MANUAL ON ENERGY CONSERVATION MEASURES IN PAPER CLUSTER MUZAFFARNAGAR




ENERGY IS LIFE
BEE
CONSERVE IT

Bureau of Energy Efficiency (BEE)

Ministry of Power, Government of India

Deloitte.

Prepared By

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ABBREVIATIONS

MSME	Micro Small and Medium Enterprises
SMEs	Small and Medium Enterprises
GOI	Government of India
BEE	Bureau of Energy Efficiency
EE	Energy Efficiency
DPRs	Detailed Project Reports
TPA	Tonnes Per Annum
MTOE	Metric Tonnes of Oil Equivalent
mn kJ	Million Kilo Joules
kW	Kilo Watt
hp	Horsepower
kWh	Kilo Watt Hour
GHGs	Green House Gasses
LSPs	Local Service Providers

1 About BEE's SME program

1.1 PROJECT OBJECTIVES

Under the provisions of the Energy Conservation Act, 2001, Bureau of Energy Efficiency has been established with effect from 1st March, 2002 by merging into it, the erstwhile Energy Management Centre, being a society registered under the Societies Registration Act, 1860, under the Ministry of Power. The mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy.

The target growth for industry sector was put at 10% during 10th Plan consistent with an overall GDP growth of 8%.The rate of growth of industry sector as measured in IIP (Index of Industrial Production) was 7.8% during April – December 2005 compared to 8.6% in the corresponding period of 2004-05 (Economic Survey, GoI, 2005-06). Manufacturing sector grew at 8.9% during this period, contributing for the overall growth of the economy. Indian industry sector accounted for nearly 43% of commercial energy consumption during 2003/04 (93 million tonnes of oil equivalent) with coal and lignite meeting nearly 1/3rd of the consumption requirements Industry sector also offers maximum potential for energy conservation. The Government of India has also recognized this when a number of energy intensive industries were included as designated consumers in the Energy Conservation Act, 2001. Under the provisions of the EC Act, the identified energy intensive industries need to comply with the conduct of regular energy audits and implementation of techno-economically viable recommendations and establishment of energy management systems through appointment of certified Energy Manager, and meeting of specific energy consumption norms once developed. To bridge the efficiency gaps in the various units within the same sub-sector, there is need to identify general and specific energy saving measures to facilitate the industries in their faster implementation in their respective plants. However the need for developing information and projects in much more in the SME sector which usually cannot obtain or source the information needed with regard to energy efficiency.

Large number of Small and Medium Enterprises (SMEs) like foundries, brass, textiles, refractories, brick, ceramics, glass, utensils, rice mills, paper manufacturing units etc, are said to have large potential for energy savings. Many of these units are in clusters located in various states of the countries. In quantitative terms, there is not much authentic information and data available with respect to their energy consumption and energy saving opportunities. Majority of SMEs are typically run by entrepreneurs who are leanly staffed with trained technical and managerial persons to deploy and capture energy efficiency practice to reduce manufacturing cost and increase competitive edge. Therefore, it will be useful to build their energy efficiency awareness by funding/subsidizing need based studies in large number units in the SMEs and giving energy conservation recommendations including technology up-gradation opportunities. It is envisaged that such interventions supported by diagnostic studies and pilot projects at cluster level focusing on energy/resource efficiency, energy conservation and technology up gradation. This would help in addressing the cluster specific problems and enhancing energy efficiency in SMEs.

BEE has decided to initiate diagnostic studies in 28 clusters to prepare cluster specific energy efficiency manuals covering Specific energy consumption norms, energy efficient process and technologies, best practices, case studies, etc. These studies would provide information on technology status, best operating practices, gaps in skills and knowledge, energy conservation opportunities, energy saving potential, etc for each of the subsector in SMEs. The studies/projects will also be aimed to provide a direction for designing sub-sector specific energy conservation programs in the SME sectors. BEE will also undertake capacity building of local service providers and entrepreneurs/ managers of SMEs. The local service providers will be trained in order to be able to provide the local services in the setting of energy efficiency projects in the clusters.

The programme will prepare detailed project reports for about 15 energy efficiency projects in per cluster. These projects will be prepared in such a way that a minimum of 5 technologies are covered and about three sizes (scale) are considered

The global objective of the project is to improve the energy intensity of the Indian economy by undertaking actions in the SME sector which directly or indirectly produces 60% of the GDP. The immediate objective of the project is to accelerate the adoption of EE technologies and practices 28 chosen clusters in the SME sector through knowledge sharing, capacity building and development of innovative financing mechanisms.

Program objectives will broadly cover 4 major activities which are part of this program.

1. Energy Use and Technology Analysis
2. Capacity Building,
3. Implementation of EE measures,
4. Facilitation of Innovative Financing Mechanisms

1.2 EXPECTED PROJECT OUTCOME

The outcome of the project will be the adoption of EE technologies and practices in chosen clusters in the SME sector through knowledge sharing, capacity building and generation of bankable energy efficiency (EE) project proposals for financing/co-financing and focusing the cluster of projects with effective communication mechanism to maximize the chances of getting bankable projects and development of innovative financing mechanisms

The project will help in assessing total energy usage in cluster, a cluster manual for each of the chosen SME cluster which will give an overview of the cluster, technologies in use, potential for energy savings, EE measures applicable, Best Practices / Technological Innovations in the cluster.

1.3 PROJECT DURATION

Duration of the project is around two and half years. Situation analysis which was the first activity as part of this program was started in January 2009. The last activity of the program is planned to get over by June- July 2011.

1.4 IDENTIFIED CLUSTERS UNDER THE PROGRAM

BEE has rolled out SME Energy Efficiency program in phases. Phase 1 comprised of 7 clusters, Phase II consists of 18 clusters and now recently 3 clusters are added in Phase III. In totality there are 28 clusters which are indentified by BEE for this study.

List of clusters with their product name and location is mentioned in the table below:

Table 1: List of BEE SME Energy Efficiency Program Clusters

Sr. No	Cluster	Product Name	State
1	Jamnagar	Brass	Gujarat
2	Warangal	Rice Milling	Andhra Pradesh
3	Surat	Textiles	Gujarat
4	Pali	Textiles	Rajasthan
5	Morvi	Ceramics	Gujarat
6	Ahmedabad	Chemical Industries	Gujarat
7	Solapur	Textiles	Maharashtra
8	Alwar	Oil Milling	Rajasthan
9	Bangalore	Machine Tools	Karnataka
10	Batala, Jalandhar and Ludhiana	Foundries	Punjab
11	Bhimavaram	Ice Making	Andhra Pradesh
12	Bhubhneswar	Brass	Orissa
13	E & W Godavari	Refractories	Andhra Pradesh
14	Ganjam	Rice Milling	Orissa
15	Gujarat	Dairy	Gujarat
16	Howrah	Galvanizing	West Bengal
17	Jagadhri	Brass and Aluminum	Haryana
18	Jodhpur	Limestone	Rajasthan
19	Jorhat	Tea	Assam
20	Kochi	Sea Food Processing	Kerala
21	Muzaffarnagar	Paper	Uttar Pradesh
22	Orissa	Sponge Iron	Orissa
23	Vapi	Chemicals & Dyes	Gujarat
24	Varanasi	Bricks	Uttar Pradesh
25	Vellore	Rice Milling	Tamil Nadu

26	Alleppey	Coir	Kerala
27	Mangalore	Tile	Karnataka
28	Tiripur	Textile	Tamil Nadu

2 Cluster scenario

2.1 OVERVIEW OF SME CLUSTER

2.1.1 Paper Industry

India's economy has experienced remarkable growth in the last 5 years. There is a clear demand growth in all-major sectors of the economy including the manufacturing sector. The Indian paper industry is poised to grow and touch 11.5 million tonnes in 2011-12 from 9.18 million tonnes 2009-10 at the rate of 8% per annum[1].

The Indian Paper Industry accounts for about 1.6% of the world's production of paper and paperboard. The estimated turnover of the industry is Rs 25,000 crore (USD 5.95 billion) approximately and its contribution to the exchequer is around Rs. 2918 crore (USD 0.69 billion). The industry provides employment to more than 0.12 million people directly and 0.34 million people indirectly. There are about 666 paper industries engaged in the manufacture of pulp, paper, and paperboards, of which about 568 units with a total installed capacity of 7.40 MT per annum are in operation, whereas 98 units with an installed capacity of 1.1 MT have been closed down. About 38% of the total paper production is based on recycled paper, 32% on wood, and the remaining 30% on agri-residue. Production of paper and paperboards increased from 5.90 MT in 2005/06 to 6.14 MT in 2006/07 and was 4.15 MT in 2007/08 (up to November). The country is almost self-sufficient in the manufacture of most varieties of paper and imports only certain speciality papers such as coated and cheque papers from Singapore, USA, UK, Japan, Germany, and Malaysia. Writing and printing grade paper, art paper, coated paper, and so on are exported to neighboring countries like Sri Lanka, Bangladesh, Nepal, and Middle East countries.

As per industry estimates, per capita paper consumption increased to 9.18 kg on 2009-10 as compared to 8.3 kg during 2008-09. Increase in demand of paper has been hovering around 8% for some time. India has emerged as the fastest growing market when it comes to consumption, posting 10.6% growth in per capita consumption of paper in 2009-10. So far, the growth in paper industry has mirrored the growth in GDP and has grown on an average 6-7 per cent over the last few years. India is the fastest growing

[1] Source - Associated Chambers of Commerce and Industry of India

market for paper globally and it presents an exciting scenario; paper consumption is poised for a big leap forward in sync with the economic growth and is estimated to touch 13.95 million tons by 2015-16. The futuristic view is that growth in paper consumption would be in multiples of GDP and hence an increase in consumption by one kg per capita would lead to an increase in demand of 1 million tons. As per industry estimate, paper production is likely to grow at a CAGR of 8.4% while paper consumption will grow at a CAGR of 9% till 2012-13. The import of pulp & paper products is likely to show a growing trend.

The increasing demand for paper brings with it new challenges of economies of scale, efficient usage of resources, need to develop and expand sustainable use of fibre, and value chain management, etc. Despite the fact that the Indian Paper Industry holds its importance to the national economy, unfortunately it stands fragmented. The average capacity of a paper mill in India is about 10,500 tonnes per annum (35 tonnes per day) compared to 85,000 tonnes per annum (260 tonnes per day) in Asia and 300,000 tonnes per annum (900 tonnes per day) in Europe and North America. The Indian pulp and paper industry is highly fragmented, with top five producers accounting for 25% of the total capacity. Several large integrated mills came onstream during the late 1970s. The government policies in the 1980s and 1990s have led to the growth of a large number of small capacity mills using agro-waste as raw material. The Indian paper industry is highly energy-intensive. The share of energy costs in the total manufacturing cost is close to 25%. Fuel and electricity are two major energy sources used in paper production. There is a growing need to modernize the Indian mills and improve productivity. Most of the paper mills operating in India, particularly small mills, are very old using out-dated technology including plant & machinery. Being protected from international competition for about four decades, Indian paper mills, in general, did not keep up with the technological advancement in the other parts of the world. Hence there is a need to adopt new and efficient technologies because of high product quality, international competition, mounting pressure from environmental regulatory, rise in energy prices, etc.

2.1.2 Cluster background

Muzaffarnagar is situated in Western Uttar Pradesh and is important industrial town with paper, sugar and steel being the major products. Muzaffarnagar paper cluster has around 29 paper units. The entire paper cluster is geographically divided into three areas, namely Bhopa Road, Jansath Road and Shamli in Muzaffarnagar district. The reason for such high concentration of mills is easy availability of raw material in the area. Paper units are normally having out-dated technologies characterized by inefficient energy and water management systems. In terms of raw material usage, mills can be broadly put in two categories – waste paper based and agro-waste based. Similarly, for finished products too, though bulk of the mills produces only kraft paper, a few of them have started producing writing paper. These mills are quite closely networked and successful development in one mill is very rapidly replicated in large number of similar mills.

The total installed capacity of all the paper mills in Muzaffarnagar is approximately 542700 MTPA. These mills are a mix of waste paper & agro. While 12 mills under the BEE SME Program are agro-cum waste paper based, 16 of them are solely waste paper based and 1 mill which is recently established is agro based.

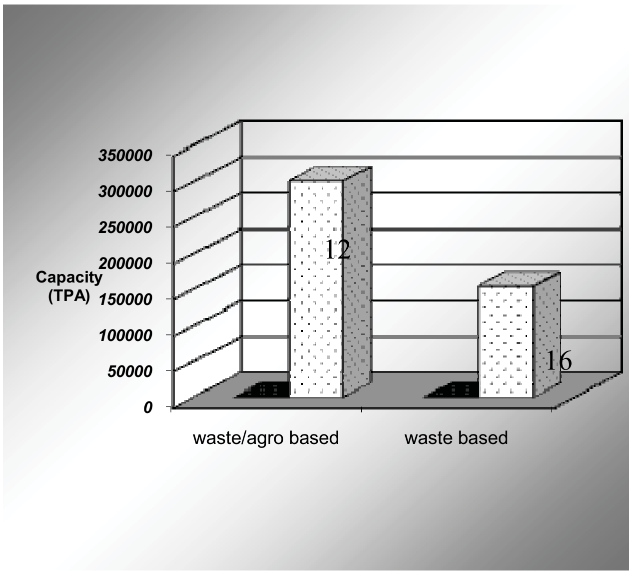

Figure 1: Distribution of paper mills in Muzzaffarnagar

An important aspect of the mills here is that some of these units have a common business operational structure due to fact that they share the same management. As such the cluster based advantage is already being derived by most of these units. A large percentage of these mills were set up in 80's and 90's in the small and medium sector.

The capacity utilization of all these mills ranges from 20% to 90%. Out of the total mills, 43% are based upon both agro and waste material whereas 57% are waste paper based. Classification can also be done based upon the product. While only 16% are involved in the manufacture of only duplex board, a healthy 66% are into making Kraft paper only & 22% make writing/printing paper along with small quantities of either duplex board or Kraft paper.

2.1.3 Product manufactured

Majority of paper mills produce Kraft Paper of varying BF (Breaking Factor) and Duplex Board. A few of them have started producing writing paper. In addition to Kraft paper and writing paper some units also produces Printing paper, Filter paper, Gray Board, Poster Paper and Hard tissue paper.

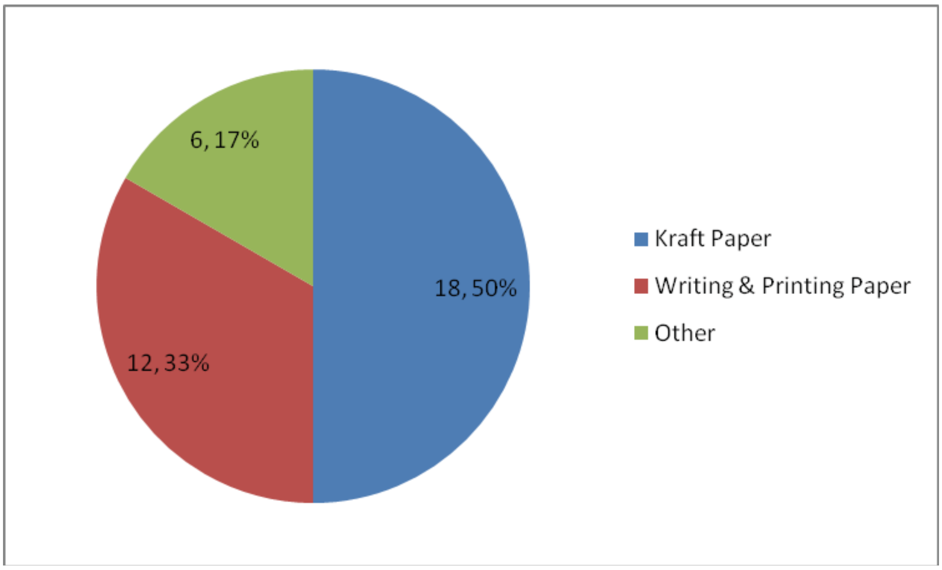

Figure 2: Product wise classification of Paper Mills

2.1.4 Classification of units

Units can be classified broadly with respect to size/capacity, raw material used and the product

Table 2: Classification of Paper Mills

Size	Raw Material	Product
75000 TPA to 3400 TPA	Agro and Waste Paper Based Waste Paper Based Agro Based	Kraft Paper Writing Paper Other

The list of units along with their product, capacity and raw material used is provided in Annexure 1.

2.1.5 Production capacity detail

The paper mills in the cluster vary widely in capacity. There are mills with capacities as low as 1750 TPA and as high as 87500 TPA. The variation with respect to capacity is represented in the chart below.

