers considering 5%savings, the total amount of power saving is 79,200 kWh per annum. Therefore, it is recommended to change existing v-belt drive to flat belt drive.

Investment, savings and payback of the energy conservation opportunity is shown in the table.

Table 4.16: Investment, savings and payback in Indian rupees (INR) and Euro (EUR)

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)	151,272	2,343.63
Investment amount (B)	110,000	1,704.20
Payback (B/A ×12) in month	10	

Source: Internal data of CPM, 2007.

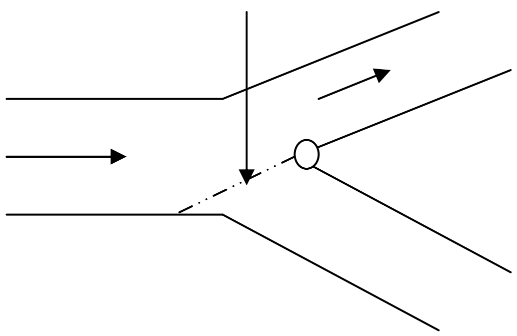
The total estimated annual saving by the proposed conversion to flat belt drives in two chippers is INR 151, 272 per annum and the investment required is INR 110, 000 with a payback period of 10 months.

4.5.2 Fixing a metallic moving gate for easy movement of bamboo in the water channel

Bamboo and bamboo bundles are transported to chipper belt conveyor through water channel. Near belt conveyors, water channel bifurcates for the feeding in chipper-1 and 2, 3 and 4, 5 and 6. During loading at chipper-1 the water channel of chipper-2 is blocked by putting a G.I. sheet but due to diversion of water in both the channels bamboo bundles do not move freely and get jammed at this point resulting in idle running of chippers. A person is assigned duty to remove the jammed bamboo bundles manually however in spite of this idle running of chippers were observed during the energy audit. If a metallic, moving guide gate is fixed as per drawing given below, in all the three water channels. This would result in uninterrupted movement of bamboo bundles and avoid idle running of chippers.

Figure 4.11: Proposed gate in flume of chipper in CPM

Metallic moving guide gate



Fixing of metallic gate as shown in the figure will result in unidirectional flow of water in the channel. As a result, there will be no interruption in the movement of bamboo bundles, which will result in reduction of idle running hours of the chippers.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.17: Investment, savings and payback in Indian rupees (INR) and Euro (EUR)

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(450 kWh×330×1.91/kWh)	283,635	4,394.30
Investment amount (B)	75,000	1,161.96
Payback (B/A ×12) in months	3	

Source: Internal data of CPM, 2007.

By fixing a guide gate in the water channel, running hours of chippers may come down to 32 hours from present 35 hours resulting in saving of 450 kWh per day amounting to INR 283,635 per annum considering 330 days operation in a year with investment of INR 75,000 only with a payback period of 3 months.

4.5.3 Replacement of 55 kW motor with 22 kW motor at re-chipper

There are two re-chippers in the chipper house for re-chipping of oversized chips coming from chip screens. It was observed that a small quantity of oversize chips are going to re-chippers. One re-chipper is equipped with 22 kW motor but another one is equipped with 55 kW motor. The re-chipper equipped with 22 kW motor is running without any operational problem therefore it is suggested to replace the existing motor by 22 kW motor. By replacement of 55 kW motor with 22 kW motor, mill can save about 10 kWh or 39,600 kWh per annum considering 330 days and 12 hrs per day operation resulting in saving of INR 75,636 per annum.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.18: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(39600 kWh ×1.91/kWh)	75,636	1,167.60
Investment amount (B)	100,000	1,549.30
Payback (B/A ×12) in months	16	

Source: Internal data of CPM, 2007.

The total estimated annual saving by the proposed conversion is INR 75, 636 per annum and the investment required is INR 100,000 with a payback period of 16 months.

4.5.4 Installation of VFD in recirculation pump of chip washing unit

In chip, washing unit one recirculation pump is provided to re-circulate the water for chip washing. During the audit, it was observed that pump was throttled by 75 % at discharge end. The pump is equipped with 90 kW motor. Current drawn by the motor was found 125 amps (80 kW).

By installation of a VFD, it is possible to regulate the speed of the motor for pumping required quantity of water instead of throttling the discharge end valve. Therefore, it is proposed to install variable frequency drive in recirculation pump of the chip-washing unit. By installation of the VFD in recirculation pump of chip washing unit, it is possible to reduce power consumption by 30% of the existing power, by controlling the speed of the motor in place of throttling resulting in saving of 30 kWh.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.19: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(30 kWh ×24×330×1.91/kWh)	475,000	7,359.10
Investment amount (B)	230,000	3,563.35
Payback (B/A ×12) in months	6	

Source: Internal data of CPM, 2007.

The total estimated annual saving is INR 475,000 per annum against investment of INR 230,000 for installation of VFD with a payback period of 6 months.

4.5.5 Installation of VFD in make up water pump of chip screen

There is a pump at effluent treatment plant, which provides effluent water after clarifier to chip washing plant as make up to mill water, which is used for chip washing. As per the data recorded, that pump has been throttled by 60 % at discharge end. This pump is equipped with 45 kW motor. Current drawn by the motor is 40 amps (26 kWh).

By installation of VFD, speed of the motor can be controlled instead of throttling the pump, which will result in reduction of power consumption by 30%. It would results in saving of 8 kWh or INR 126,000 per annum.

Investment, savings and payback of the energy conservation opportunity is shown in the table

Table 4.20: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(8 kWh ×24×330×1.91/kWh)	126,720	1,963.25
Investment amount (B)	140,000	2,169.00
Payback (B/A ×12) in months	13	

Source: Internal data of CPM, 2007.

The estimated cost saving per annum by installation of VFD in motor is INR 126,720 per annum against investment of INR 140,000 with a pay back period of 13 months.

4.5.6 Installation of VFD on the pump carrying excess water from chip washing unit to Effluent Treatment Plant (ETP)

At chip, washing unit one pump is provided to pump effluent water, left out with mud and dust after washing chips from chip washing unit to ETP. As per the audit data, the pump was throttled by 60 % at discharge end. This pump is equipped with 45 kW motor. Current drawn by the motor was found 25 amps (16 kWh).

By adopting this proposal mill can reduce its power consumption by 30 % through controlling the rpm of motor in place of throttling of discharge end resulting in saving of 4.8 kWh or 38, 016 kWh in a year.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.21: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(4.8 kWh ×24×330×1.91/kWh)	72,610	1,124.93
Investment amount (B)	140,000	2,169.00
Payback (B/A ×12) in months	23	

Source: Internal data of CPM, 2007.

By installing VFD, an amount of INR 72,610 can be saved per year against investment of INR 140,000 with a pay back period of 23 months.

4.5.7 Closing of side panels doors of dryer hoods of both machines

During detail audit, it was observed that the lifting doors of both machines are always partially lifted and all basement area is open. The closed hood is therefore working as semi closed hood and lot of air infiltration is takes place from machine house. This reduces the drying efficiency of dryers and hence more steam is consumed for drying the same quantity of paper. It also reduces the efficiency of pocket ventilation system and increases steam consumption in PV system. Beside this, the condition of side panels of hood was not proper resulting in heavy infiltrations from sides. The insulation of side panels was also in bad shape. All these reduce the efficiency of hood, resulting in more power consumption at exhaust fans. It is recommended that machine should run with lifting door in down position. The doors should be lifted only at the time of paper break and should be brought down after rethreading of paper. Also all infiltration should be stopped and insulation of side panels and roof should be repaired / replaced.

By proper insulation, repairing and stopping infiltration of air in hood, efficiency in drying will be improved. Assuming 1% improvement in hood efficiency, mill can save 0.24 t/hr steam or 1,900 t steam per annum.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.22: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(1900 t ×485/t steam)	921,500	14,276.64
Investment amount (B)	500,000	7,746.41
Payback (B/A ×12) in months		7

Source: Internal data of CPM, 2007.

An amount of INR 921,500 can be saved by repairing dryer hood side panel against investment of INR 500,000 with a pay back period of 7 months.

4.5.8 Change of fan design and material to reduce running load of PV fan motor

The PV system fan of Utmal machine has designed motor rating of 160 KW running on v-belt. As per audit study, the running load was found to be about 90 KW. The fan blades are made of cast iron and quite heavy in weight this resulting in high torque. It is recommended that cast iron fan blades should be replaced with FRP/aluminum blades. The FRP/aluminum blades are light in weight and require much less starting torque and running load. FRP fans are advantages compared to metallic fans, as intricate optimized computer-generated aerodynamic blade profiles can be duplicated with precision by molding fiberglass into fan blades that maximize air flow and are more efficient in power demand and airflow output. Furthermore, fiberglass fan blades generally have a longer life span as they are less affected by moisture, humidity, and corrosive chemicals. Over time, metal blades may corrode and rust from moisture or chemical exposure. Power saving in the range of 20-40 % can be achieved by using FRP fan. By changing the existing cast-iron blades of PV fan with FRP, there will be saving in the running load. Considering 20% reduction in running load, power saving will be18 KWh. So by replacing existing fan an amount of 142,560 kWh per annum can be saved with an investment of INR 200, 000.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.23: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A)(142560 kWh × 2 /kWh)	285,000	4,415.45
Investment amount (B)	200,000	3,098.55
Payback (B/A ×12) in months	9	

Source: Internal data of CPM, 2007.

An amount of INR 285,000 can be saved by replacing existing cast iron fan by FRP fan at an investment of INR 200,000 with a pay back period of 9 months.

4.5.9 Insulation of hot surfaces in paper machine

It was observed that various pipelines and paper machine dryers having higher temperature are not insulated resulting in high heat losses through these un-insulated surfaces in the form of radiations. It is suggested to put proper insulation on all bare surfaces to reduce the heat loss through radiation and save the energy wastage**.**

Table 4.24: Steam saving potential of un-insulated hot surfaces at paper machine in CPM

Location	**Diameter**	**Length (Meter)**	**Temp °C**	**Steam saved t**
PV system	2"	38	138	102
	8"	15	200	331
Drying cylinder face (77 dryers)	1.5m×77		105	2,156
Total				2,589

Source: Internal data of CPM, 2007.

Providing insulation on the un-insulated surfaces enormous heat energy can be saved, which is equivalent to 2,589 tone steam per annum.

Investment, savings and payback of the energy conservation opportunity is shown in table below.

Table 4.25: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A)(2,589 t × INR 485 /t steam)	1,255,665	19,453.80
Investment amount (B)(19,000+200,000+545,000)	584,000	9,047.80
Payback (B/A ×12) in months	6	

Source: Internal data of CPM, 2007.

An amount of INR 1,255,665 per annum can be saved by investing INR 584,000 with pay back period of 6 month.

4.5.10 Use of paper machine backwater at different showers at paper machine

As per the audit, observation different showers installed on wire at different locations are using fresh water. These are 5 wire roll showers each with flow rate of 300 lpm – 500 lpm, one breast roll with fan type nozzle with flow rate of 100 lpm, two wire edge cleaning shower after forward drive roll with 2.5 mm diameter bore and flow rate of 120 lpm.

All these showers can use paper machine clarified backwater from save all, instead of fresh water. This will save the fresh water consumption of paper machine. Therefore, it is proposed to use clarified backwater instead of fresh water. Amount of fresh water saving in different showers based on 330 days operation in a year is tabulated below:

Table 4.26: Amount of fresh water that can be replaced by clarified water at paper machine

Flow of water through showers for an annum	Total quantity of water m^3
Wire roll showers: $5 \times 300 \times 60 \times 24 \times 330 \times 10^{-3}$	712,800
Breast roll showers: $1 \times 100 \times 60 \times 24 \times 330 \times 10^{-3}$	47,520
Wire edge cleaning shower: $2 \times 120 \times 60 \times 24 \times 330 \times 10^{-3}$	114,048
Total quantity of water	874,368

Source: Internal data of CPM, 2007.