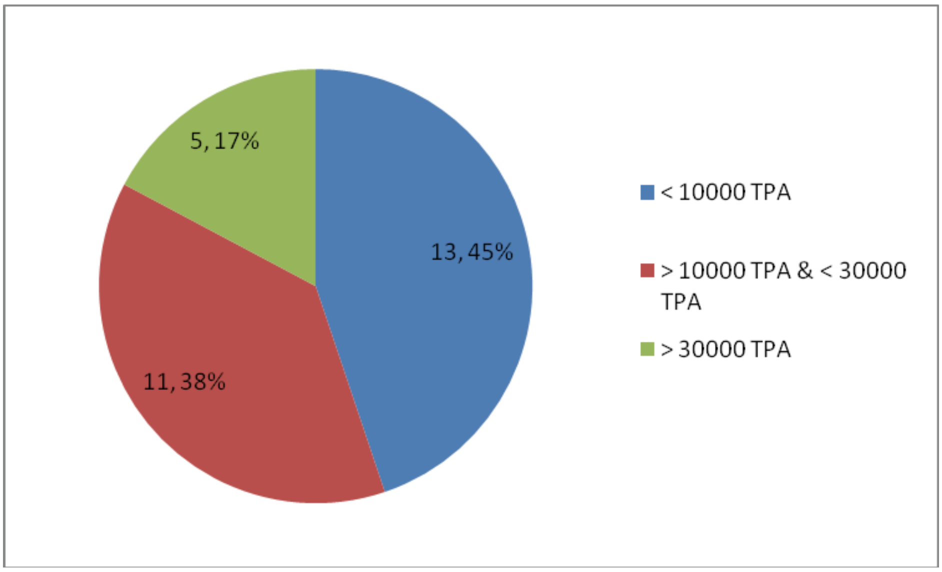

Figure 3: Production capacity wise classification of Paper Mills

2.1.6 Raw materials used

The paper mills in Muzaffarnagar are either based on waste paper or agro residue. While 12 mills under the BEE SME Program are agro-cum waste paper based, 16 of them are solely waste paper based and 1 mill which is recently established is agro based. The variation with respect to raw materials used is represented in the chart below.

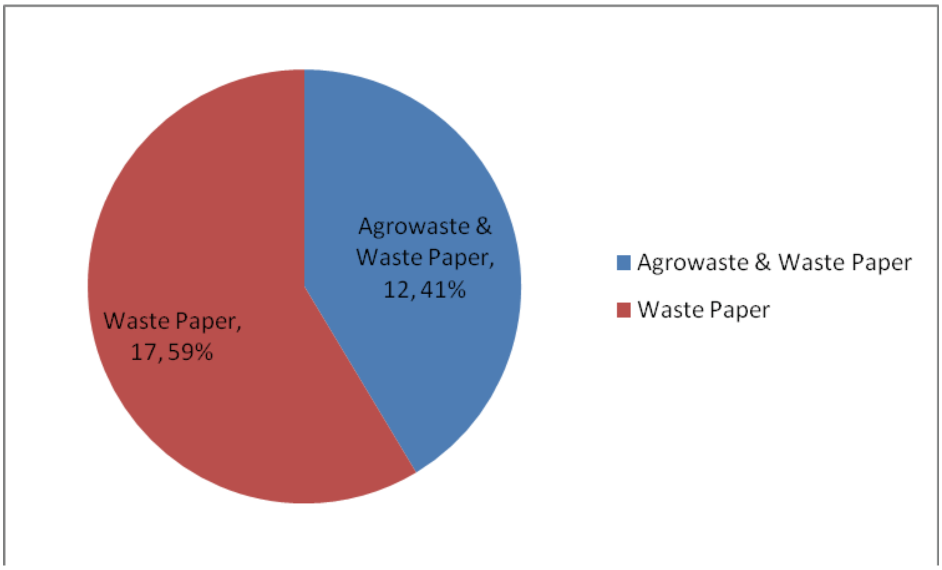

Figure 4: Raw material wise classification of Paper Mills

2.2 ENERGY SITUATION IN THE CLUSTER

Energy is an essential input and a major cost driver in Paper manufacturing. Nearly 26% of the Indian paper Plants have the energy cost to the total cost falling in the range of 20-30% as can be seen from Figure 5 below. However there are examples of world-class paper mills in India with comparable energy consumption. From cursory analysis, it can be stated that there is a possibility of 20-30% reduction in energy consumption of the paper mills in the cluster.

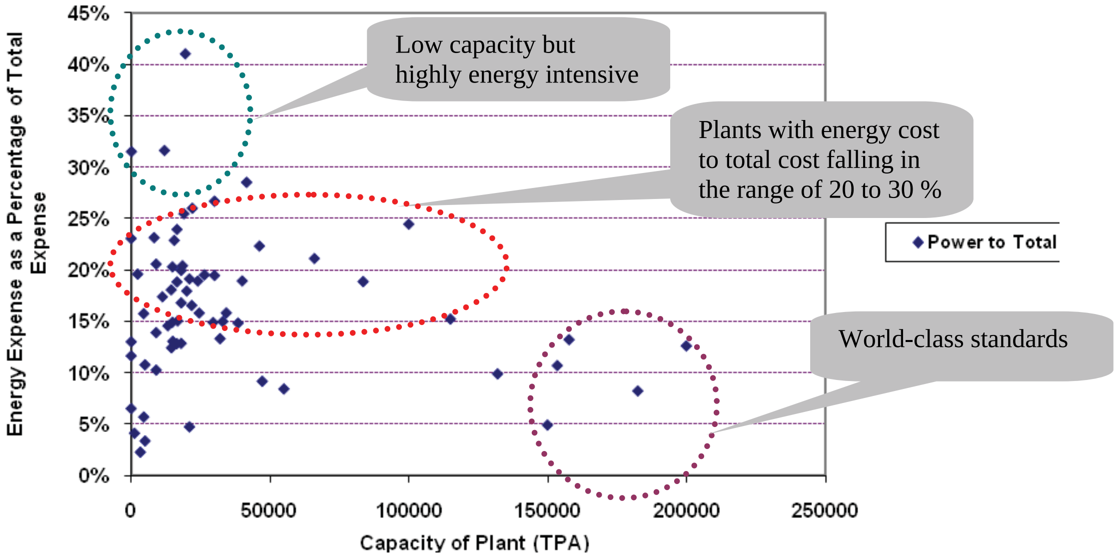

Figure 5: Energy Cost to the total cost in Indian Paper plants

The input costs in manufacturing vary widely depending upon the location of the mill, raw material usage and also finished product profile. Figure 6 below shows the figures for a large section of mills in India.

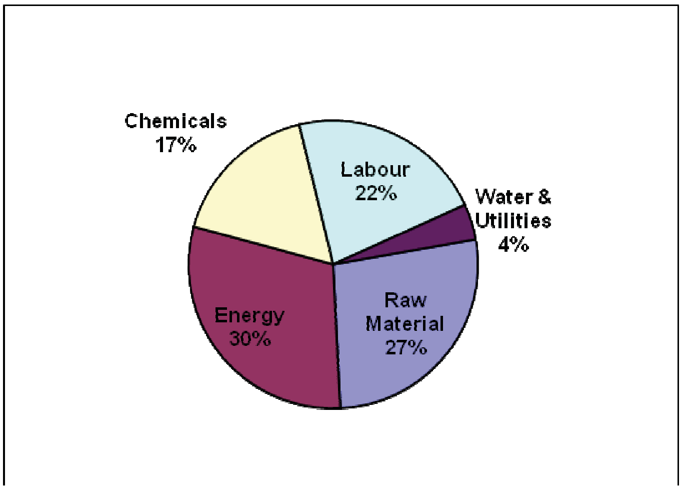

Figure 6: Percentage Contribution of Inputs in Paper Production

However, as would be seen from a later analysis of some of the bigger integrated mills, energy consumption constitutes about 20% of the manufacturing cost on an average.

The figure may vary from mill to mill but it is quite evident that the industry is highly energy intensive. The consumption of steam in a wood based paper mill is 10 to 11 tons/ ton of paper compared to international standards of 6.5 – 8.5 t/t while the power is 1500-1700 kWh/ton of paper compared to 1150-1250 kWh achieved in more efficient units. Almost the entire process of manufacturing is energy intensive as shown in Table below.

Table 3: Energy Consumption in Indian Paper Mills

SN	Section/Equipment	Steam (T/t of paper)	Fuel (GJ/t of paper)	Electricity (KWh/t of paper)	Final Energy (GJ/t of paper)
1.	Chipper			112-128	0.4-0.5
2.	Digester	2.7-3.9	12.5-18.0	58-62	12.7-18.2
3.	Evaporator	2.5-4.0	11.5-185		11.5-18.5
4.	Washing & Screening			145-155	0.5-0.6
5.	Bleaching	0.35-0.4	1.6-1.8	88-92	1.9-2.2
6.	Soda Recovery	0.5-1.1	2.3-5.1	170-190	2.9-5.8
7.	Stock Preparation			275-286	0.99-1.03
8.	Paper Machine	3.0-4.0	13.8-18.5	465-475	15.5-20.2
9.	Deaerator	0.8-1.2	3.7-5.5		3.7-5.5
10.	Utilities and Others			248-252	0.89-0.91
	Total	10-16	46.2-73.8	1500-1700	51.6-80.0

&&

Based on the available data, a number of mills have been analyzed and the specific energy consumption determined as shown in Table below:

Table 4: Specific energy consumption norms for India

Parameter	**Writing and Printing**		**Kraft**		**Boards**	
	Agro	Waste	Agro	Waste	Agro	Waste
Steam T/T	5.8	2.8	4.1	2.3	2.2	2.4

&& SOURCE: IPPTA

Power (kWh/T)	1200	700	650	550	615	685
Steam (GJ/T)	24.6	12	17.6	9.9	9.4	10.3
Power (GJ/T)	4.3	2.5	2.3	2	2.2	2.5
Final Energy (GJ/T)	29	14.5	19.9	11.8	11.6	12.8

++

These figures are by and large 25 to 30% higher compared to the best achieved by number of mills in India and 30 to 40% higher compared to international benchmark. This observation is also in line with findings from numerous audit reports carried out by energy consulting firms from time to time and Governmental agencies like BICP etc.

75-85% of the energy requirement in the paper manufacturing process is in the form of process heat (made available through steam) while 15-25% is needed as electrical power. It is one of the most challenging tasks to benchmark energy cost due to the various diversity factor and also significant difference in the delivered price of fuels due to location factor. It is however, still possible to develop a model for each individual factory for the specific power and steam consumptions. Figure 7 below shows typical energy consumptions for some of the factories producing different kinds of papers.

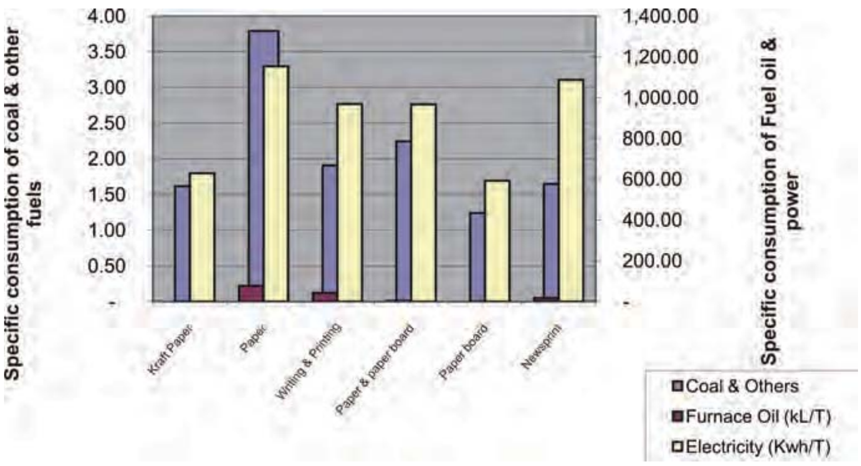

Figure 7: Energy Usage Vs Product type

++ *SOURCE: INDIA'S PULP & PAPER: PRODUCTIVITY & ENERGY EFFICIENCY, LBNL, 1999*

These figures compared to some of the international benchmark (Figure 8 and Figure 9) indicate energy savings opportunity by 30 to 50%. Though like to like comparison may not be very valid for reasons explained earlier, such comparison still provide a directional approach for targeting energy efficiency improvement efforts.

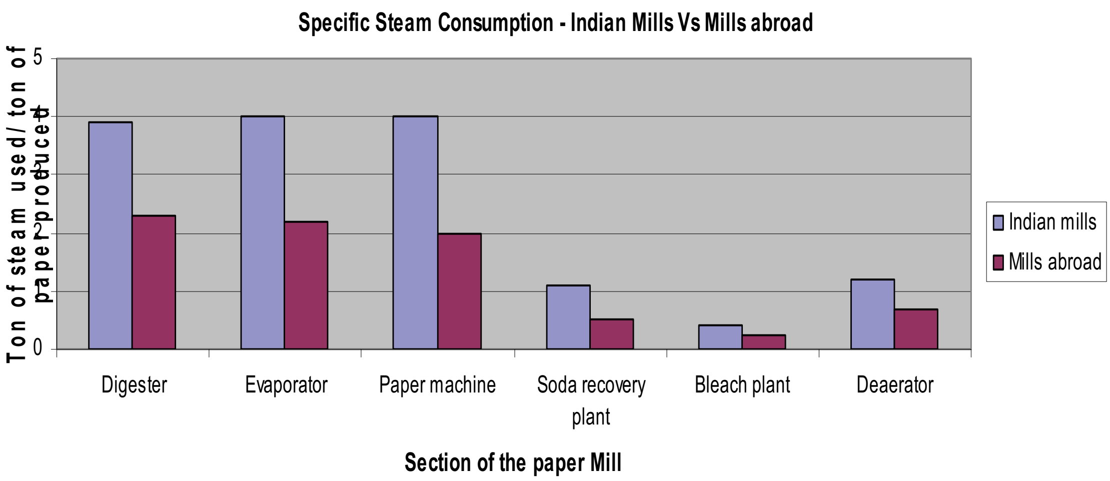

Figure 8: Specific Steam Consumption – Indian Paper Mills Vs International Mills

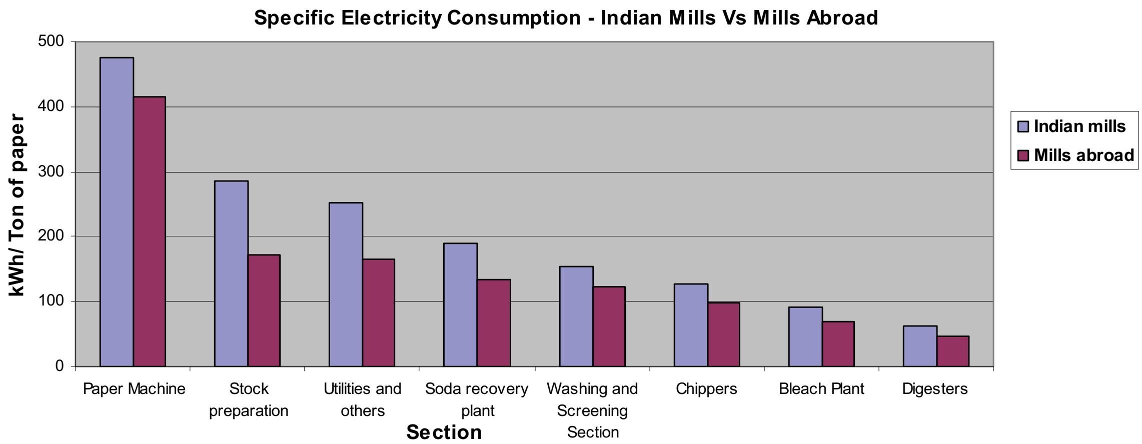

Figure 9: Specific Electricity Consumption – Indian Paper Mills Vs International Mills**

** *SOURCE: LAWRENCE BERKLEY STUDY*

2.2.1 Types of Fuels Used and Prices

The paper mills in the Muzaffarnagar cluster use various types of fuels like coal, biomass, pet coke etc. The primary fuel used in all the mills is coal and biomass. Rice husk, pith and bagasse are the major biomass used in the cluster. In few mills wood chips are also used as a supplementary fuel. The details are of the same are provided in table below:

Table 5: Fuel & Electricity Details in Muzaffarnagar Paper cluster

Sr. No	Fuel	Approx. Calorific Value of Fuels, kCal/kg	Price
1	Coal	3,800	2,770 to 3,800 Rs/MT
2	Rice Husk	3,300	2,500 Rs/MT
3	Bagasse	2,000	550 to 750 Rs/MT
4	Wood	3,500	1,200 Rs/MT
5	Electricity	-	3.00 to 4.45 Rs/kWh

2.2.2 Energy Consumption in Typical Paper Unit

Energy consumption (thermal energy & electrical energy) in Paper unit depends on capacity of unit and raw material used in the unit. Annual Electrical energy and thermal energy consumption in typical paper mill is presented in tables below:

Table 6: Annual Energy consumption in different capacities of Agro Waste and Waste Paper based units

Parameter	Unit	<= 10000 TPA	10000 to 30000 TPA	> 30000 TPA
Electricity[2]				
Annual Consumption	kWh	6,165,556	9,387,530	-
Rate	Rs/kWh	4.23	3.72	-
Fuel				
Annual Consumption	MT	2,141	13,633	36,074
Gross Calorific Value	kCal/kg	2,877	2,664	3,727
Rate	Rs/MT	1,622	2,124	3,217
No. of Units	-	2	6	4
Gross Electricity	kWh	12,331,112	56,325,180	-

[2] All paper units with capacity >30000 TPA have cogeneration units. As such the entire energy consumption is represented in terms of fuel only

Consumption				
Gross Fuel Consumption	Heat, GJ	51,561	912,290	2,250,896
Gross Energy Consumption	MTOE	2,288	26,564	53,593
Total Energy Consumption	MTOE		82,445	

Table 7: Annual Energy consumption in different capacities of Waste Paper based units