Investment, savings and payback of the energy conservation opportunity is shown in the Table 4.27(See Table 4.27, p.71).

Table 4.27: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A) (874,368 m^3× INR 2/ m^3)	1,748,736	27,092.85
Investment amount (B)	250,000	3,873.20
Payback (B/A ×12) in months	2	

Source: Internal data of CPM, 2007.

By using machine backwater instead of fresh water an amount of INR 1,748,736 can be saved by investing INR 250,000 with pay back period of 2 month.

4.5.11 Replacement of hot water pump of cooling tower at Caustic and Chlorine (C&C) Plant

There are two hot water pumps with motor rating 37KW running continuously at cooling tower of C&C Plant. Instead of running two pumps, one pump can make up the requirement, if it is replaced by energy efficient pump and motor of 55 KW. Presently pumps are running with 34.7 kW power each.

An amount of 118,800 kWh power or INR 226,908 per annum can be saved if it is replaced by 55 kW motor considering 24 hours operation for 330 days in a year.

Table 4.28: Energy consumption and saving potential of cooling tower pumps in C&C plant

Description	Power kW
Power consumption of existing pumps : 34.7 kW ×2 (say,70 kW)	70
Estimated power consumption of proposed pump(considering full capacity):	55
Amount of power saving	15

Source: Internal data of CPM, 2008

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.29: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A) (15kW×7,920 h ×1.91/kWh)	226,908	3,515.45
Investment amount (B)	270,000	4,183.06
Payback (B/A ×12) in months	15	

Source: Internal data of CPM, 2008.

Therefore, it is proposed to replace the existing pumps by new one, which results in saving of INR 226,908 per annum at an investment of INR 270,000 with pay back period of 15 month.

4.5.12 Replacement of aluminum blades with FRP blades in cooling tower of C &C plant

There are two fans in cooling tower of C&C plant with 30kW, 1500-rpm motor. Out of two, one fan has been replaced by FRP fan and its performance is satisfactory. An amount of 9,500 kWh has been saved in a year with an investment of INR 46,000. So it is proposed to replace the other fan with FRP one.
Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.30: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A) (9,500kWh×1.91/kWh)	18,000	278.85
Investment amount (B)	46,000	712.65
Payback (B/A ×12) in months	30	

Source: Internal data of CPM, 2008.

By adopting this proposal mill can save an amount of 9,500 kWh power or INR 18,000 at an investment of INR 46,000 with pay back period of 30 month.

4.5.13 Replacement of pulley to increase rpm of freon compressor in C&C plant

There are three reciprocating compressor to liquefy the Cl_2 gas in chlorine and caustic plant. The capacity of each compressor is 55,000 kcal/hr. Each compressor is equipped with 45 kW motor and rpm of compressor is reduced to 600 by providing lower diameter pulley in compressors against the pulley diameter 27 cm in motor. The rpm of motor is 1,500. Out of three compressors, two compressors remain in operation most of the time to fulfill the requirement of the process. Rarely only one compressor is put in operation when Cl_2 gas loading is less liquefaction system. The running load is about 41 amps (26.5 kW) in each compressor. As per manufacturer specification, the compressor can run up to 900 rpm.

It is suggested that by increasing the rpm of one compressor (out of three), mill can avoid continuous operation of two freon compressors. The rpm may be increased up to 750/800 from existing 600 by lowering the size of pulley at compressor side. By adopting this proposal, mill can fulfill the process requirement by running only one compressor in place of two compressors. After increasing the rpm, the running load will be about 33 kWh in place of present 26.5 kW and one compressor drawing 26.5 kW will be stopped resulting in net saving of 20 kWh. Considering 4,000 hrs operation of two compressors mill can save INR152, 800.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.31: Investment, savings and payback in INR and EUR

Category	**Amount**	
	INR	**EUR**
Cost savings per annum (A) (20kWh×4,000×1.91/kWh)	152,800	2,367.30
Investment amount (B)	15,000	232.33
Payback (B/A ×12) in months	2	

Source: Internal data of CPM, 2007.

An amount of INR 152,800 can be saved by investing INR 15,000 with pay back period of one month.

4.5.14 Replacement of existing vacuum pump with new energy efficient one provided with drum filter in C&C plant

A vacuum pump is provided with drum filter of brine sludge at C&C plant. Against design suction vacuum of 510 mm Hg it is developing only 400 mm Hg, where as the plant requirement is 450 – 500 mm Hg resulting poor filtration of brine sludge. It is suggested to replace existing vacuum pump with new energy efficient vacuum pump. The specification of the existing and proposed energy efficient vacuum pump is shown in the table.

Table 4.32: Specification of vacuum pumps

Description	**Existing vacuum pump**	**Proposed vacuum pump**
Capacity (m^3/ hr)	760	800
Suction vacuum(mm Hg)	510	600
Motor rating (kW)	45	30
Running load (kWh)	36	24

Source: Internal data of CPM, 2008.

By adopting this proposal, mill can save 12 kW per hour resulting in saving of INR 95,000 per annum considering 12 hours of operation for 330 days. In addition, filtration of brine sludge will improve significantly.

Investment, savings and payback of the energy conservation opportunity is shown in the Table 4.33 (See Table 4.33, p.74).

Table 4.33: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A) (12kWh×4,000×1.91/kWh)	95,000	1,472.00
Investment amount (B)	300,000	4,648.85
Payback (B/A ×12) in months	38	

Source: Internal data of CPM, 2007.

An amount of INR 95,000 can be saved per year by replacement of the existing pump with an energy efficient one at an investment of INR 300,000 with a pay back period of 38 month.

4.5.15 Installation of level controller in sludge sump and interlocking with sludge pump

Primary clarifier underflow is being pumped to sludge sump. One overflow line is provided in sludge sump. The level is maintained in sludge sump manually, some time overflow is envisaged. The pump is running with 9 kW load and operating for 20 hours a day. To avoid overflow from sludge sump, it is suggested to install a level controller in the sump and interlocking with the sludge pump. By adopting this suggestion, mill can reduce excess running of sludge pit pump by 7.5 %, which is equal to 495 hours considering pump is in operation for330 days.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.34: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A) (495 × 9kWh×1.91/kWh)	8,500	131.70
Investment amount (B)	15,000	232.40
Payback (B/A ×12) in months	22	

Source: Internal data of CPM, 2007.