Parameter	Unit	<= 10000 TPA	10000 to 30000 TPA
Electricity			
Annual Consumption	kWh	6,054,698	8,489,054
Rate	Rs/kWh	4.23	3.68
Fuel			
Annual Consumption	MT	1,082	5,384
Gross Calorific Value	kCal/kg	3,047	2,687
Rate	Rs/MT	2,761	1,188
No. of Units	-	11	5
Gross Electricity Consumption	kWh	66,601,683	42,445,269
Gross Fuel Consumption	Heat, GJ	151,793	302,805
Gross Energy Consumption	MTOE	9,341	10,859
Total Energy Consumption	MTOE	20,200	

Annual energy consumption in different type of units is calculated and details of the same are presented in same below:

Table 8: Annual Energy consumption in different type of Paper units

S. No	Type of Unit	Energy consumption (MTOE)
1	Agro Waste and Waste Paper Based	82,445
2	Waste Paper Based	20,200

3	Total	102,645

Total annual energy consumption in cluster is around 102,645 MTOE (Metric Tonne of oil equivalent). Percentage of total energy consumption in different type of units in cluster is presented in figure below:

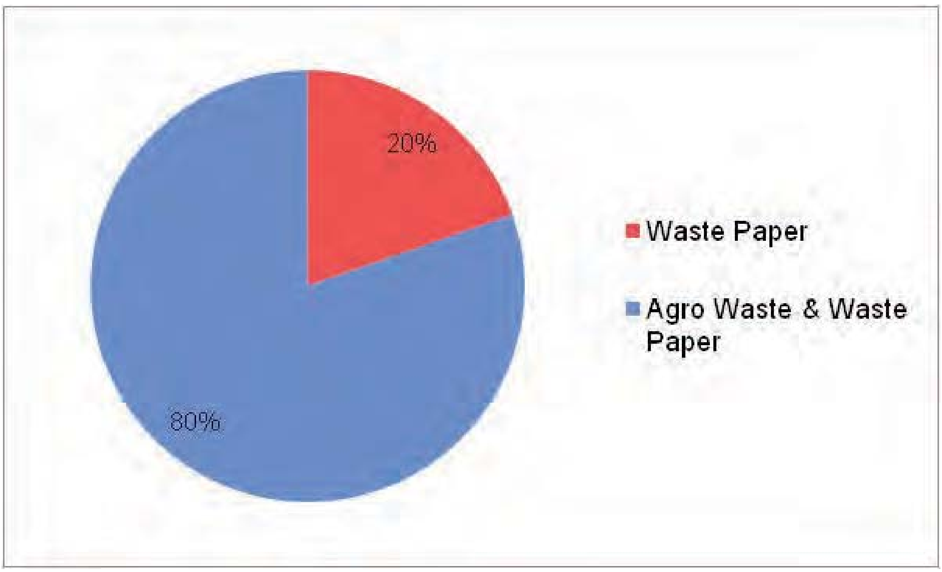

Figure 10: Percentage of total energy consumption in different type of units

2.2.3 Value of Specific Energy Consumption of Typical Paper unit in Muzaffarnagar Paper cluster

The electricity demand of the paper mills in Muzaffarnagar SME cluster is either met through supply from electricity grid or in house generation. The paper mills with grid connection only have DG set as a backup in the event of grid breakdown. Most of the units are self dependant in terms of electricity and have in house facilities to meet the electricity demand. The units have installed biomass/coal based thermal cogeneration systems to meet the steam and power demand of the paper mill simultaneously. The cumulative power generation capacity of the cluster is around 68.3 MW. While some of these systems are efficient with high pressure configuration, there are still a few at medium pressure ratings.

All the units have installed boilers to meet the steam demand of the paper unit. If the unit has captive thermal power generation facility, the steam demand is met through the cogeneration system installed. In other mills where the electricity is supplied through frid, low or medium pressure boilers are installed for stem generation. The specific energy consumption of a typical mill in the cluster is represented below

Table 9: Specific energy consumption

Sr. No	Parameter	Value
1	Specific Electricity Consumption	550 to 1,080 kWh/MT
2	Specific Fuel Consumption	10.13 to 18.15 GJ/MT

Comparing these values with the table in section 2.2 depicting the norms of typical Indian mills, it can be clearly seen and observed that 10.13 to 18.15 GJ/MT is quite higher for Kraft and Board manufacturing paper mills using agro/waste paper as raw material. The 550 to 1,080 kWh electricity consumption per MT of paper is also on the higher end. Considering this fact, there is clear indication of the potential of energy saving opportunities in the cluster.

2.3 MANUFACTURING PROCESS/TECHNOLOGY OVERVIEW

2.3.1 Process technology

Paper is a natural product, manufactured from a natural and renewable raw material, wood. Wood is the primary raw material for the pulp and paper industry. Wood is made from cellulose fibres that are bound together by a material called lignin. The paper industry in Muzaffarnagar cluster uses either the waste paper or agro residue as a source of lignin needed for paper manufacturing process. Recovered paper has become as important a source of new paper as wood - recovered paper now accounts for more than half of the fibres used in the production of paper. However, fibre cannot be usefully recycled endlessly; so there is an ongoing need to feed the supply of recovered fibre with virgin fibre in the form of agri residue. The papermaking process can be broadly divided into three stages:

- Pulping

- Papermaking
- Finishing

PULPING

Paper is made from the cellulose fibres that are present in hardwood and softwood trees. In a pulp mill, the fibres are separated from one another into a mass of individual fibres. Whether using wood or recovered paper, the first step is to dissolve the material into pulp. Regardless of the type of pulping process used, the wood or recovered paper is broken down into its component elements so that the fibres can be separated. After separation, the fibres are washed and screened to remove any remaining fibre bundles. The pulp may then be used directly to make unbleached papers, or bleached for white papers. The water is then pressed out and the residue is dried. The pulping results in a mass of individual fibres being produced. In an 'integrated paper mill' the pulp will be fed directly to a paper machine. Alternatively, it will be dried and pressed into bales ready for use as a raw material in paper mills.

The pulp-making process

1. Timber and debarking
2. Pulp is graded and classified according to: the method of the production (e.g. chemical or mechanical pulp); the species of tree used (e.g. softwood or hardwood); and by level of processing (e.g. bleached or unbleached). Pulp generated from recovered paper is similarly graded.

Making Pulp from Agro residue

In chemical pulping, the Agro Residue (Baggasse)/Wood chips are cooked in a digester with chemicals. Cooking removes lignin, breaking up the wood into fibres. The process results in a slurry, where fibres are loose but intact and have maintained their strength. Generally, chemical pulp is based on one of two processes: sulphate or sulphite. Most chemical pulp is made by the alkaline kraft or sulphate process which uses caustic soda and sodium sulphate to "cook" the wood chips. In the unbleached stage, a dark brown, but very strong pulp results which can be bleached to a high brightness if required. The cooking chemicals are recovered back to the process through evaporation and burning plants. Cooked pulp is washed and screened to achieve more uniform quality.

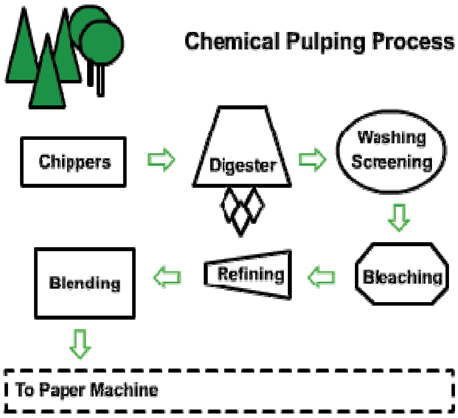

Figure 11: Agro-residue Chemical Pulping Process

The alternative method is the sulphite pulping process. This method is based on an acid cooking liquor process, and it is best suited for specialty pulp. The sulphite mills produce easily bleached pulps, generally with hydrogen peroxide. These pulps fulfil today's demand for "chlorine free" products in the disposables sector and also in printing and writing papers.

The yield in both chemical processes is much lower than in the manufacture of ground wood, as the lignin is completely dissolved and separated from the fibres. However, the waste lignin from the sulphate and some sulphite processes, can be burnt as a fuel oil substitute. In modern mills, recovery boiler operations and the controlled burning of bark and other residues makes the chemical pulp mill a net energy producer which can often supply power to the grid, or steam to local domestic heating plants.

Making pulp from recovered paper

Recycled paper is a type of paper that completely or partially consists of recycled fibres. These fibres can have very different origins and therefore also very different characteristics when it comes to being a component in new paper. Newsprint, tissue and paperboard are the products primarily produced using recycled paper as raw material. Collected paper must first be sorted into different categories. The sorting can take place either directly in the paper mill or at special sorting stations. How the sorting takes place depends to a large extent on how the collection of the paper takes place, which varies from country to country. In most cases bales or loose paper waste is transported to the pulper using conveyor belts. Before printed paper, such as office waste and newspapers, can be processed into graphical paper grades, the ink needs to be removed. There are two main processes for de-inking waste paper - washing and flotation.

In the washing process the waste paper is placed in a pulper - a huge tank that liberates the paper fibres from the paperweb by agitation with large quantities of water - and broken down to slurry. Staples and other undesirable material are removed by using centrifugal screens, thereby diminishing the risk of damage in the processes that follow. Most of the water containing the dispersed ink is drained through slots or screens that allow ink particles through. The pulp does not pass through. Adhesive particles, known as ‘stickies', are removed by fine screening.

In the flotation process the waste is made into slurry and contaminants are removed. Special surfactant chemicals are added to the slurry, which produces froth on the top of the pulp. Air is then blown into the slurry. The ink adheres to the bubbles of air and rises to the surface. As the bubbles reach the top, a foam layer is formed that traps the ink. The foam is removed before the bubbles break so the ink does not go back into the pulp.

When completed, the clean, useful fibre is piped to a storage chest and consequently to the papermaking machine, while the excess materials are skimmed off or dropped through centrifugal force into a sludge that is then burned for fuel, otherwise used or landfilled.

Pulpwood normally arrives at the paper mill in the form of very thick sheets and recovered paper normally arrives in the form of large, compressed bales. Both these materials have to be broken down so that the individual fibres they contain are completely separated from each other. This process is performed in large vessels, known as ‘pulpers', where the raw materials are diluted with up to 100 times their weight of water and then subjected to violent mechanical action using steel rotor blades.

The resulting slurry (known as papermaking stock) is then passed to holding tanks. During this preliminary stage, auxiliary chemicals and additives may be added. The auxiliary chemicals are usually combined with the fibrous raw materials at levels from below 1% to 2% and can be sizing agents, which reduce ink and water penetration, and process anti-foaming agents. Common additives consist of clay, chalk or titanium dioxide that are added to modify the optical properties of the paper and board or as a fibre substitute. The stock is then pumped through various types of mechanical cleaning equipment to the paper machine.

PAPER MAKING

In the pulp and papermaking industry 95% of the water used is cleaned and reused on-site. On the paper machine, more water is added to produce a fibre suspension of as little as 1-to-10 parts fibre to 1000 parts water and the resulting mixture is passed into a head-box which squirts it through a thin, horizontal slit across the full machine width (typically 2 - 6 m) on to a moving, endless wire mesh.

Raw material fibres and chemicals (and 99 % of water) are pumped to the head box, which feeds the stock evenly onto the wire section. This is a woven plastic mesh conveyor belt that can be 35 metres long and as wide as the machine. As the paper stock flows from the head box onto the wire, water is removed on this wire section by a mixture of gravity and suction in a process known as sheet formation where the fibres start to spread and consolidate into a thin mat, which is almost recognisable as a layer of paper on top of the wire mesh. The paper machine can travel at speeds of up to 2000m/minute and by the time the paper stock has traveled half way down the wire, a high percentage of water has drained away. By the time the thin mat of fibres has reached the end of the wire section, it has become a sheet of paper, although very moist and of little strength. It then passes to the press section.

This consists of a number of sets of heavy cylinders through which the moist paper passes. More moisture is squeezed out and drawn away by suction. The paper then passes to the drier section. This consists of a large number of steam-heated drying cylinders which have a temperature of slightly over 100°c. Synthetic drier fabrics carry the web of paper round the cylinders until the paper is completely dry.

Part way down the bank of drying cylinders is the size press, where a solution of water and starch can be added in order to improve the surface for printing purposes. Instead of sizer, a coater can be used which is what happens when coated papers are produced. At the end of the drying process, the paper is smoothed using an "ironing" method, which consists of hot polished iron rollers mounted in pairs, one above the other (calenders or soft calenders). This also helps to consolidate, polish and glaze the surface of the paper.

Still traveling at very high speeds, the paper comes off the machine ready for reeling up into large reels (also called parent reels), which can be cut or slit into smaller ones, according to customer requirement. These large reels are produced and changed without any interruption to the production process.

PAPER FINISHING

The characteristics, appearance and properties of paper and board are supplemented and enhanced by their final treatments. These may be simple processes where the reel is slit into a number of more narrow reels or cut into sheets or more complicated processes such as coating.

Coating improves the opacity, lightness, surface smoothness, lustre and colour-absorption ability of paper. It meets exacting quality demands regarding surface smoothness. Coating means that a layer is applied to the paper, either directly in the papermaking machine or separately. Varieties of coated paper range from pigmented to cast-coated. The coat consists of a mix of pigments, extenders such as china clay and chalk, and binders such as starch or latex. In addition, various chemicals are added to give the paper the desired characteristics.

For even smoother paper surface, super-calendering is required. This is done primarily for magazines and coated papers. The paper passes through rollers, which are alternately hard and soft. Through a combination of heat, pressure and friction, the paper acquires a high lustre surface. The paper becomes somewhat compressed during the process and is therefore thinner than its matt finished equivalent.

2.3.2 Process flow diagram

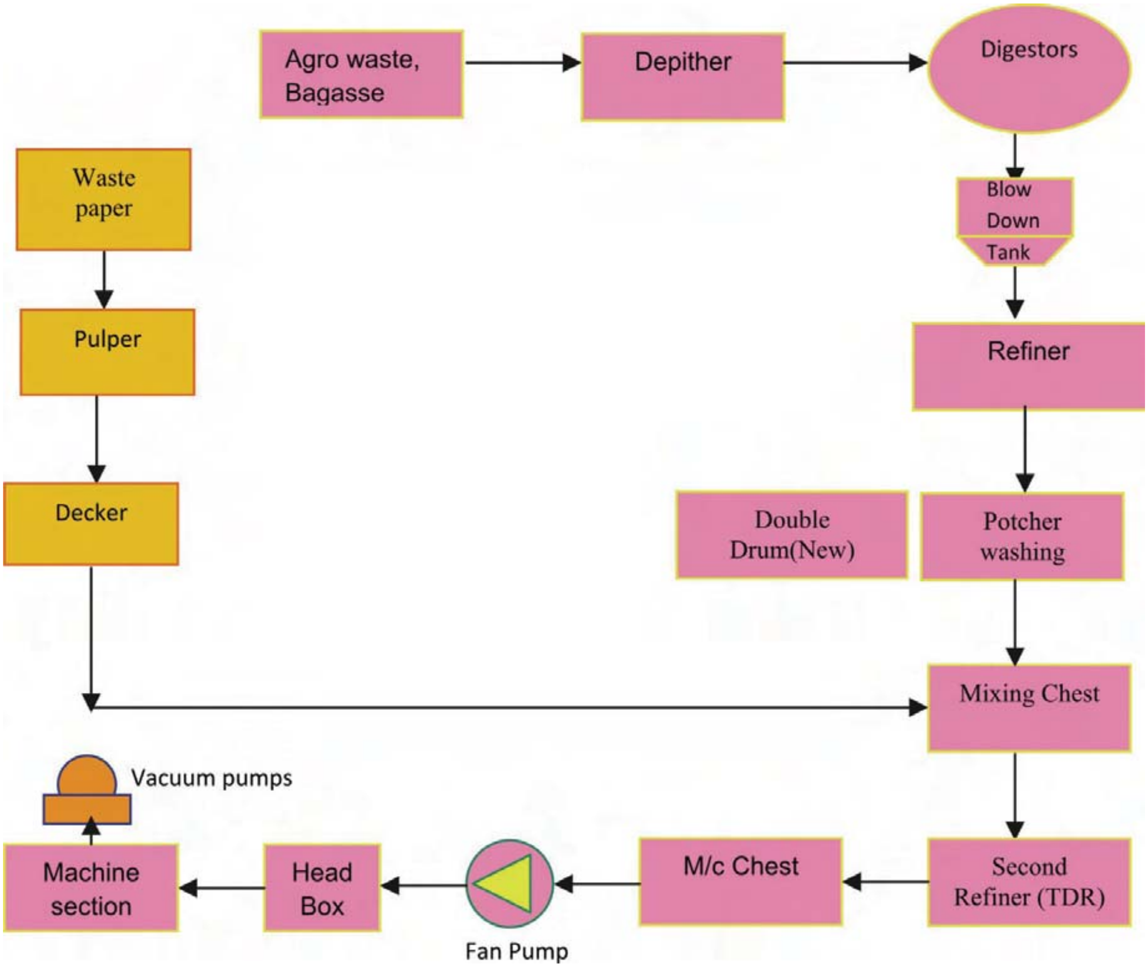

Figure 12: Process Flow diagram representing waste paper & agro residue as raw material

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

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

a) Lack of awareness on energy efficiency
b) Energy efficiency not on priority list
c) Lack of instrumentation and non-availability of data
d) Limited technical manpower
e) Non availability of funds to implement energy conservation measures

Some of these barriers are detailed below.

2.4.1 Technological Barrier – Lack of awareness on energy efficiency

Majority of the entrepreneurs in paper cluster do not have any in depth technical expertise and knowledge on energy efficiency. They are dependent on local technology suppliers, service companies or limited in-house technical expertise, who normally also rely on established and commonly used technology. The lack of technical know-how has made it difficult for the paper unit owners to identify the most effective technical measures.