An amount of INR 8,500 can be saved by investing INR 15,000 with pay back period of 22 months.

4.5.16 Use of effluent water in place of fresh water over low solid drain

One spray pipeline with thirty nozzles is provided over low solid drain to kill the foam. The water discharge from one nozzle was measured about 60 lpm therefore total discharge from 30 points will be 1,800 lpm fresh water which is equivalent to 2,592 m^3 / day or 8,55,360 m^3

per annum. The fresh water so used can be replaced by effluent water, by modifying the nozzle to get better spray for killing the foam.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.35: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A) (855,360 m^3× INR 2/ m^3)	1,710,720	26,503.90
Investment amount (B)	200,000	3,098.55
Payback (B/A ×12) in months	22	

Source: Internal data of CPM, 2007.

The fresh water consumption can be reduced by 855,360 m^3 per annum resulting in saving of INR 1,710,720 by investing an amount of INR 200,000 with pay back period of 22 months.

4.5.17 Replacement of v- belt by flat belt in vacuum pump of ETP

There is a vacuum pump in ETP, which is being operated by V-belt drive. The major disadvantage of V-belt is that it absorbs a great amount of useful power and adds running costs. These power losses are typically dissipated in the form of heat, which in turn has a deteriorating effect on the V-belt life. The explanation for the greater efficiency of flat belts over v-belts lies in the method of achieving pulley grip. The wedging action of V-belts involves an irreversible energy loss, as each belt is continuously wedged into the pulley groove and pulled out again. The loss is aggravated by misalignment and unmatched V-belts in a set. Further, loss of energy occurs in the flexing of solid rubber and in the shuffling of power between V-belts in a set. Another disadvantage with the V-belt drive system is the irregular wear of pulley grooves, which causes a set of V-belts to run on different pitch circle diameter.

Flat belts are much more flexible than the v-belt. Therefore, it requires less energy for travel around the pulley thus it saves energy. It is suggested that all fans and motors should have flat belt drive system. The proposal involves replacement of present v-belt pulleys with the flat belt pulleys.

Table 4.36: Energy consumption data of vacuum pump at ETP

Equipment	Load kW	Operating hours	Annual power consumption, kWh	Saving 5% of existing power kWh
Vacuum pump	54	7,920	427,680	21,384

Source: Internal data of CPM, 2007.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.37: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	**EUR**
Cost savings per annum (A) (21,384 kWh× INR1.91/kWh)	40,843	632.80
Investment amount (B)	35,000	542.30
Pay back (B/A ×12) in months	11	

Source: Internal data of CPM, 2007.

Estimated savings by the proposed conversion to flat belt drives is INR 40,843 per annum and the investment required is INR 35, 000 with payback period of 11 months.

4.5.18 Replacement of existing aerators by energy efficient aerators

There are twenty numbers surface aerator for aeration of effluent in the aeration basin tank. These are equipped with 50 hp motors drawing 50 amps current (32 KW). These aerators can be replaced with new energy efficient aerators, which have improved design resulting in better oxygen transfer with less power consumption. As suggested about 30 to 40% energy can be saved by utilizing energy efficient aerators. Considering 30% saving of existing load mill can save 10 kW in each aerator. In addition to the power saving, deposition at bottom of aeration tank will be reduced drastically with the improved aerators due to improved agitation for the bottom impeller design.

Investment, savings and payback of the energy conservation opportunity is shown in the table below.

Table 4.38: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	**EUR**
Cost savings per annum (A) (10 kWh×20×24×360× 1.91/kWh)	3,300,480	51,133.75
Investment amount (B)	4,400,000	68,168.45
Payback (B/A ×12) in months	11	

Source: Internal data of CPM, 2007.

An amount of INR 3,300,480 can be saved per annum by replacing existing aerators with an investment of INR 4,400,000 and pay back period is 11 month.

4.5.19 Installation of plant wise energy conservation system in lighting

The section wise power consumption in lighting at CPM is shown in the table below.

Table 4.39: Section wise power consumption in lighting at CPM

S.N.	Location	Lighting load (W)	
		Indoor	Outdoor
1	Pulp mill and Chipper house.	34,175	7,015
2	Recovery section.	23,150	18,975
3	C &C, CD, Substation, and Administrative building.	66,968	13,885
4	Workshop, Tech building, Bamboo yard and Stores.	31,979	57,070
5	Paper machine, Finishing house, Distribution etc.	149,700	5,985
Sub Total		305,972	102,930
Grand Total			408,902

Source: Internal data of CPM, 2007.

It is recommended that mill may install section wise energy conservation system to reduce their power consumption by 25% in lighting. These can be installed in series to the lighting mains or distribution wise. The installation needs only cables of suitable capacities for input and out put termination.

By adopting this proposal, mill can reduce its power consumption by 25% in lighting.In addition, acute failure of electrical consumables such as bulbs, tubes, chokes etc can be prevented due to control of high voltage by energy conservation system.

Table 4.40: Lighting power saving potential at CPM

Description	Power consumption in lighting (kWh)
Power consumption (indoor): (305.972 KW ×18×365h)	2,010,200
Power consumption (indoor): (102.93KW ×12×365h)	450,800
Total power consumption	2,461,000
Total power saving after installation of proposed system	615,250

Source: Internal data of CPM, 2007.

Investment, savings and payback of the energy conservation opportunity is shown in the Table 4.41(See Table 4.41, p.78).

Table 4.41: Investment, savings and payback in INR and EUR

Category	Amount	
	INR	EUR
Cost savings per annum (A)(615,250 kWh×INR1.91/kWh)	1,175,127	18,206.00
Investment amount (B)	1,275,000	19,753.35
Payback (B/A ×12) in months	13	

Source: Internal data of CPM, 2007.

An amount of INR 1,175,127 per annum can be saved with an investment of INR 1, 275,000 for the installation of section wise energy conservation system. Lighting hours for indoor and out door is considered to be 18 hours and 12 hours a day.

4.5.20 Summary of energy conservation opportunities

The cost savings and investments of the proposed energy conservation opportunities are summarized in the Table 4.42. An amount of INR 12,124,152 can be saved per annum by investing INR 8,885,000. By implementing energy saving proposals mill can reduce consumptions of electricity, steam, and water by 3,468,584 kWh, 4,489 t, 1,729,728 m^3 respectively per annum.

It is clear from the table that investment required to implement the energy conservation opportunities is only 1.5% of the profit. Therefore, it can be concluded that management of CPM can implement the energy savings proposals without external financing. The cost savings to the revenue, 0.32% is very insignificant; however, these proposals act as initiation of the energy management program. In addition to the financial benefits, there will be reduction in carbon dioxide and other green house gases.

Table 4.42: Summary of cost savings, investment of the opportunities, revenue, and profit of CPM in 2006-07

Total cost savings per annum (INR)	Investment amount (INR)	Revenue FY 2006-07 (INR)	Profit FY 2006-07 (INR)	Ratio (Investment / profit)	Savings / Revenue
12,124,152	8,885,000	3,730,000,000	590,000,000	1.5 %	0.32 %

Source: Internal data of CPM, 2008.

4.6 Project baseline and Performance Measurement Verification (PMV)

The Performance Measurement and Verification (PMV) involve the measurement of parameters in accordance with the standard engineering protocols, codes and practices, at pre-defined periodicity and time. This forms basis for first establishing the baseline parameters and then evaluating the performance after implementation of energy saving proposals. The details of these protocols also can be obtained from the Energy Valuation Organization (EVO) in its website.

In order to assess the performance of any energy saving proposal (ESP's), the baselines for individual projects are established or worked out from the measured data based on individual projects. For this plant operating conditions, sample testing of equipment and filling of the data formats obtained from the plant is performed. The inputs for establishing the baseline, the results of the baseline establishment, measurement criteria, and the traceability factors are shown in the following Table 4.43.

Table 4.43: Base line establishment, measurement criteria, and traceability

S.N.	Inputs	Outputs	Measurement Criteria	Traceability
1	Individual project baseline	Baseline equipment energy consumption	Spot measurement, log book trend, historical data	Measurement data & performance report countersigned
2	Plant operating conditions	Month wise baseline variation operating parameters, energy consumption, Model for estimating the adjustments	Historical data, MIS, Fuel supplier invoices	Balance sheet
3	Sample testing of selected equipments & system	Actual running condition of the equipment & energy consumption	Spot measurement, Logbook trend, Historical data	Annual efficiency report of equipment, previous test reports
4	Filled in data formats obtained from the plant	Energy consumption & cost, inventory of equipments, specific energy, water, steam consumption	Data format obtained from mill	Balance sheet

Source: CPPRI, 2007.

4.6.1 Baseline establishment and PMV for individual ESP's

This forms the basis of comparison between present energy consumption levels with post-implemented energy consumption levels. For this, based on the individual energy savings proposal, parameters to be measured, measurement criteria, and the measurement period should be established and compared with before and after implementation of the proposals.

Before planning the implementation of the projects, mill should make proper measurements of parameters and record section wise details to keep history of its working in order to establish the operating conditions of equipment like flow, pressure, power consumption, vacuum, steam pressure, condensate temperature etc. These data will be used to establish the baseline for individual ESP's and based on these baseline parameters mill effectively assess the project performance.

4.6.2 Baseline and PMV adjustments

Many factors affect the performance of the equipment and the achievement of savings. The parameters that are predictable and measurable can be used for routine adjustments. Such adjustments reduce the variability in reported saving, or provide a greater degree of certainty in reported saving. Unpredictable parameter within the boundaries of a saving determination may require future non-routine baseline adjustments like change in usage pattern. Therefore, during planning measurement and verification process, consideration should be given to:

- predictability,
- measurability.

Likely impact of all plausible factors in each category is shown in table.

Table 4.44: Factors of affecting baseline and PMV adjustment

S.N.	Parameters	Remarks
1	Variation in production	Average production can be considered
2	Quality & price of fuel	If there is a variation in the calorific value, this has to be factored. An average value can be considered
3	Quality & price of raw material	The raw material conditions should be considered since there are a lot of variations. An average cost has to be considered
4	Installed equipment intensity, schedule	Field measurements have to be carried out for sample equipment, system & detailed schedule documented
5	Equipment life, both energy saving potential and non-energy saving potential related	Provision are to be made in the budgets for replacement on completion of service life during the service period

Source: CPPRI, 2007.

4.7 Action plan for implementation of the energy management program

Although energy management concept is there for quite some time, however in recent years with the emergences of carbon trading and clean development mechanism it has become business usual for the industries. It not only helps in reducing cost of energy but also helps in reducing environmental impact and improves image of the company. Energy efficiency is extremely important for energy intensive industry like pulp and paper.

Therefore, it is suggested that HPC management should take advantage of this to obtain benefit out of it and to formulate a comprehensive action plan for implementation of EMP.

1. Assessment of energy management program: Any successful energy management programme within a company needs the total support and commitment of senior management. It should be given importance in corporate objectives. Top management should asses the benefits obtainable from the program and accordingly establish energy management policy suitable for the organization. Energy management is a continuous process and therefore corporate management should formulate energy management strategy aligned with the business strategy of the company.

2. HPC management should set goal and objectives to improve energy efficiency in the mills. Accordingly, energy management cell should formulate an action plan to meet each specific corporate energy goal and involves all plant team members. The goal should be specific, measurable, attainable, and realistic and should have a time frame.

3. At present energy management has emerged as important part of business. To meet the challenges arising out of legal compliances and to obtain benefits, it is suggested to strengthen the energy management cell of the company. The concepts and benefit of energy management should be imbibed in all employees.