2.4.2 Financial Barrier – Non availability of funds to implement energy conservation measures

The entrepreneur in Muzaffarnagar paper cluster typically makes investments related to business perspective. They are comfortable investing on project expansion for improving the production capacity as they consider it a more viable proposition as it clearly shows up in the sales ledger. Further, the energy conservation activities not being a common practice in the cluster makes them feel that it is not a viable proposition for investment. In view of this, and given the limited financial strength of paper mill entrepreneurs, they would not take the risks to invest in energy efficiency measures.

2.4.3 Limited technical manpower

Skilled workers are locally available to run the paper mills in the cluster. However, there are very few engineers employed in the mills and the production process remains traditional. This is one of the lacunae of the Muzaffarnagar Paper Cluster.

Specialized training with local service providers for better operation and maintenance of equipments, importance of the energy and its use will create awareness among workforce. These programs should be organized with equipment suppliers.

Likewise in these small and medium sized paper mills the key external industry drivers include technology and process innovations/ equipment that can drive efficiency and access to capital. The cluster's needs are likely to include access to technical expertise and minimization of technical and financial risks. This project can provide them with access to financing, increase awareness on how technology can serve as a driver for profitability and build technical skills. Successful project implementation with effective dissemination can enhance replication potential in other paper clusters. In the larger perspective, this project can set a trend in helping small and medium paper mills leverage donor funds and access private capital markets for investments in environment friendly projects.

For the banks and financial institutions the needs include increasing awareness on benefits of energy efficiency and opportunities for profitability improvement through energy cost reduction, capacity building for appraising energy efficiency investments and developing a pipeline for project financing. This project can help develop demonstration projects, which can help banks design guidelines/ qualifications for bankable energy efficiency projects, develop project pipeline through replication in other clusters and help and design loan programs and financial products to address needs of 2nd tier industry.

2.5 CLUSTER ASSOCIATION DETAILS

Name of the association	UP Paper Mill Association
Contact Person	Mr. Pankaj Aggarwal
Profile	President-UP Paper Mill Association
Contact Details	179, Patel Nagar, New Mandi, Muzaffarnagar, 251001, Ph: 0131 2468589, email: bindlas@usa.com

UP Paper mill association is a body of large, dynamic paper manufactures with global vision. This association presents a platform for development of mutual understanding among the industries and discussion relating to common problems and solution of problems. Association is actively engaged to promote the interest of local paper industry and help it achieve the global competitiveness. Therefore the association readily agreed to BEE SME program and has cooperated at all times in order to reap the benefits of this program. The major objectives of this association are:

a) To promote the spirit of fraternity among its members to improve professional efficiency.

b) To create the awareness about the fast changing technology of the world for better productivity and quality.

c) To provide a common platform to its members to exchange their achievements ideas, experience and problems

3 Energy Audit and Technology Assessment

3.1 METHODOLOGY ADOPTED FOR ENERGY USE AND TECHNOLOGY ASSESSMENT

A team of competitive engineers having experience in the paper sector was involved in carrying out the study at a paper mill. The study was carried out in different phases.

The general scope was as follows:

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

3.2 BOUNDARY PARAMETERS

Following boundary parameters were set on coverage of the audit

- Audit covered all possible energy intensive areas & equipments like paper machine (vacuum pumps, machine drive, machine pumps, rewinders, process), pulp mill (stock pumps, refiners, etc), power plant, steam and condensate distribution, raw water pumps and distribution, other utilities etc.
- All appropriate measuring system including portable instruments was made use of.
- The identified measures normally fall under short, medium and long-term measures.

3.3 GENERAL METHODOLOGY

The general methodology followed is captured in the following chart

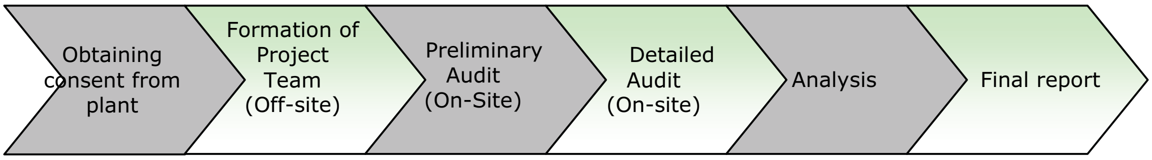

Figure 13: General methodology followed by Deloitte

The study was conducted in 3 stages:

- Stage 1: Preliminary energy audit (PEA) of the plant to understand process energy drivers, assessment of the measurement system, assessment of scope, measurability and formulation of audit plan.
- Stage 2: Detailed Energy audit (DEA)
- Stage 3: Off site work for data analysis and report preparation

The three stages of the study are discussed as follows:

3.3.1 Preliminary Audit

A total twenty numbers of Preliminary energy audit studies were conducted in cluster: The purpose of preliminary audit was to

- Assess the energy conservation potential
- Make an assessment of the measurement system
- Finalize the schedule of equipments and systems for testing and measurement
- Arrange for the infrastructure requirements at site
- Ensure completion of the following measurement requirements
    - Check all the existing measurement and analytical facilities and assess additional requirements for measurement and testing needed for detailed audit.
    - Make arrangements for making available additional instruments where portable instruments cannot be used

- Make arrangements for providing tapings and other connection points required for connecting portable instruments
- Finalize the testing and measurement schedule

- Discuss and finalize the total project schedule.

3.3.2 Detailed Audit

Eleven detailed energy audit studies were conducted in Muzaffarnagar Paper cluster. The activities carried out by the team in detailed energy audit included:

- Study of the system & associated equipments.
- Conducting field testing & measurement
- Data analysis for preliminary estimation of saving potential at site
- Site trials for further validation

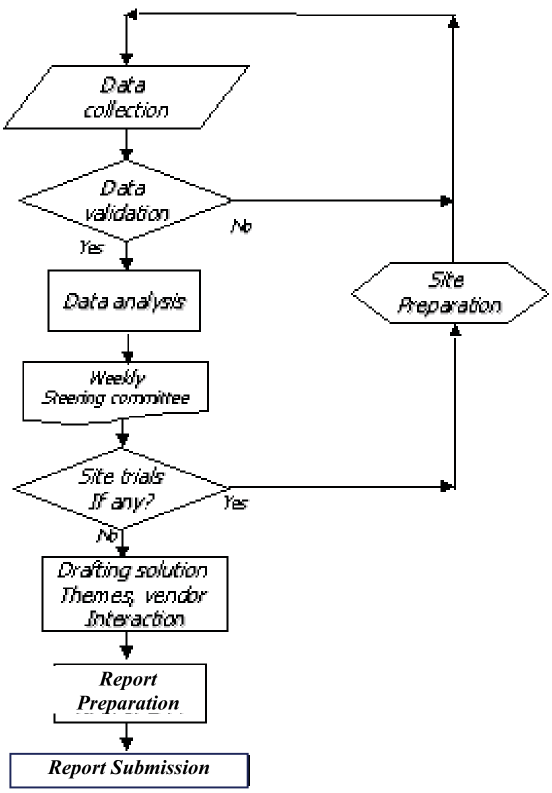

Figure 14: Audit Methodology

The detailed audit consisted of system study to identify the energy losses (thermal/ electrical) and then to find solutions to minimize the same. This involved data collection, measurements/ testing of the system using calibrated, portable instruments, analyzing the data/ test results and identifying the approach to improve the efficiency. All the above were done by following standard codes. Audit methodology is depicted in figure 11 as shown above.

3.3.3 Post Audit Off–site Work

Post audit off-site work carried out included

- Revalidation of all the calculations for arriving at the final savings potential, identify and articulate individual energy saving projects.
- Financial analysis of the various options to arrive at the best approach
- Vendor interaction
- Report preparation/compilation and acquiring client's acceptance.
- Outlining procurement specifications for replacement hardware
- Energy saving project costing
- Prioritization of projects for implementation

3.4 OBSERVATIONS MADE DURING THE ENERGY USE AND TECHNOLOGY STUDY

3.4.1 Manufacturing process and technology/equipments installed

The paper mills in Muzaffarnagar cluster have energy saving opportunities both in the process and utility side. During the energy audit carried out, it was observed that a few paper mills were performing fairly well in terms of energy efficiency. These mills have adopted the latest and energy efficient technologies available both on the process and utility side. Still there are fairly large numbers of unit that have potential to improve energy efficiency.

The technology for basic paper manufacturing is available in the country and there are several vendors, some of the prominent ones being L&T, Eicher, Servall Engineering, Jessop & Co, Mechano Paper Machines etc. Many of these companies are also having tie-up with reputed global technology suppliers. There are three aspects of the present paper technology in India so far. These are

- Options which have largely been implemented by industry
- Commercially available technologies which are under active consideration
- Advanced technologies

The major technology improvements have been largely made possible due to the following:

- Material improvement
- Instrument improvement
- Technology transfer
- Global trends
- High competitiveness

A number of mills have taken initiatives for technology up gradation with support from vendors in quite a few areas like:

- Pulping to achieve better quality of pulp, besides deriving cost reduction benefits in terms of energy, water, chemical and also space saving
- Paper machines for increased productivity, better product quality and higher energy efficiency.
- Waste paper treatment plants for utilizing various grades of waste paper to obtain speck-free pulp. The use of waste paper is expected to go up to 35% or more in the future.
- Self-sufficiency in power generation with improved steam power cycle efficiency thereby reducing input energy cost.

Most of the paper mills in Muzaffarnagar cluster are using old equipments and in the event of breakdown get them replaced either internally or locally. As such the equipments installed:

- Do not meet the best efficiency levels available
- Are mostly over designed capacities leading to inefficient operating levels

3.4.2 Housekeeping Practices

Housekeeping practices were poorly maintained in the majority of paper mills. There were no specific guidelines or procedure mentioned in any of the units for the operation of machines/equipments. Records were poorly maintained and there is no proper monitoring of parameters such as fuel consumption, steam leakage etc. It was seen the spillage of the bagasse from the belt conveyors when transferring the bagasse from the depither to a digestor. The leaking and overflow of water taps in the mill leading to water consumption amount was increased. The insulation of steam pipeline has been in bad condition.

By improving the housekeeping/operational practices in Paper units, efficiency will improve by around 1-5%. Some of the suggested house-keeping practices are mentioned below:

a) A major fraction of solid waste generated can be minimized by practicing good housekeeping. The various in house approaches to reduce the generation of solid waste are:

    i. Good management of raw material storage facilities..

    ii. Application of cleaner technologies.

    iii. Use of efficient save all for maximum fibre recovery.

    iv. Adoption of proper retention aids.

    v. Maximum recycling of streams – closure of screening and washing system , paper machine back water etc to an extent that it does not affect the efficiency of the system and product quality.

    vi. Proper combustion of fuels.

b) Adequate oil circulation and lubrication can be done which is critical to assure proper fluid film thickness, to assure contaminants are removed from machine-lubricated contact surfaces for less paper breakage and uniform consistency of paper produced.

c) Repairing all leakage, keeping taps closed when they are not in use and cleaning rolls in paper machines.

Table 10: Housekeeping practices with associated benefits

Sr. No	Good Housekeeping pratices	Anticipated benefits	Environmental Impacts
1	Screening of fine piths and dust in the depithed bagasse	Reduction in cooking Chemicals and steam. Decrease in power consumption	Marginal reduced pollution load
2	Repairing the belt conveyor to prevent the bagasse spillage.	Reduction in input material	Reduced pollution load
3	Replacing old water taps to avoid water leakage	Reduction in water leaking	Reduced water consumption
4	Installation of self closing valves for the pressurized raw water to minimize water wastage	Reduction in water leaking	Reduce water consumption
5	Insulation of the steam pipeline and digester	Reduced steam requirement	Reduce air pollution
6	Cleaning the roll in the paper machines to avoid breakage paper	Reduced breakage paper amount	Reduce polution load, Better Production.

3.4.3 Availability of Data and Information

A majority of the paper mills in Muzaffarnagar cluster do not have any instrumentation or data monitoring systems to monitor various operational parameters in processes/equipments/utilities. Few instruments are installed in some of the units in the cluster for monitoring of operational parameters in their units. Accuracy of readings from these instruments is also poor.

Most of entrepreneurs in cluster are not interested in sharing the energy consumption data, due to various reasons. Very few entrepreneurs share their energy consumption against production data in the respective months.

3.5 TECHNOLOGY GAP ANALYSIS

The awareness for energy conservation has reached a stage where the paper mills should take the initiative adopt energy efficient technologies. With the increase in global competition energy conservation and optimization is a good tool to bring down their energy cost and thus the overall manufacturing costs. Most of the small-scale paper mills have out-dated technologies; better and efficient technologies are available. Energy efficiency measures can be broadly classified into two categories.

Generic EE Measures

- Pumps, fans, compressors and associated system
- Piping
- Boiler efficiency and fuel management
- Turbo-generator efficiency improvement
- Lighting
- Heat recovery
- Energy measurement, instrumentation and control system
- Load optimization & rationalization
- Rationalizing Distribution system
- Fuel Substitution
- Power factor and harmonics

Process EE Measures

- Technology up gradation
- Process synthesis
- Process optimization
- Process up gradation
- Co-generation
- Automation
- Work rationalization
- Process integration including Cogeneration
- Heat recovery including heat exchanger networking
- SCADA and DCS for process monitoring and control

The table below provides the technology gap analysis of the paper units in the cluster with respect to the present status in the cluster and the better technology available for improving the energy efficiency.

Table 11: Muzaffarnagar Paper Cluster Technology Gap Assessment

S. No.	Technology / Equipment	Present Status	Options Available for EE Improvement
1	Boiler	Generally operating on low efficiency level because of lack of monitoring and control systems.	Monitoring and control systems like oxygen control in flue gas, etc. are available readily that contribute to overall efficiency improvement of boiler.
2	Boiler Auxiliaries	The operating efficiency of fans and pumps are being used in boilers is generally on the lower side. Lack of monitoring and control systems also lead to loss of energy.	High efficiency boiler auxiliaries are available. Installation of the same will lead to energy savings. Adequate monitoring and control systems are available to optimize the performance of boiler auxiliaries leading to energy savings.
3	Condensate Recovery System	Most of the mills have poor condensate recovery systems leading to tremendous heat loss through flash steam and radiation.	Smart and efficient condensate recovery systems are available to recover entire heat energy being lost from steam condensate.
4	Digester Blow Down Heat	Flash steam generated during digester blow down is not recovered and the heat is lost to atmosphere.	There is a possibility to recover the heat lost in flash steam and use it to generate hot water for use in process.
5	Steam Dryers	Traditional condensate	Efficient condensate

		evacuation systems are installed in paper mills. These have a low operating efficiency and mechanical reliability.	evacuation systems are available that improve the condensate evacuation from dryers leading to improved heat transfer in dryers.
6	Process Pumps	There are few pumps operating on lower efficiency level.	There is a possibility to replace these low efficiency pumps with high efficiency pumps. This will lead to reduction in electricity consumption.
7	Pulp Washing	Traditional single drum and twin drum washers are being currently used in agro residue based paper mills.	Installation of screw press leads to reduction in electricity consumption, water consumption and produces thicker (usable) black liquor.
8	Pulping	Traditional pulpers are installed in most of the paper mills.	High consistency pulpers are available that provide better slushing at lower specific energy, chemicals and thermal energy consumption levels. It also provides good quality of pulp leading to higher production by reducing the number of paper breaks.
9	Paper Machine	The paper mills in the cluster do not have ventilation system on paper machine.	Installation of Pocket Ventilators improves the drying rate, moisture profile and production for paper machines. The ventilators

			prevent sweating, corrosion and fibre build up.
10	Paper Machine	Most of the paper mills have conventional head box installed that provide head by naturally depending on the level of pulp maintained in the head box.	Pressurized head box is available. They provide better quality of paper and ease the operation at high speeds. The overall productivity of the paper mill increase leading to reduced specific energy consumption.

3.6 ENERGY CONSERVATION MEASURES IDENTIFIED

3.6.1 ECM 1 – Boiler Efficiency Improvement

3.6.1.1 Description

Maintaining an optimum air to fuel ratio in the boiler is key to improved boiler operating efficiency. A stable combustion condition requires the right amounts of fuels and oxygen. The combustion products are heat energy, carbon dioxide, water vapor, nitrogen, and other gases (excluding oxygen). In theory there is a specific amount of oxygen needed to completely burn a given amount of fuel. In practice, burning conditions are never ideal. Therefore, more air than ideal must be supplied to burn all fuel completely. The amount of air more than the theoretical requirement is referred to as excess air. Boilers normally run at about 10 to 20 percent excess air. Failing to maintain adequate excess air levels and supplying high air to fuel ratio in the boiler leads to tremendous energy losses in terms of heat generated by fuel being taken away with nitrogen and unused oxygen.

Measurements were carried out to observe the oxygen level in the exit flue gases. The oxygen level in most of the boilers in the paper mills of Muzaffarnagar cluster was found to be on the higher side. The high level of oxygen in flue gas indicates surplus supply of air in the boiler for combustion of fuel. Consequently the unused air comes out from the boiler along with the flue gas and indicates high level of oxygen in the flue gas. For the boiler under consideration in the study, the oxygen level in the flue gas was observed to be in the range of 13% corresponding to an efficiency level of 61.1%. With adequate instrumentation and control this oxygen level can be brought down to the range of 5% - 7% corresponding to an efficiency level of 70%. The graph below represents the current efficiency level of the boiler with reference to the oxygen level in flue gas and the efficiency level that can be achieved.

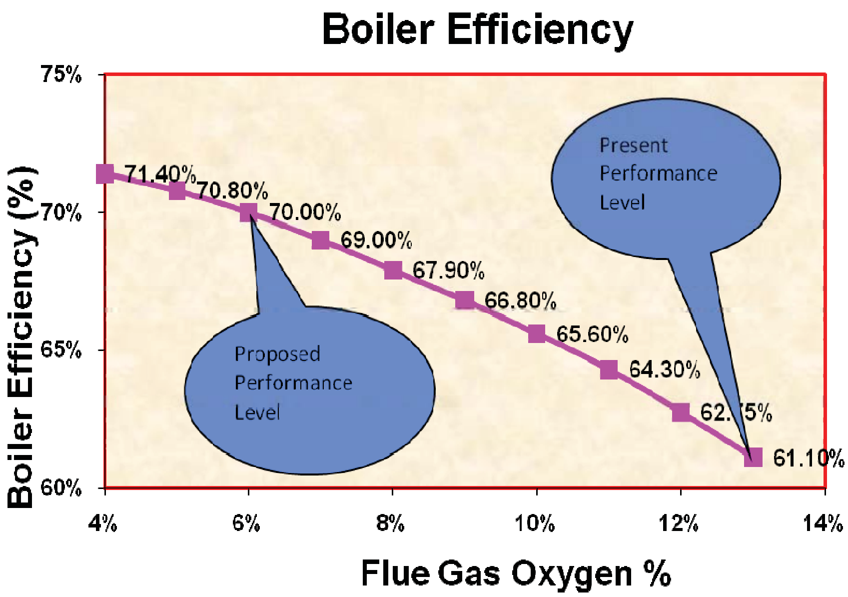

Figure 15: Operating and proposed efficiency graph

The proposed efficiency level can be achieved by installing a flue gas oxygen controller, which consists of an oxygen sensor with PID controller. This system will work more efficiently if it is coupled with a combustion control loop consisting of steam transmitter and controller.

3.6.1.2 Benefits

Optimization of the air to fuel ratio in boiler will lead to intake of optimum amount of air required for complete combustion. This will lead to reduction in the amount of heat loss, which was being carried away with the surplus amount of air present in the flue gas. Reduction of heat loss in flue gas will lead to overall efficiency improvement of the boiler and consequently less amount of fuel will be required to generate an equivalent. In addition to the direct saving of fuel, installation of flue gas oxygen control will lead to reduced electricity consumption in the FD and ID fans of the boiler. This is merely because of the fact that less amount of air will be supplied by the ID fans and less amount of flue gas will be handled by ID fan. With the installation of flue gas oxygen controller, the amount of air input by FD Fan will be controlled. This will lead to reduction in the amount of excess air that was fed in the absence of controller. Reduced excess air intake will correspond to reduced flue gas losses. Installation of controller will reduce the amount of air input and flue gas output. As a consequence the amount of electricity consumption in FD and ID fans will also decrease. Thus the proposed ECM will help save both fuel and electricity consumption in the boiler.

3.6.1.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical boiler energy efficiency project has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the table below.

Table 12: ECM 1 cost & benefit details

SN	Description	Value
1	Present Efficiency Level	61.1%
2	Present Fuel Consumption (TPH)	1.62
3	Proposed Efficiency Level	70.0%
4	Proposed Fuel Consumption (TPH)	1.42
5	Fuel Savings (TPH)	0.21
6	Annual Operating Hours	8,000
7	Energy savings (mn kJ/yr) @ CV 3,338 kCal per kg	23,070
8	Monetary savings (₹/yr) @ ₹ 2,707 per Tonne	4,469,372
9	Estimated project cost (₹)	3,025,000
10	Payback Period (yrs)	0.68

3.6.1.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure

b) Cost of implementation

3.6.2 ECM 2 – Boiler Feed Water Pump Efficiency Improvement

3.6.2.1 Description

The boiler feed water-pumping system was studied in detail and analyzed for energy efficiency improvement. The study involved measurement of boiler feed water flow, head delivered by the pump, power consumption and pressure drop. At many instances it was observed that the pump is operating on lower efficiency range. The pumps installed are old and new high efficiency pumps are available. The boiler feed water pump considered under the study was a high pressure pump with following specifications:

Table 13: Boiler Feed Water Pump Design Parameters

Flow	**m^3/hr**	**60**
Suction Pr	M	+ve
Discharge Pr	M	900
Rated Capacity of Drive	kW	250

The boiler feed water pump operating parameters were observed as follows:

Table 14: Boiler Feed Water Pump Operating Parameters

Flow	**m^3/hr**	**44.9**
Suction Pr	m	12
Discharge Pr	m	900
Power Consumption	kW	261

The boiler feed water pump operating efficiency was estimated to be 46%. Higher efficiency pumps are available for the same application. Replacement of this pump with new efficient pump will lead to electricity savings.

3.6.2.2 Benefits

Replacement of the present low efficiency pump with a higher efficiency pump will lead to energy savings. The high efficiency pump will consume less electricity as compared to the present low efficiency pump. It is possible to operate the new efficient pump at an efficiency level of around 60% which is available up to 68% Design efficiency. This will lead to an energy saving of approximately 60 kW.

3.6.2.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical boiler energy efficiency project has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the table below.

Table 15: ECM 2 cost & benefit details

SN	Description	Value
1	Present Efficiency Level	46%
2	Present Electricity Consumption (kW)	261
3	Proposed Efficiency Level	60%
4	Proposed Electricity Consumption (kW)	201
5	Electricity Savings (kW)	60
6	Annual Operating Hours	8,000
7	Energy savings (kWh/yr)	477,736
8	Monetary savings (₹/yr) @ ₹ 3.91 per kWh	1,867,948
9	Estimated project cost (₹)	2,250,000
10	Payback Period (yrs)	1.20

3.6.2.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation

3.6.3 ECM 3 – Boiler Feed Water Pump Pressure Drop Reduction

3.6.3.1 Description

The boiler feed water-pumping system was studied in detail and analyzed for energy efficiency improvement. It was observed that there is considerable pressure drop across the main control valve that amounts to a loss of 10% to 20% of total power consumption. A typical system representing pressure drop at control valve is shown in the schematic below

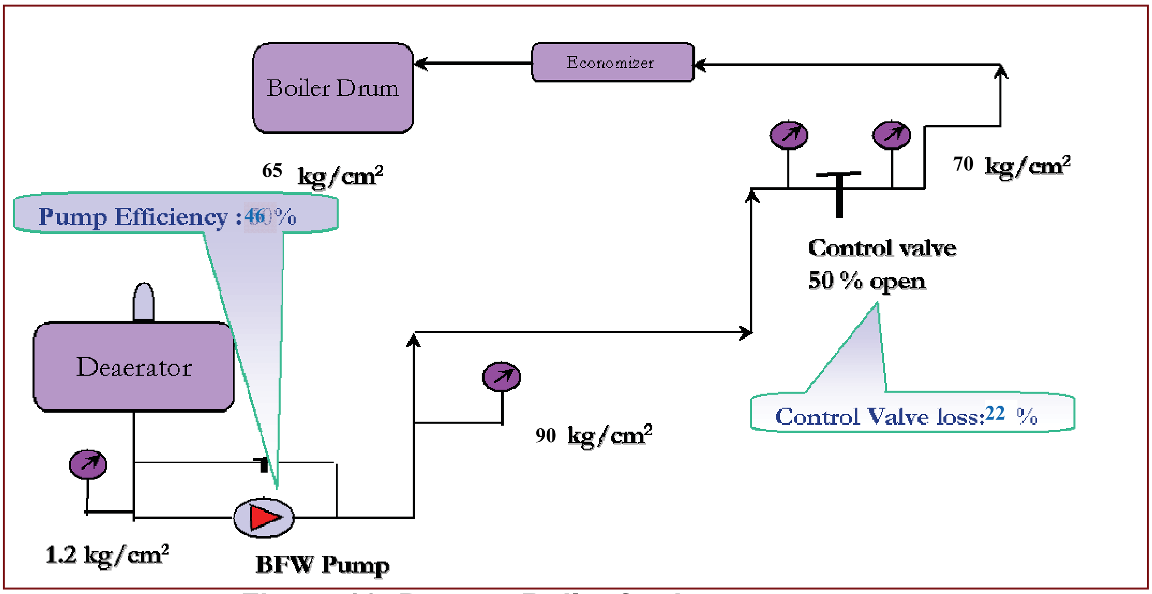

Figure 16: Present Boiler feed water system

There is a possibility of reducing the losses across the control valve by having an adequate instrumentation and control system installed. The logic of the control loop would be such that the control valve would be in line only when the boiler load is below 70 % of rated capacity. Hence there is a big potential to save energy for most of the operating hours. The schematic below represents the proposed system

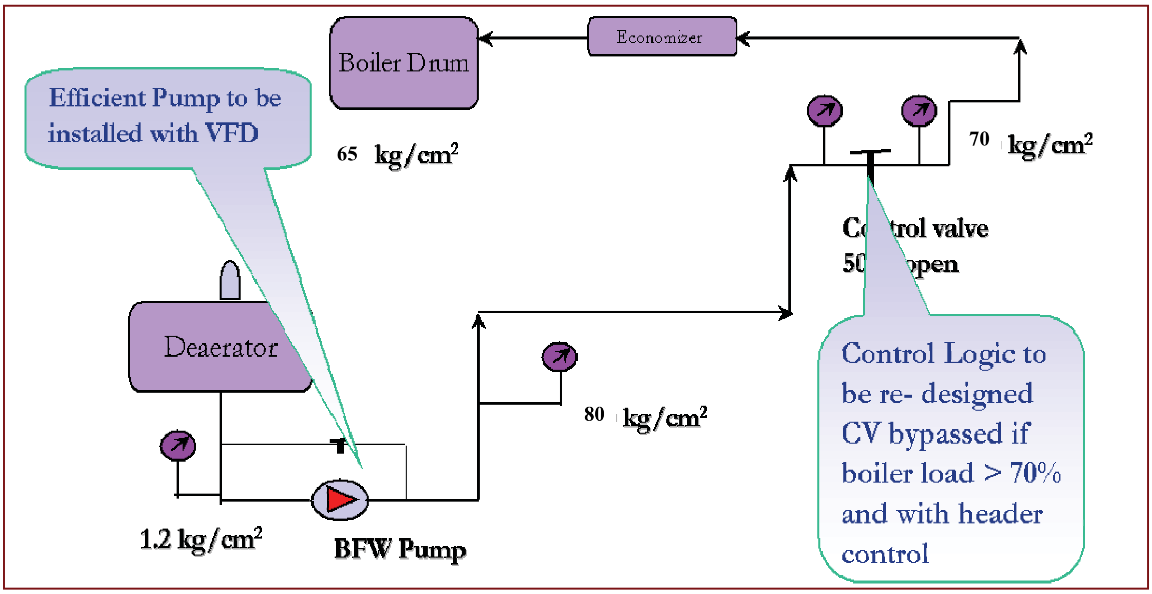

Figure 17: Proposed Boiler feed water system

3.6.3.2 Benefits

With the new logic and control system and VFD there is a possibility to save electricity by reducing the pressure drop across the main control valve as indicated in the diagram above. With the installation of this ECM the boiler feed water pump will require less electricity as compared to the present situation wherein approximately 22% of the energy supplied is wasted as pressure drop across the control valve.

3.6.3.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical boiler feed water pump pressure drop reduction project has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 16: ECM 3 cost & benefit details

SN	Description	Value
1	Present Pressure Drop (kg/cm^2)	20
2	Proposed Pressure Drop (kg/cm^2)	10
3	Pressure Drop Reduction (kg/cm^2)	10
4	Electricity Savings (kW)	33
5	Annual Operating Hours	8,000
6	Energy savings (kWh/yr)	260,794
7	Monetary savings (₹/yr) @ ₹ 3.91 per kWh	1,019,705
8	Estimated project cost (₹)	1,150,000
9	Payback Period (yrs)	1.13

3.6.3.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation

3.6.4 ECM 4 – Boiler Fans Efficiency Improvement

3.6.4.1 Description

During the Detailed Energy Audit, Performance analysis for boiler fans – both FD & ID was carried out. It was observed that the operating efficiencies were on the lower side. In the absence of design details it is difficult to understand the reason for such low efficiency. The possible reason for low efficiency could be system overdesign/mismatch and machinery wear & tear. Higher efficiency fans are available that will considerably reduce the power consumption in the fans. The schematic flow diagram of the FD fan is provided below.

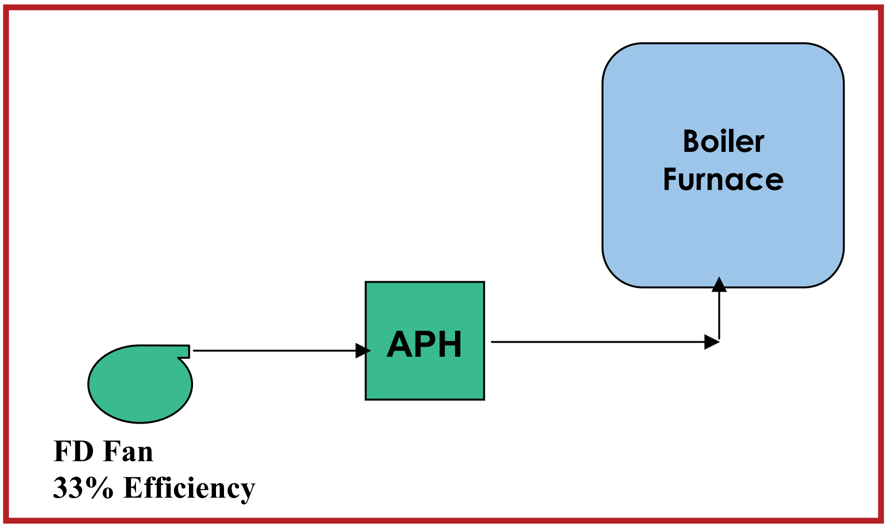

Figure 18: FD Fan Schematic Diagram

FD fan supplies air required for combustion in the boiler. Mostly the air is sucked from outside and supplied with high positive draft in the boiler furnace. In many boilers with waste heat recovery systems, the outlet air duct from FD fan passes through air pre-heater (APH) taking the heat from exit flue gases before entering the boiler furnace. Considering a typical unit the FD Fan efficiency was found out to be 35%. There is a possibility to save energy by replacing the existing fan with high efficiency fan. It is possible to operate the new efficient fan at an efficiency level of around 50% which is available up to 75% Design efficiency. This will lead to an energy saving of approximately 21 kW. The parameters observed during the study are:

Table 17: Boiler FD Fan Operating Parameters

Flow	m^3/hr	4.71
Suction Pr	m	0
Discharge Pr	m	450
Power Consumption	kW	67

3.6.4.2 Benefits

Increase in efficiency level of the boiler F D Fan will lead to reduced power consumption. Implementation of this ECM will lead to savings in electricity.