4. Process analysis and energy optimization: Pulping is a complex process, it is difficult to ensure that energy saving at one part of the operation do not lead to losses elsewhere. A system engineering approach is essential to ensure that any energy efficiency project reduces the global energy use of the mill, and doesn’t merely shift the energy use to another area. As such, it is suggested to appoint reputed consultant equipped with computer based simulation techniques to asses the energy optimization in the processes.

5. Expertise of both technical and financial knowledge is required to find out energy conservation opportunities. Therefore, it is suggested to appoint a reputed energy consultant to implement measures, which reduce energy consumption, and costs in a technically and financially viable manner.

6. Project Identification and Selection: While selecting an energy conservation project, apart from economic viability, other criteria like cross- effect should also be considered; otherwise, it may have impact on total return. The economic benefits arising from

reducing energy consumption may exceed the energy cost savings, and could include a credit for every tone of CO_2 emissions reduction achieved by either reducing fossil fuel consumption or switching from a dirty fuel to a cleaner one.

7. As one of the activities of the energy management cell, CPM should make educating all employees on energy management a priority. The corporate wide communication helps to transfer best practices from one plant to another. Therefore, management should establish a well communication plan.

8. Benchmarking is one of the first steps a mill should undertake. Benchmarking enables senior management to compare the relative performance of their mills with similar mills or with a model mill representing the current best practice. It provides the motivation for looking at energy conservation opportunities in mill operations.

9. Efficiency of equipment has a direct impact on energy consumption. So while making decision with regards to replacement, or installation of new equipment management should have strategic plan to go for energy efficient equipment, so that total cost of owner ship is minimized.

10. Every year budget is prepared and allocated to different cost centers based on its utilities, like replacement of spares of equipments, consumables, lubricant, annual maintenance and procurement of new equipment as capital one. It helps to have better allocation and accountability of fund. Therefore, to have accountability and effectiveness of the program it is proposed to allocate separate fund for energy management program.

11. Financing energy efficiency projects: Projects relating to energy cascading and processes changes almost always involve high cost coupled with high return. These projects may be carried out by financing from external sources. Energy services companies (ESCO), offer several energy efficiency services, generally bundled with the financing. They conduct energy audit of the facility, structure financing for the measures and install the energy efficiency equipment. This may be the one of the effective means of financing energy efficiency projects.

12. Continuous performance monitoring and improvement: Continuous monitoring and improvement system must be put in place. Once capital budgets have been allocated and the projects implemented, it is important to be able to show that the savings continue to be reaped, year after year. As well, it is important to treat energy efficiency as a continuous improvement process: once a set of projects has been implemented, it is important to start planning the next iteration in the energy efficiency program.

13. A corporate awareness program could effectively increase the knowledge of employees to improve energy efficiency of the equipment and processes. Therefore, to enhance knowledge of employees relating to energy, there should be a comprehensive awareness

and educational training plan in place. Employees should be encouraged to participate in energy management program through recognition, and rewarding.

14. Apart from the above training programme, management should adopt best human resources management practices, giving more focus in cohesive team building; improving inter-group relationship; creating continuous learning environment; motivation of employees; and knowledge management.

5. RECOMMENDATIONS AND CONCLUSIONS

Energy management is a continuous process and participation of all employees is must for its successful implementation. As per the ECA,(2001) it is an obligation to have an energy management program in an energy intensive industry like pulp and paper. As such, apart from recommendations made in the previous chapter, the corporate management has a big role to play in education and training of employees, employee involvement and awareness and institutional capacity building for energy management.

Management needs to integrate energy management in to the business strategy of the company rather than merely focusing on regulatory compliance. They should use industry's capabilities and resources in a responsible and sustainable way. The fundamental problem lies in the fact that market prices for energy and raw materials tend to reflect only their direct costs. Prices reflect neither ecological costs, in terms of damage to the environment, nor the depletion of natural capital when a non-renewable source is used. Corporate management should resolve the problem that will encourage and facilitate managers to measure the contribution to the environment.

A corporate awareness program could effectively increase the knowledge of employees to improve energy efficiency of the equipment and processes. They should encourage the employees to follow good house keeping; bring energy conservation ideas to the energy management cell. The energy management team should work with all employees to develop ideas for energy conservation initiatives. The first step in improving energy efficiency in industry is good house keeping .The activities include (Dincer and Rosen, 2007):

- carrying out inspection to encourage conservation
- institutional training program on operating energy intensive equipment
- scheduling energy intensive activities
- turning of equipment when not in use
- installing and using energy monitoring equipment
- insulation of hot surfaces
- repairing leaks of steam and water.

At any given time, the mix of technologies used by the industry ranges from outdated to the state of the art. As observed by the researchers in pulp and paper industry, most of the state of the art technologies use 12% to 38% less energy than a mix of process currently used. So management must have a strategic planning to adapt to the new technologies by modernization and technical up gradation in phase manner.

Researches found that in pulp and paper industry, wear alone reduces pump efficiency significantly compared with their original performance. So management should adopt a mechanism to measure the performances of various pumps and to take necessary energy conservation activities like replacement of less efficient pump with energy efficient one in phase manner.

The purpose of the study was to analyze the energy management program and to find out energy conservation opportunities in various processes of Cachar Paper Mill. Industrial energy efficiency is frequently overlooked by policy makers concerned about energy supply and use. Although designing an industrial energy efficiency program takes time and must be undertaken with some care, the opportunities for improving the efficiency of industrial facilities are substantial.

Energy management is a continuous process and participation of all employees are must for its successful implementation. In order to educate people at all levels, to create awareness, energy management program should have better educational plan in place. It is clear from the literature that there should be a strategic energy planning in place and it should be integrated with the business strategy.

It has been observed that adoption of energy management program like utilization of renewable source of energy i.e. use of bamboo dust for generation of producer gas not only helps in reduction of furnace oil, but it also helps in reduction of carbon dioxide emission along with the economic benefits.

It has become clear from the study that the mill is running with higher specific consumption of electricity, steam and water as compared to the best operating mills in India. So there exists lot of energy conservation opportunities as compared to the best operating mills .In the analysis it has been observed that a significant amount of steam, water, and electricity can be saved by implementing the energy conservation opportunities in different sections as recommended. Thus it will reduce the cost of energy and hence cost of production. During the study 19 energy saving proposals have been recommended grouped under low, medium and high cost with low, medium and high return. It will result in saving of INR 12,124,152 per annum with investment of INR 8,885,000.

The mission and vision statements of HPC reflect its focus towards the commitment of the top management towards implementation of energy management program. HPC’s greater thrust for higher productivity is in harmony with its concern for a cleaner environment, energy efficiency. Therefore it is hoped that HPC’s economic strength will be significantly enhanced by the implementation of energy efficient processes and systems.

LITERATURE AND SOURCES

Literature

1. Barrat, R. (1996): The energy audit, in Misra, K.B. (Ed.): Clean production: environment and economic perspectives. Springer, Verlag, Berlin.
2. Bedell, J. M. and Short, D. (2008): Strategic energy planning: A sustainable approach for long-term energy efficiency. *ICSC Certified Professionals Newsletter*, February 2008, volume: 3, issue: 1.
3. Bennett, C. J., and Whiting, A. (2005): Navigating energy management: A roadmap for business. The Conference Board; *Executive action series*, September 2005, No: 160.
4. Bureau of Energy Efficiency (BEE). (2004): General aspect of energy management and energy audit. Bureau of Energy Efficiency, New Delhi. (URL:http://www.bee-india.nic.in/sidelinks/Announcement/book1.html), (Accessed 15 June 2008).
5. Capehart, B. L., Turner, C., Kennedy, W. J. (2003): Guide to energy management. Fourth edition, The Fairmont Press, inc., Lilburn.
6. Chandler, A. (1962):"Strategy and structure-chapters in the history of the American enterprise''. The MIT press, Cambridge, Massachusetts.
7. CIPEC. (2002): Energy efficiency planning and management guide. Natural Resources Canada, Ottawa.
8. de Beer, J., Phylipsen, D., Bates. (2001): Economic evaluation of carbon dioxide and nitrous oxide emission reductions in industry in the EU. Brussels: European Commission DG Environment.
9. de Beer, J.G., Harnisch, J., Kerssemeeckers, M.K.(2000): Greenhouse gas emissions from Iron and Steel Production. IEA Greenhouse Gas R&D Programme, Cheltenham, UK.
10. Dincer, I. and Rosen, M. (2007): Exergy: energy, environment and sustainable development. Elsevier, Linacre house, Jordan hill, Oxford.
11. Drucker, P. F. (1974): Management: tasks, responsibilities, and practices. Butterworth Heinemann, Linacre House, Jordan Hill, Oxford, Woburn.
12. Energy Efficiency and Conservation Authority (EECA): Energy audit manual New Zealand, 2007. (URL: http://www.eecabusiness.govt.nz/emprove/emprove-library/implementation/conduct-an-audit/guide/energy-audit-manual-07.pdf), (Accessed July 2007).
13. European Climate Change Programme (ECCP). (2001): Long report. Brussels: European Commission, DG Environment. (URL:http://europa.eu.int/comm/environment/climat/pdf/eccp_longreport_0106.pdf), (Accessed 25 July 2008).
14. Galitsky, C., Price, L., Worrell, E. (2004): Energy efficiency programs and policies in the industrial sector in industrialized countries. Lawrence Berkeley National Laboratory, LBNL-54068. (URL:http://repositories.cdlib.org/lbnl/LBNL-54068), (Accessed 15 July 2008).

15. Galitsky, C., Worrell, E., Radspieler, A., Healy, P., Zechiel, S. (2005): BEST winery guide book: benchmarking for energy and water savings tool for the wine industry. Berkeley, CA: Lawrence Berkeley National Laboratory, LBNL-3184.
16. Guide for energy management overview: Energy Star. (URL:htpp//www.energystar.gov/index.cfm?c=guidelines.guidelinesndex), (Accessed 11 July 2008).
17. Intergovernmental Panel on Climate Change (IPCC). (2001): Climate change 2001: Synthesis report. Cambridge, UK and New York, Cambridge University Press. (URL: http://www.ipcc.ch/pdf/climate-changes-2001/synthesis-spm/synthesis-spm-en.pdf), (Accessed 1 August 2008).
18. Jauch, L. R. and Glueck, W. F. (1988): Business policy and strategic management. McGraw Hill, Singapore.
19. Lackner, P. and Holanek, N. (2007): Step by step guidance for the implementation of energy management. Österreichische Energieagentur – Austrian Energy Agency, Vienna.
20. Martin, N., Worrell,E., Price, L.(1999): Energy efficiency and carbon dioxide emission reduction opportunities in the U.S. cement industry.Berkeley,CA: LawrenceBerkeley National Laboratory, LBNL-44182.
21. Mashburn, W. (2007): Effective energy management, in Turner, W. C. and Doty, S. (eds.): Energy management handbook. The Fairmont Press, Lilburn.
22. McKane, A., Price, L., Can. S. (2007): Policies for promoting industrial energy efficiency in developing countries and transition economies. UNIDP, Vienna.
23. McKane, A., Williams, R., Perry, W., Tienan, L. (2007): Setting the standard for industrial energy efficiency. EEMODS, Beijing.
24. Mike, R.: Strategic energy management delivers bottom-line benefits. *Pulp & Paper*, November 2007. (URL:http://findarticles.com/p/articles/mi_qa3636/is_200711/ai_n21138029), (Accessed 18 July 2008).
25. Parish. A.: Managing Energy: A strategic guide for SME's strategic energy. Ireland. (URL:htp://www.sei.ie/get File. asp? FC_ID=182&docID=699), (Accessed 1March 2008).
26. Price, L., Worrell, E., Sinton, J., Yun, J. (2003): Voluntary agreements for increasing energy-efficiency in industry: Case study of a pilot project with the steel industry in Shandong province, China. Berkeley, CA: Lawrence Berkeley National Laboratory, LBNL-52715.
27. Price, L., Sinton, J., Worrell, E., Phylipsen, D., Xiulian, H.: Energy use and carbon dioxide emissions from steel production in China. *Energy*, May 2005, volume: 27, No: 5.
28. Price, L., Galitsky, C., Kramer, K.J., McKane, A. (2008): International experience with key program elements of industrial energy efficiency or greenhouse gas emissions reduction target-setting programs. Berkeley, CA: Lawrence Berkeley National Laboratory, LBNL-63807, Rev.1.