3.6.4.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical boiler FD Fan improvement project has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 18: ECM 4 cost & benefit details

SN	Description	Value
1	Present Efficiency Level	35%
2	Present Electricity Consumption (kW)	67
3	Proposed Efficiency Level	50%
4	Proposed Electricity Consumption (kW)	46
5	Electricity Savings (kW)	21
6	Annual Operating Hours	8,000
7	Energy savings (kWh/yr)	165,190
8	Monetary savings (₹/yr) @ ₹ 3.91 per kWh	645,892
9	Estimated project cost (₹)	775,000
10	Payback Period (yrs)	1.20

3.6.4.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Non availability of products in local market

3.6.5 ECM 5 – Flash Steam Recovery

3.6.5.1 Description

During the study it was very commonly observed that in paper machine section, the flash steam generated from the return condensate of dryers is not utilized properly and vented into the atmosphere. Under the existing system condensate is collected into an open vessel and the flash steam generated from hot condensate is lost to the atmosphere. The schematic diagram of the present system is shown below:

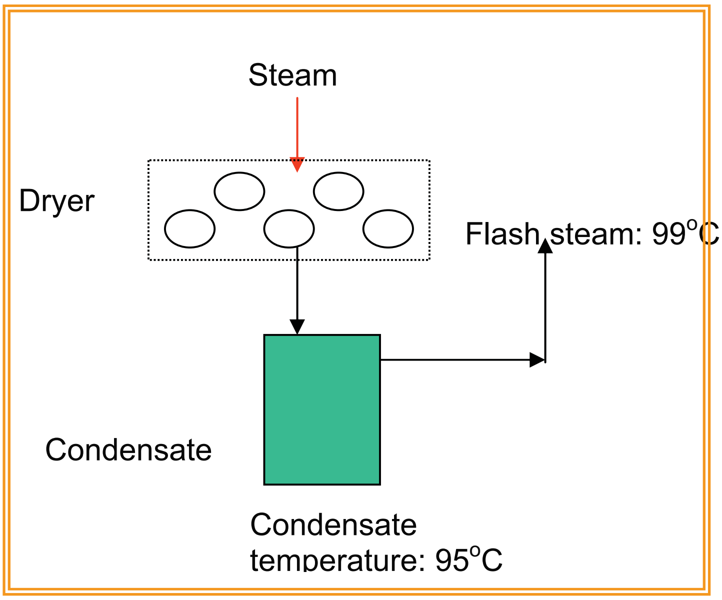

Figure 19: Existing System

The average steam consumption at the paper machine is 6.5 TPH at 3.8 kg/cm^2. The flash steam generated from the condensate is estimated to be 0.3 TPH. There are possibilities to recover the heat which is presently lost in flash steam. One of the options is to recover the heat in flash steam using a Heat Exchanger as shown below. The water can be heated up to 75 deg C. The heat exchanger will be of direct contact type. The arrangement is shown below:

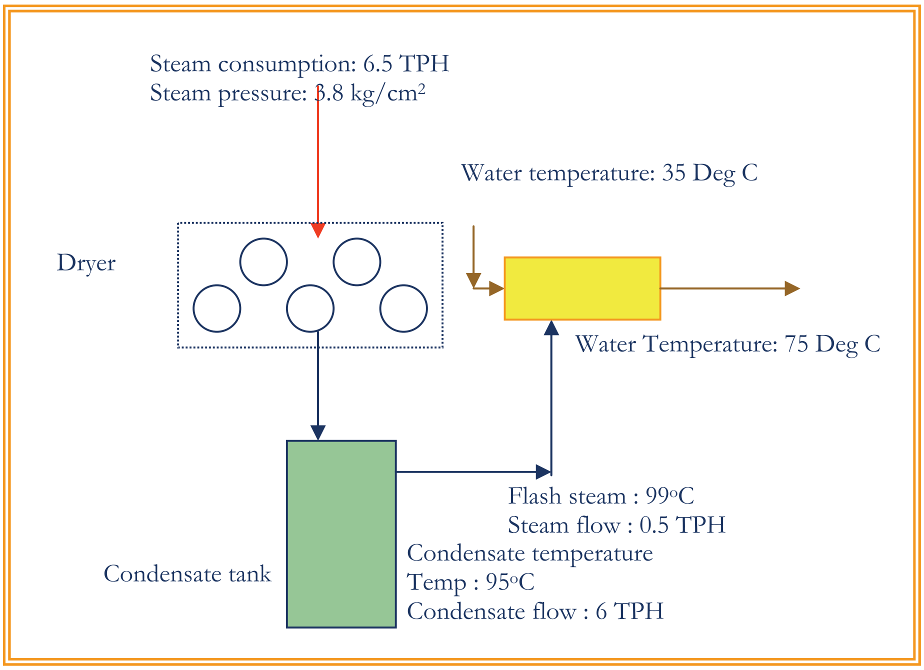

Figure 20: Proposed Scheme for Heat Recovery– Option 1

The other option is to recover this steam with the installation of thermo compressor, which again can be used for heating purpose. In a thermo compressor high pressure motive steam accelerates through the nozzle. As it enters the suction chamber at supersonic speeds, it entrains and mixes with low pressure steam from the suction inlet (refer figure below).

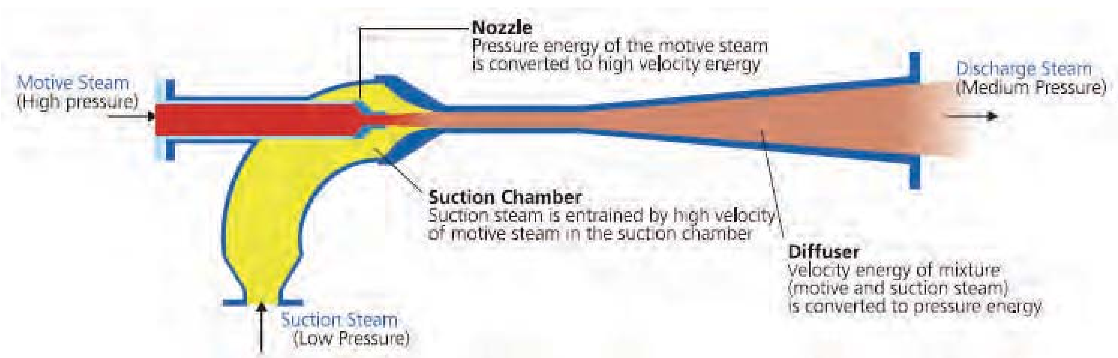

Figure 21: Working of a Thermo Compressor

The resultant steam mixture then enters the convergent-divergent diffuser where its velocity reduces and its kinetic energy is converted to pressure energy. The resultant steam discharged from the thermo compressor can again be used in process. The scheme is represented in the Figure below:

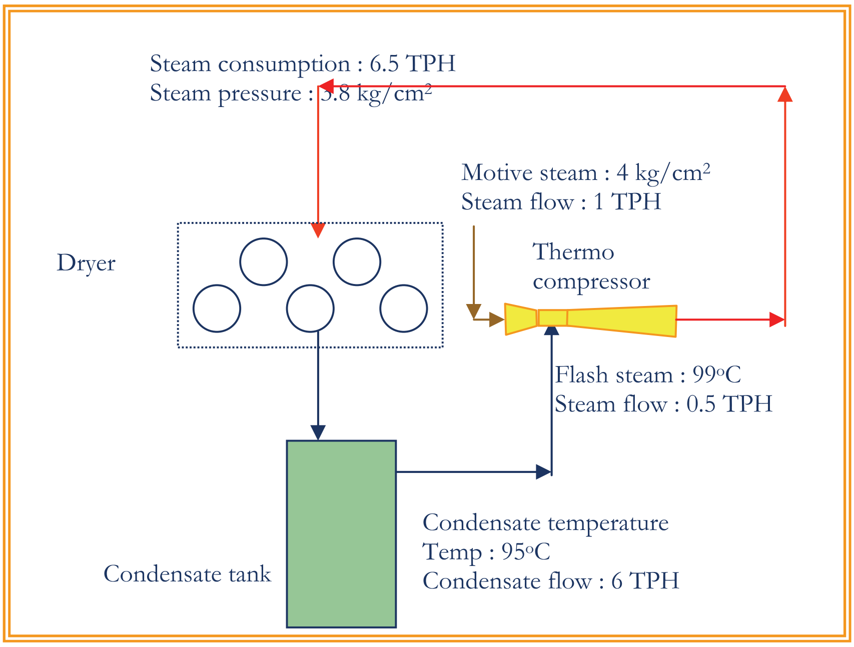

Figure 22: Proposed Scheme for Heat Recovery–Option 2

3.6.5.2 Benefits

It is generally observed that the condensate recovery tank installed at the paper machine section is open type and non-insulated. The flash steam thus generated escapes from the vessel and also there is loss of heat from the surface of tank. There is an opportunity to recover and utilize this flash steam. Also insulating the condensate tank will reduce radiation heat losses. A complete condensate recovery system with flash steam recovery is the optimum solution. This measure will lead to reduction in overall steam consumption consequently saving fuel used in the boiler.

3.6.5.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical steam flash recovery project has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the table below.

Table 19: ECM 5 cost & benefit details

SN	Description	Value
1	Present - Flash Steam Generated (TPH)	0.35
2	Proposed - Flash Steam Recovered (TPH)	0.35
3	Enthalpy of Flash Steam (kJ/kg)	2675
4	Heat Content of Flash Steam (kJ/hr)	940,272
5	Fuel Saved (kg/hr) @ 80% boiler eff. & 3,338 kCal/kg GCV	84
6	Annual Operating Hours	8,000
7	Energy savings (mn kJ/yr)	9,403
8	Monetary savings (₹/yr) @ ₹ 2,707/MT	1,821,614
9	Estimated project cost (₹)	1,100,000
10	Payback Period (yrs)	0.60

3.6.5.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation
c) Non availability of product in local market

3.6.6 ECM 6 – Digester Blow Heat Recovery

3.6.6.1 Description

The Agro residue based paper mills use digester to cook the raw material. These digesters are generally 14 feet to 16 feet in diameter. Bagasse and wheat straw are generally used as raw material after de-pithing and/or cutting. The average cycle time of each digester is approximately 11 - 12 hours. Generally the steam used for cooking purpose is at temperature of 170 deg C and 4 kg/cm^2 of pressure. Once the agro residue is cooked in digester the material is taken out by blowing down the digester. For digester blow down, pressurized backwater is used. Since the digester is in a pressurized state, entire content blows out from the digester. At this moment the condensate present flashes and gets converted to steam, which is vented to the atmosphere. The achematic diagram for the present system is shown in figure below.

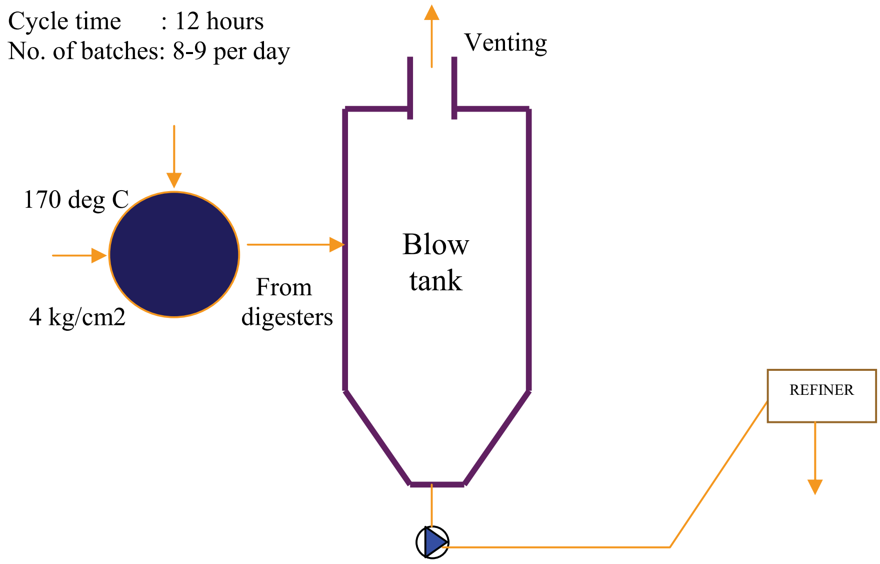

Figure 23: Present System

The flash steam from digester is not clean, hence it cannot be recovered with a thermo compressor to use for other heating purposes. However, this heat can be recovered to generate hot water which in turn can be used for the lye mixture tank, potcher, showers, spray showers, hydropulpers and other hot water requirement areas. It is recommended to install a heat recovery tank for collecting a flash steam and the hot water can be used in process. The proposed system is represented in the figure below.

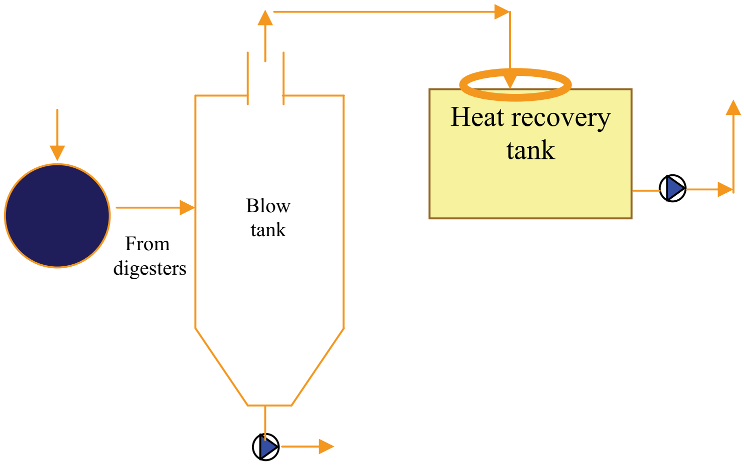

Figure 24: Proposed System

3.6.6.2 Benefits

It is generally observed that the flash steam generated, while the digester blows, is vented to atmosphere. Recovery and utilization of this flash steam will lead to reduction in overall steam consumption consequently saving fuel used in the boiler.

3.6.6.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical steam flash recovery project from digester blow down has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the table below.

Table 20: ECM 6 cost & benefit details

SN	Description	Value
1	Present - Flash Steam Generated (Tonne per batch)	0.89
2	Proposed - Flash Steam Recovered (Tonne per batch)	0.89
3	Enthalpy of Flash Steam (kJ/kg)	2,847
4	Heat Content of Flash Steam (kJ/Batch)	2,519
5	Fuel Saved (Tonne per batch) @ 80% boiler eff. & 3,338 kCal/kg GCV	0.18
6	Annual Operating Batches @ 10 Batch/day & 330 days/yr	3,300
7	Energy savings (mn kJ/yr)	8,314

8	Monetary savings (₹/yr) @ ₹ 2,707/MT	1,610,685
9	Estimated project cost (₹)	2,050,000
10	Payback Period (yrs)	1.27

3.6.6.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation
c) Non availability of product in local market

3.6.7 ECM 7 – Steam Consumption Reduction by Efficient Condensate Evacuation from Dryers

3.6.7.1 Description

Traditional siphons require high differential steam pressures to evacuate condensate from paper machine dryers. Stationary siphons are preferred for these applications, because the differential pressure requirement remains quite low. Smooth condensate flow into syphon pipe ensures optimal heat transfer. This reduces the steam consumption by 5% to 10% in the dryer section and improves overall dryer operating efficiency.

High speeds create mechanical problems for stationary syphons. All cantilever stationary syphons are mounted and supported from outside the dryer cylinder. Because the stationary syphon remains fixed in place, it must be able to withstand the impact of the condensate that is rotating with the dryer. Stationary syphons with low stiffness will deflect, vibrate, and eventually fail. This new cantilever stationary syphon is designed to provide both improved operating efficiency and mechanical reliability as shown in figure below.

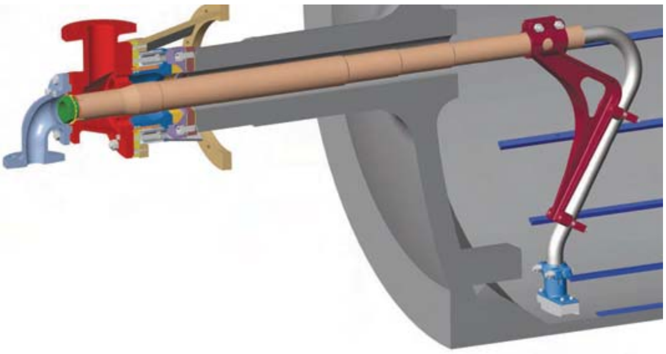

Figure 25: Stationary Syphon

3.6.7.2 Benefits

Improved condensate evacuation will lead to improved heat transfer between steam and paper on the dryer surface. This is typically because of the fact that the latent heat of steam will be efficiently utilized in this scenario. In the situation wherein condensate evacuation is not proper and it remains filled inside the dryer, the latent heat content of steam will be lost to the condensate and will not be optimally utilized. With efficient heat transfer in the dryers, the overall steam consumption will also get reduced, leading to a reduction in fuel consumption in boiler.

3.6.7.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical dryer section of a paper mill has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the table below.

Table 21: ECM 7 cost & benefit details

SN	Description	Value
1	Present - Average Steam Consumption in Paper Machine (TPH)	4.00
2	Proposed - Average Steam Consumption in Paper Machine (TPH)	3.72
3	Savings in Steam Consumption (TPH)	0.28
4	Enthalpy of Steam (kJ/kg) @ 3.8 kg/cm^2 saturated	2,745
5	Annual Operating Hours	8,000
6	Energy savings (mn kJ/yr)	8,785
7	Monetary savings (₹/yr) @3,338 kCal/kg GCV, 70% boiler eff. & ₹ 2,707/MT fuel rate	1,702,011

8	Estimated project cost (₹)	1,390,000
9	Payback Period (yrs)	0.82

3.6.7.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation
c) Non availability of product in nearby region

3.6.8 ECM 8 – Energy Efficiency Improvement in Process Pumps

3.6.8.1 Description

The performance evaluation of pumps in the paper mills was carried out to determine their operating efficiencies. This involved the study of following operating parameters:

- Flow
- Suction
- Discharge head
- Power consumed by the pump motor

This data was then analyzed to determine the operating efficiencies of the pump. It was observed that efficiency level of some of the pumps studied is on the lower side. There is a possibility to replace these low efficiency pumps with high efficiency pumps. This will lead to reduction in electricity consumption of the mill. The typical efficiency levels observed were in the range of 20% to 60%. Depending on type of application the pump efficiency levels can be improved upto 50% to 70%. The table below provides the details of the pumps studied.

Table 22: Details of pumps

Pump	Fan Pump PM1	Fan Pump PM2	Submersible Water Pump	Chest Pump 3	High Pr. Pump
Flow (m^3/hr)	58.63	395.83	180.00	120.00	8.00
Discharge Pr. (kg/cm^2)	3.5	3.5	5.0	3.0	13.8
Power Cons. (kW)	32.98	70.66	45.00	23.00	16.85

Operational Efficiency (%)	18.83	59.33	60.52	47.36	19.83

3.6.8.2 Benefits

Improved pump efficiency will lead to reduced electricity consumption providing energy saving. This is typically because of the fact that the power input for the same amount of work performed would be reduces after installation of higher efficiency pumps.

3.6.8.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical process pump improvement project has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 23: ECM 8 cost & benefit details

SN	Description	Fan Pump PM1	Fan Pump PM2	Submersible Water Pump	Chest Pump 3	High Pr. Pump
1	Present Efficiency (%)	18.83	59.33	60.52	47.36	19.83
2	Proposed Efficiency (%)	70.0	70.0	70.0	70.0	55.0
3	Energy Saving (kW)	5.00	10.77	3.05	4.96	6.00
4	Annual Operating Hours	8,000	8,000	8,000	8,000	8,000
5	Energy savings (kWh/yr)	40,000	68,234	81,924	39,670	48,000
6	Monetary savings (₹/yr) @ ₹3.91/kWh	156,400	266,795	320,323	155,110	187,680
7	Estimated project cost (₹)	60,000	270,000	81,000	130,000	110,000
8	Payback Period (yrs)	0.38	1.01	0.25	0.84	0.59

3.6.8.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure

b) Non availability of product in nearby region

3.6.9 ECM 9 – Installation of Screw Press

3.6.9.1 Description

The twin drum washers arrangement is shown in the figure below. There is small clearance between the two drums. The pulp squeezes between the two drums and pulp is washed out.

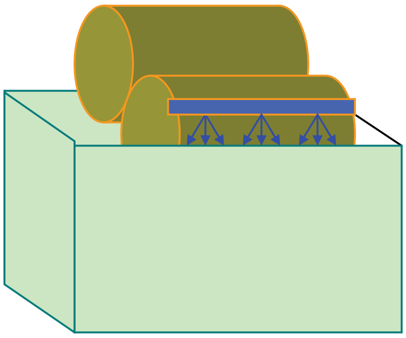

Figure 26: Twin Drum Washer

Prior to twin drums, potchers were used in most of the mills. Bleaching is done at 5% consistency in potchers, whereas with this system bleaching at 20% consistency is possible. Some of the benefits of using twin drum washers over potchers are listed below:

- Better washing of pulp can be achieved
- Quality of the duplex board is improved
- Due to quality improvement the higher gsm paper with high quality can be made.
- Water consumption in this case is 50% so the load on ETP reduces.

With the advancement of technology, now there is better washing equipment available called screw washer, which replaces the present twin drum washing system of agro based paper mills. The screw washer leads to reduced water consumption, produces thicker (usable) black liquor and replaces 2 to 3 double drum washers with 1 screw leading to reduced electricity consumption. A couple of mills in the cluster have already adopted the technology and have saved considerable amount of energy.

Figure 27: Screw Press

It can achieve a high daily productivity with low energy consumption and can handle the low consistency pulp efficiently. The thickened pulp dryness is even and the output rate is stable with the property of the fibre being little influenced and without clogging.

3.6.9.2 Benefits

Use of screw washer will lead to reduced electricity consumption providing energy saving. At the same instance it leads to enhanced productivity.

3.6.9.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical washing section of paper mill has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 24: ECM 9 cost & benefit details

SN	Description	Value
1	Present – Average Electricity Consumption	631.30
2	Proposed – Average Electricity Consumption	565.20
3	Electricity Savings (kW)	66.10
4	Annual Operating Hours	8,000
5	Energy savings (kWh/yr)	528,800
6	Monetary savings (₹/yr) @	2,067,608

	₹3.91/kWh	
7	Estimated project cost (₹)	4,555,000
8	Payback Period (yrs)	2.20

3.6.9.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure

b) Cost of implementation

3.6.10 ECM 10 – Installation of High Consistency Pulper

3.6.10.1 Description

High consistency pulping gives better slushing at lower specific energy, chemicals, and thermal energy consumption. The high consistency provides good quality of pulp since there is less fibre cutting. This automatically increases the quality of paper leading to higher production by reducing the number of paper breaks. Apart from production increase high consistency pulper will also lead to reduced electricity consumption.

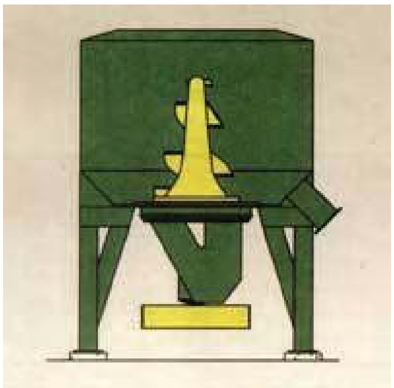

Figure 28: High Consistency Pulper

3.6.10.2 Benefits

Highly efficient separation of fibrous and non-fibrous materials such as plastics, films, adhesives, latex book binding without breaking them and making their subsequent removal easier, thus improving production. It also leads to savings in chemicals, steam and energy consumption in deinking or in disintegrating wet strength grades and other impregnated papers.

3.6.10.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical paper mill has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 25: ECM 10 cost & benefit details

SN	Description	Value
1	Present – Average Electricity Consumption (kW)	134
2	Proposed – Average Electricity Consumption (kW)	116
3	Electricity Saving (kW)	18
4	Annual Operating Hours	8,000
5	Energy savings (kWh/yr)	144,000
6	Monetary savings (₹/yr) @ ₹3.91/kWh	563,040
7	Estimated project cost (₹)	2,000,000
8	Payback Period (yrs)	3.55

3.6.10.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation
c) Lack of availability in the region

3.6.11 ECM 11 – Installation of Pocket Ventilation System

3.6.11.1 Description

Pocket Ventilators improve the drying rate, moisture profile and production for paper machines. The ventilators prevent sweating, corrosion and fibre build up. Pocket ventilators are custom engineered for various quality of paper produced.

3.6.11.2 Benefits

The benefit of the Hood is to provide a consistent drying environment around the driers and also recover heat from the exhaust. The colder the ambient temperature, the benefits of a closed hood seem to be that much more accentuated not just from the energy perspective but from the fear of condensate dripping onto paper web, while in tropical climates the heat recovery benefit is restricted to essentially sensible enthalpy. However a well designed hood with heat recovery can provide reduction in energy consumption between 10-15%. A high velocity well controlled pocket ventilator can also enhance heat and mass transfer in saturated moist pockets, and lead to lower energy consumption. A good pocket ventilator can also lead to increased machine speeds up to 5%.

3.6.11.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical paper mill has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 26: ECM 11 cost & benefit details

SN	Description	Value
1	Present - Average Steam Consumption in Paper Machine (TPH)	9.00
2	Proposed - Average Steam Consumption in Paper Machine (TPH)	8.55
3	Savings in Steam Consumption (TPH)	0.45
4	Enthalpy of Steam (kJ/kg) @ 3.8 kg/cm^2 saturated	2,745
5	Fuel Savings (kg/h) @80% boiler eff. & 3,338 kCal/kg CV	
6	Annual Operating Hours	8,000
7	Energy savings (mn kJ/yr)	12,354
8	Monetary savings (₹/yr) @ 2,707 ₹/MT fuel cost	957,380
9	Estimated project cost (₹)	2,000,000
10	Payback Period (yrs)	2.09

3.6.11.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation
c) Lack of availability in the region

3.6.12 ECM 12 – Installation of Pressurized Head Box

3.6.12.1 Description

Most of the paper mills have conventional head box installed that provide head by naturally depending on the level of pulp maintained in the head box. Pressurized head box is available that create and maintain the head by pressurized air over the pulp in the chamber. The constant head provides better quality of paper and eases the operation at high speeds. The overall productivity of the paper mill increase leading to reduced specific energy consumption.

3.6.12.2 Benefits

Installation of pressurized head box on the paper machine will lead to improved paper quality and reduced paper breakage leading to reduction in the production loss due to paper breakage. The increase in the production level will lead to reduced specific energy consumption of the paper machine. A good pressurized head box system can lead to reduction in specific energy consumption of paper machine by 5%.

3.6.12.3 Financials

The project cost benefit analysis is represented through simple pay back analysis. For conservativeness a typical paper mill has been chosen to demonstrate the benefits. With the improved system, the possible savings are as shown in the tables below.

Table 27: ECM 12 cost & benefit details

SN	Description	Value
1	Present - Average Steam Consumption in Paper Machine (TPH)	9.00
2	Proposed - Average Steam Consumption in Paper Machine (TPH)	8.73
3	Savings in Steam Consumption (TPH)	0.27
4	Present – Average Electricity Consumption (kW)	943
5	Proposed – Average Electricity Consumption (kW)	915
6	Electricity Saving (kW)	28
7	Enthalpy of Steam (kJ/kg) @ 3.8 kg/cm^2 saturated	2,745
8	Fuel Savings (kg/h) @80% boiler eff. & 3,338 kCal/kg CV	66.30
9	Annual Operating Hours	8,000
10	Energy savings (mn kJ/yr)	7,411

11	Energy savings (kWh/yr)	226,320
12	Monetary savings (₹/yr) @ 2,707 ₹/MT fuel cost & ₹3.91/kWh	2,320,760
13	Estimated project cost (₹)	4,500,000
14	Payback Period (yrs)	1.94

3.6.12.4 Issues in implementation

a) Lack of awareness on proposed energy conservation measure
b) Cost of implementation
c) Lack of availability in the region

3.7 BARRIERS IN IMPLEMENTATION

The role of market failures and other barriers to improved energy efficiency is well-studied and agencies are working to surpass the same. In spite of these efforts and benefits of energy efficiency, the implementation of energy efficiency projects in India is not wide spread, typically in the SME sector. Despite the huge replication potential considering the fact that SMEs are mostly cluster based in India, Energy Efficiency enhancement activity is still not the focus area for them. The barriers foreseen towards the implementation of identified energy conservation measures are:

a) Technological Asymmetry

Technological Asymmetry is quite prevalent in developing countries like India. SMEs generally have less access to EE technologies than their publically-owned counterparts and other large private or multinational companies.

b) Information Barriers

The other barrier anticipated to adoption of energy conservation measures is the lack of awareness among the industry managers of the potential gains from improved efficiency. Information gaps are present in all aspects of the market, consumers lack knowledge to procure efficient end-use equipment and the company’s decision makers lack effective management tools and procedures to account for the economic benefits of efficiency improvements.

c) Other Priority Areas

For most of the business owners, energy efficiency is not the priority area. For them the priority is either production or some other activity with higher returns. One of the reasons for non-priority can be the lack of awareness of benefits achieved from implementation of energy conservation measures.

d) Barrier of Inertia

This is one of the most daunting barrier to this activity is that Energy Efficiency is not a central concern for most businesses typically in the SME sector. This barrier creates a strong inertia that is difficult for any EE effort to overcome and can be result of a combination of the barriers described above.

3.8 AVAILABILITY OF TECHNLOGY SUPPLIERS/LOCAL SERVICE PROVIDERS FOR IDENTIFIED ENERGY CONSERVATION PROPOSALS

Technology suppliers/local service providers for identified major energy saving proposals mentioned in above sections in cluster are available in cluster, except few of the new developed proposals.

Details of the identified technology supplier/local service providers in Muzaffarnagar paper cluster are furnished in Annexure and same is attached along with this report.

3.9 IDENTIFICATION OF TECHNOLOGIES FOR DPR PREPARATION

From energy use and technology audit studies carried out in Muzaffarnagar Paper cluster, it became evident that there is considerable potential in all cluster units for energy conservation by replacing the old/obsolete technology/equipments with energy efficient technologies/equipments.

As the process and equipments are more or less similar in all cluster units, most of the technologies/equipments identified can be replicated as per the requirement of the units and detailed project reports for the specific technologies prepared also can be replicated in different paper units as per the capacity requirement. The following technologies/equipments were considered for preparation of detailed project report.

a) Boiler Efficiency Improvement

b) Boiler Feed Water Pump Efficiency Improvement

c) Boiler Fans Efficiency Improvement

d) Digester Blow Heat Recovery

e) Energy Efficiency Improvement in Process Pumps

f) Installation of Screw Press

g) Installation of High Consistency Pulper

h) Installation of Pocket Ventilation System

i) Pressurized Head Box

The number of units identified for technology up gradation projects is presented in table below.

Table 28: Details of Technology Upgradation Projects Identified in Cluster

S. No.	***Technology***	***No. of DPRs***	***Remarks***
1	Boiler Efficiency Improvement	1	Replicability is high in the cluster; however associated investment would not vary much.
2	Boiler Feed Water Pump Efficiency Improvement	2	High replicability. Two units selected with the consideration of boiler size.
3	Boiler Fans Efficiency Improvement	2	High replicability. Two units selected with the consideration of boiler size.
4	Digester Blow Heat Recovery	1	Replicability in 9 to 10 mills. However the investment required for all would be almost same.
5	Energy Efficiency Improvement in Process Pumps	1	High replicability. No technological innovation, hence one unit selected to represent the typical scenario
6	Installation of Screw Press	2	Replicability in 9 to 10 mills. Investment will vary with size of mill.
7	Installation of High Consistency Pulper	2	Replicability in 18 to 20 mills. Investment will vary with size of mill.
8	Installation of Pocket Ventilation System	2	Replicability in big mills only (9 to 10). Investment will vary with size of paper machine.
9	Pressurised Head Box	2	Replicability in big mills only (9 to 10). Investment will vary with size of paper machine.
	Total No. DPRs	15	

4 Environmental Benefits

The total energy saved after the implementation of project as demonstrated in the section 6 is 9,537,288 kWh of electricity and 396,982 mn kJ of heat per year. Considering that 50% of this electricity saved is from grid and rest is from biomass and similarly 50% of heat is from coal and rest is from biomass, the total GHG emission reduction potential of this activity amounts to 22,832 tons of CO2 emission reduction.

Table 29: GHG emission reduction potential

SN	Description	Value, t CO_2e
1	GHG emission reduction from electricity	3,815
2	GHG emission reduction from fuel	19,017
3	Total	22,832

Apart from the GHG emissions this energy conservation project will also reduce the Sox & NOx emissions arising from use of fossil fuel.

5 Small Group Activities/Total Energy Management

5.1 INTRODUCTION

Energy is one of the most important resources to sustain our lives. At present we still depend a lot on fossil fuels and other kinds of non-renewable energy. The extensive use of renewable energy including solar energy needs more time for technology development. In this situation Energy Conservation (EC) is the critical needs in any countries in the world.

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

(1) Economic factors

(2) Environmental impacts

5.1.1 Economic Factors of Energy Conservation

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

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

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

- 1974: setting up of fuel efficiency team by IOC, NPC and DGTD (focus still on industry)
- 1975: setting up of PCAG (NPC main support provider) : focus expanded to include agriculture, domestic and transport

- 1978: Energy Policy Report of GOI: for the first time, EE as an integral part of national energy policy – provided detailed investigation into options for promoting EE
- Post 1980, several organizations started working in EC area on specific programs (conduct of audits, training, promotion, awareness creation, demonstration projects, films, booklets, awareness campaigns, consultant/product directories)
    - Some line Ministries and organizations like BICP, BIS, NPC, PCRA, REC, Ministry of Agriculture, TERI, IGIDR, CSIR, PETS (NPTI)
    - State energy development agencies
    - Industry associations
    - All India financial institutions

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

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

5.1.2 Environmental impacts of Energy Conservation

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

5.2 SMALL GROUP ACTIVITIES (SGA)

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

5.2.1 Importance of SGA

SGA are activities by group of employees at operator (working Group) level. They aim to solve problems that occur at the place taken care of by each employee and put emphasis on participation and team work. Factories can apply small group activities to many kinds of work along with normal work or other measures that are already underway. The burden on employees will not increase because of small group activities. They are not only bringing benefits to factories but also boosting the knowledge and ability in performing jobs of employees, improving communication among employees, increasing creativity, and make it possible to express their own proposal with less hesitation to management. As a result, employees will start to think “This is our problem.” This SGA can be applied to Energy Conservation, too, with successful results, as shown in Figure 30.

5.2.2 How SGA leads to Energy Conservation?

An excellent example of organizational structure that promotes energy management emphasizing participation is that they form overlapping small groups as in figure 31. The feature of this structure is that a small group for energy management is distributed to

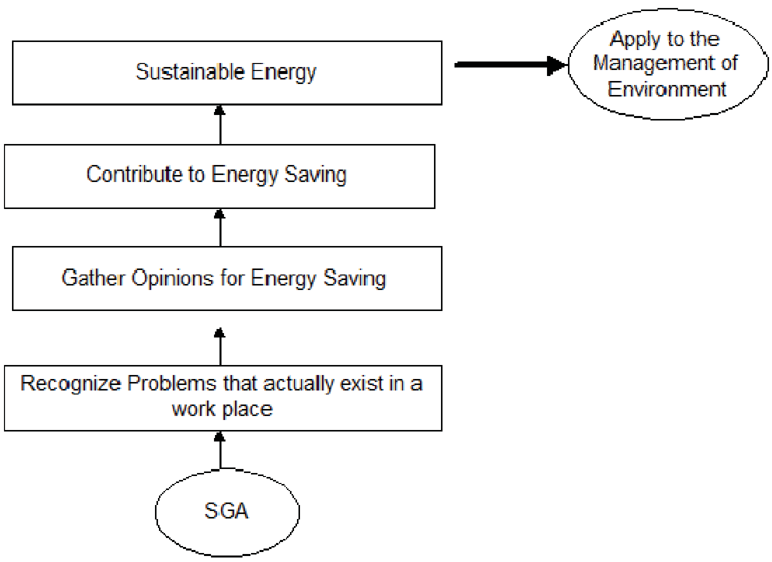

Figure 29: Relationship of SGA and energy saving

various sections as in figure 32, which is a recipe for success of Total Energy Management (TEM) and makes various communications and management of activities more efficient and effective.