29. Price, L., Worrell, E., Phylissen, D. (1999): Energy use and carbon dioxide emissions in energy-intensive industries in key developing countries. Conference Paper, Earth Technologies Forum, volume: 25, issue: 12, September 27-29, 1999.
30. Porter, M. E. (1980): Competitive strategy-techniques for analyzing industries and competitors. The Free Press, A Division of Macmillan Inc., New York.
31. Richarz, C., Schulz, C., Zeitler, F. (2007): Energy efficiency: Principles. 1st edition, Wessel-Kommunikation, Baden-Baden.
32. Schultz, S. and Bridger, B. (2004): Making energy efficiency a competitive advantage. 3 M Stem-winder, November 9-22, 2004.
33. Schmidt, P.S. (2007): Steam and condensate systems, In Turner, W. C. and Doty, S. (eds.): Energy management handbook. The Fairmont Press, Lilburn.
34. Schumacher, K. and Sathaye, J. (1999): India's cement industry: productivity, energy efficiency and carbon emissions. Environmental, Berkeley, CA: Lawrence Berkeley National Laboratory, (LBNL-41842).
35. TERI. (2003): The energy resources institute energy data directory and yearbook 2002-03. TERI, New Delhi.
36. Tripp, D. (1998): Training in energy management through open learning: A Broad-Scale, independent study program prepares energy managers with a 16-Step "Hands-On" tutorial. *Canadian Property Management*, December 1998. (URL:http://www.cietcanada.com/pubart.htm#Temol), (Accessed 19 July 2008).
37. Tripp, D. and Dixon, S. (2003): Making energy management " Business as Usual": Identifying and responding to the organizational barriers. (URL: http://www.cietcanada.com), (Accessed 28 March2008).
38. Turner, C., Capehart, B. L., Parkar, S. A., Doty, S. (2007): Introduction to energy management, in Turner, C. and Doty, S. (eds.): Energy management handbook. The Fairmont Press, Inc., Lilburn.
39. UNIDP (2005): Business partnership programme: A joint government of India, FICCI, and UNIDO initiative. December 2005. Austria Centre, Vienna. (URL: http://www.unido.org/fileadmin/import/45314_presentationficci.pdf),(Accessed 25July 2008).
40. World Energy Council (2004): Energy efficiency: A worldwide review – indicators, policies, evaluation. World Energy Council, London. (URL: http://www.worldenergy.org/documents/eepi04.pdf), (Accessed 2 August 2008).
41. Worrell, E., Martin, N., Price, L. (2001): Energy efficiency and carbon dioxide emissions reduction opportunities in the U.S.iron and steel industry. *Energy, The International Journal*, 2001, volume: 26, p. 513-536, LBNL-47910.
42. Worrell, E., Price, L., Galitsky, C. (2004): Emerging energy-efficient technologies in industry: Case studies of selected technologies. Berkeley, CA: Lawrence Berkeley National Laboratory, LBNL-54828.

Sources:

1. Annual Report: Ministry of Commerce and Industry 2005-06. India, 2006.
2. Annual Reports of HPC (Hindustan Paper Corporation) 2004-2005, 2005.
3. An energy efficiency guide to industrial plant managers in Ukraine.(1999): Advanced international studies unit. Pacific North West National Laboratory.
4. Bamboo Sector; (URL: http://investinmizoram.nic.in), (Accessed 15 July 2008).
5. Bureau of Energy Efficiency, India (URL:htp:// www.bee-india.nic.in/), (Accessed 2 March 2008).
6. Center for Pulp and Paper Research Institute and Jaakko Poyry Study, 2006.
7. Central Pollution Control Board, India: Water consumption norms, Paper industries. (URL:www.cpcb.nic.in/oldwebsite/New%20Item/EXECUTIVESUMMARYfinal.pdf), (Accessed 18 July 2008).
8. Central Pulp and Paper Research Institute (URL: http:// www.cppri.org.in/publication 1999 html), (Accessed 10March2008).
9. Chemical Pulping and Chemical Bleaching, 2007, (URL:http://www.cpcb.nic.in/New%20Item/pub_paper_mills),(Accessed 31 July 2008).
10. Diary of HPC, 2007.
11. Energy management policy guideline for energy intensive industry in India by Bureau of Energy Efficiency (URL:htp://www.energymanagement. training.com/energy management/Energy%20Management%20Practices%20-%20pulp%20and%paper.pdf), (Accessed 15March2008).
12. Globalization of the paper industry, 2007: Over-investment in China. (URL: http://www.pulpandpaper.net), (Accessed19January2008).
13. GERIAP (2006): Energy efficiency guide for industry in Asia. United Nations Environment Programme. (URL:http://www.energyefficiencyasia.org/brochure_pub.html), (Accessed 15 July 2008).
14. HPC –Performance Report 2007-2008. India, 2008.
15. Hindustan Paper Corporation Limited. (HPC): (URL: http://www.hindpaper.in), (Accessed 30 July 2008).
16. Indian Pulp and Paper Mills, 2007 (Process Wise List of Indian Pulp and Paper Mills). (URL: http://www.energymanagertraining.com), (Accessed 15 August 2008).
17. Ministry of Statistics and Programme Implementation, India, 2007, National Account Statistics 2007, New Delhi. (URL: http:// www.mospi.nic.in/), (Accessed 17 July 2008).
18. The Energy Conservation Act, 2001, India. (URL:http://wwww.petroleum bazzar.com/library/EC_ActPdf), (Accessed 1March 2008).
19. Tripp, D. (1998): The human side of energy management: Energy management and jobs. *EnergyManagerMagazine*, July1998 (URL:http//www.cietcanada.com/pubart.html#Temol), (Accessed 15 July 2008).