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

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

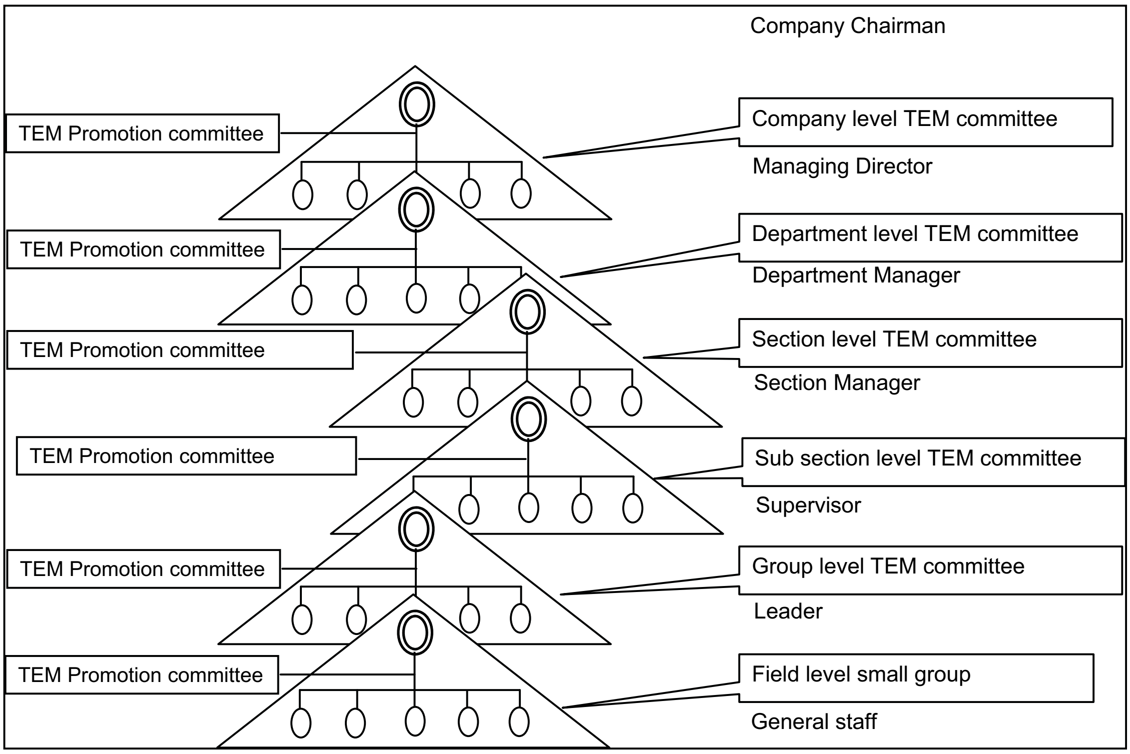

Figure 30: Example of Organizational Structure with Overlapping

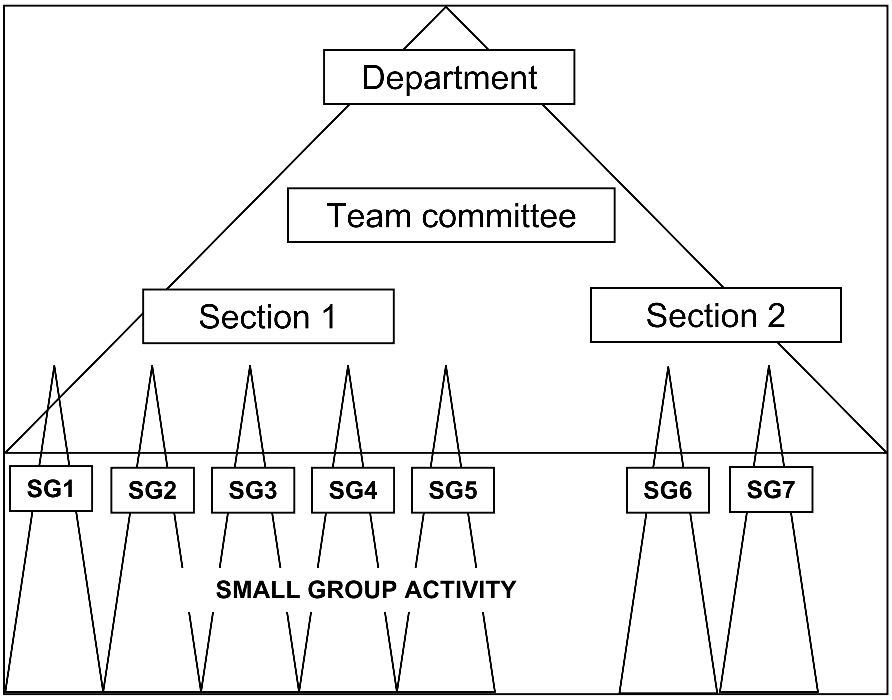

Figure 31: Positioning of SGA in Main Job Structure

5.2.2.1 Executives level

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

5.2.2.2 Level of Total Energy Management promotion office

- Make sure that whole activities are done in the correct direction, without delay and smoothly
- Find a suitable method that makes it possible to implement activities continuously and without slowdown
- Listen to opinions and suggestions from small groups in order to use for improving

- Provide advice for Total Energy Management to various groups
- Persons in charge of the office must be those with good personal relationship, friendly, and with spirit of good service

5.2.2.3 Medium level

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

5.2.2.4 Workers/Operators level

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

5.2.2.5 Responsibility of Energy Conservation committee

- Gather and analyze information on costs related to energy every month
- Analyze and solve problems related to energy
- Find a method for energy conservation
- Prepare energy conservation plan
- Follow-up the result of implementing the plan
- Perform activities such as public relationship for encouraging employees to participate

- Offer training to small group in each department

5.2.3 Steps of Small Group Activities for Energy Conservation

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

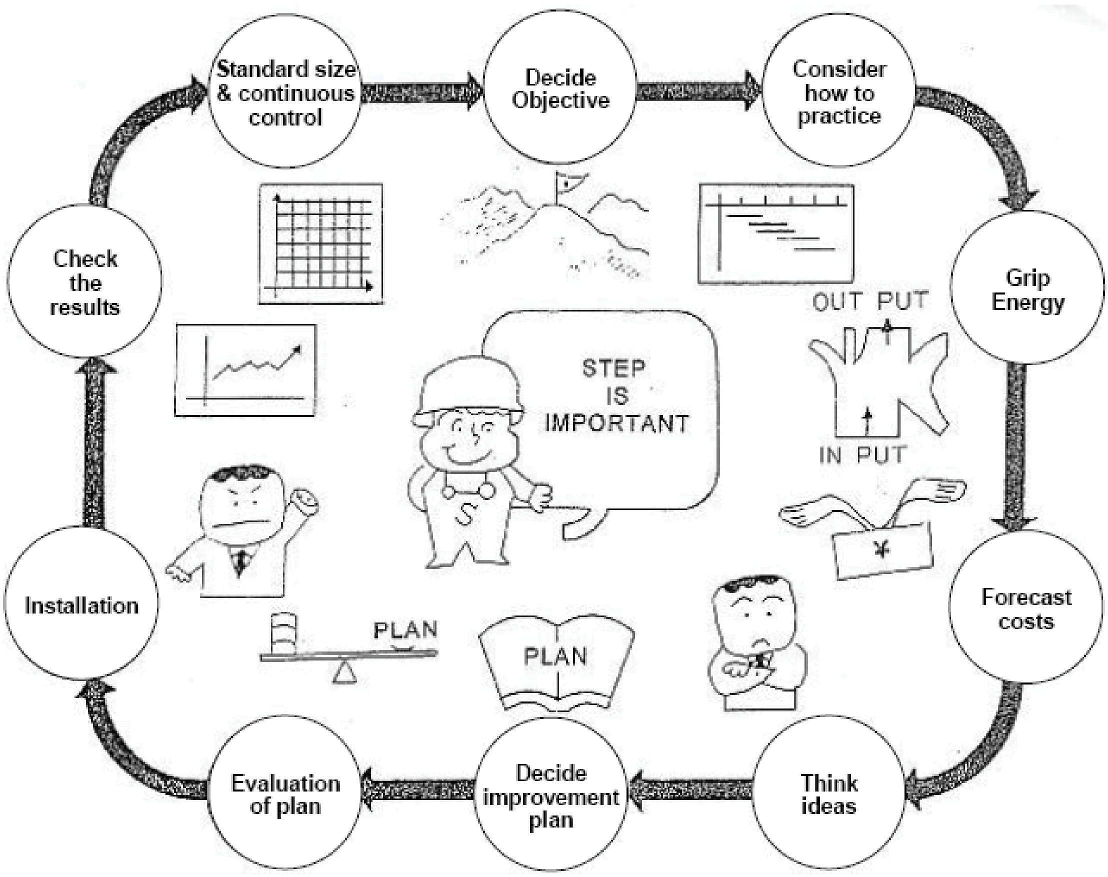

Figure 32: 10 Stages for Success

- Plan: Make an efficient plan in order to improve operation
- Do: Implement according to the plan
- Check: Check if implementation was according to the plan
- Act: Judge what to improve, what to learn and what to do from what we have checked

Figure 33: SGA Circle

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

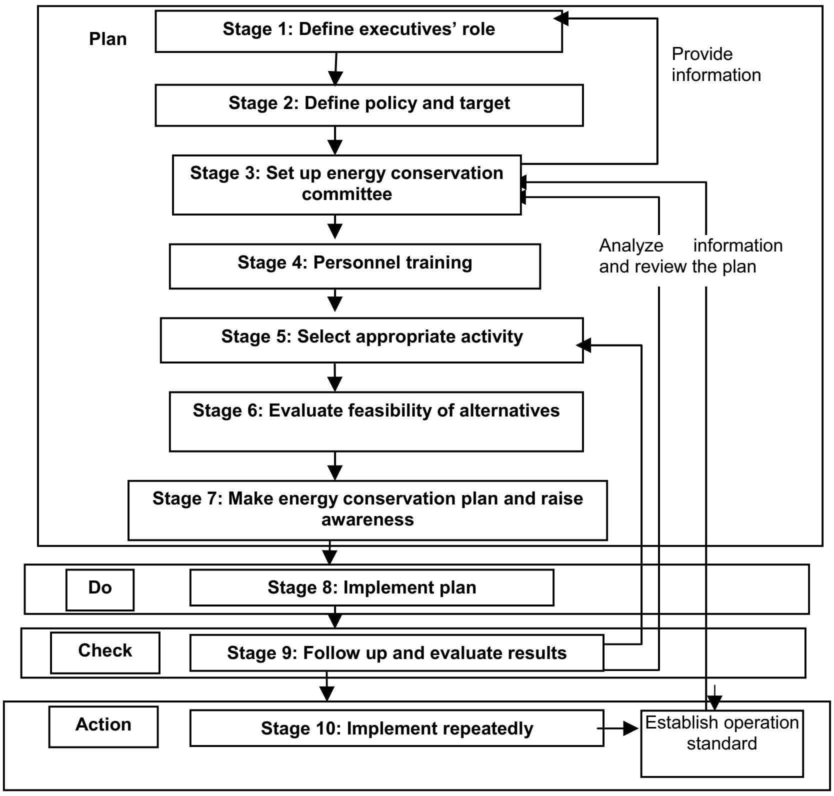

Figure 34: 10 Stages for Success

5.2.3.1 Stage 1: Define Executive's Role

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

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

5.2.3.2 Stage 2: Define Policy and Target

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

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

5.2.3.3 Stage 3: Set up Energy Conservation Committee

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

5.2.3.4 Stage 4: Personnel Training

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

5.2.3.5 Stage 5: Select Appropriate Activity

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

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

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

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

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

We have identified the following problems through small group activities.

- Issues on material quality or production that influence energy usage
- Behavior on energy usage
- Efficiency of machines or equipment that uses energy
- Awareness toward environment and energy usage
- Safety costs for energy conservation

5.2.3.7 Stage 7: Make Energy Conservation Plan and Raise Awareness

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

5.2.3.8 Stage 8: Implement Plan

Implement according to the plan of each group.

5.2.3.9 Stage 9: Follow Up and Evaluate Results

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

5.2.3.10 Stage 10: Implement Repeatedly

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

Dos and Don'ts in Energy Conservation

Don't Emphasize the mistakes in the past. It is better to talk about the present.

Don't Be worried about the theory or principles. Don't spend too much time in discussion or analysis of problems in meeting rooms.

Don't Think that an activity can be done perfectly from the beginning. It is necessary to do the job continuously by having experiences and judging by ourselves.

✓ Do Start with an activity that requires small amount of investment.

✓ Do Raise awareness so that all employees understand the necessity and importance of energy conservation and participate in it.

✓ Do Start the activity now without postponing to tomorrow.

5.2.4 Tools that are Used Often for Small Group Activities for Energy Conservation

5.2.4.1 5S

5S is a contraction derived from the Japanese words **Seiri, Seito, Seiso, Seiketsu,** and **Shitsuke**. It is simple methodology that is also extremely useful in practical and realistic life. 5S is a set of actions to be followed through every day activities to advance the operational surroundings and circumstances. 5S is made in order to provide fortification to every personage in diverse profitable and industrialized fields. 5S is an extremely practical contrivance and skill set for anyone who wants to generate a more prolific environment within the workplace or who wants to make it their profession to make other people's businesses more proficient and productive. 5S occupy a list of products including eyewear, ear protectors and safety gears. Look into these different products that make up the significance of an industrialized security supply.

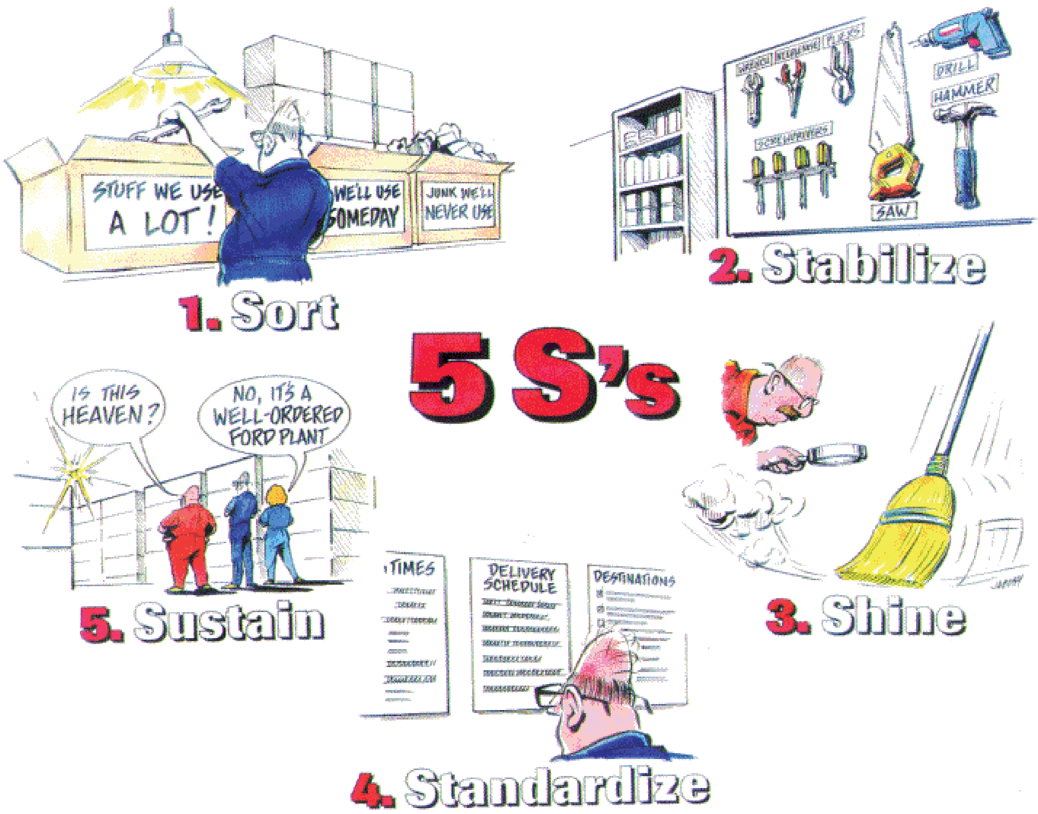

Figure 35: 5S's

Lean Six Sigma experts promise or guarantee for the efficiency of 5S as an enlightening enhancement to better working surroundings in an association. If you dig up Six Sigma guidance that is paid for by your company, you will be in a position to work for your company and make things better for you as well as for everyone. 5S is very useful in lots of industries and job markets, but can often fail simply because of the lack of recognition concerning changes in the office.

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

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

2. Seito/Systemize **-** This step in 5S process consists of removal of unwanted items permanently and one more task that to be take place is decision that means you have to decide that what is required to be in what place. Place the items in such manner that you could retrieve them within 30 seconds of requirement.

3. Seiso/Brush away/Sweep **-** Examine all the items on the daily basis. The process is not that much time consuming, but essential to clean up your workplace and most required in 5S. The conscientiousness to keep the office clean should be circulated between everyone in the group.

4. Seiketsu /Homogenize **-** This important step of 5S involves the visual control, which is important to keep your organization well organized and clean. It is a complete evaluation to improve the working conditions.

5. Shitsuke/Self Control **-** This step is quite essential, but critical because it involves all the discipline to ensure the 5S standards, it also takes charge of dedication and commitment.

5.2.4.2 QCC (Quality Control Circle)

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

6 Conclusion

6.1 ALL ENERGY SAVING MEASURES IDENTIFIED

Table 30: List of Energy Conservation Measures Identified

Sr. No	Energy Conservation Measure
1	Boiler Efficiency Improvement
2	Boiler Feed Water Pump Efficiency Improvement
3	Boiler Feed Water Pump Pressure Drop Reduction
4	Boiler Fans Efficiency Improvement
5	Flash Steam Recovery
6	Digester Blow Heat Recovery
7	Steam Consumption Reduction by Efficient Condensate Evacuation from Dryers
8	Energy Efficiency Improvement in Process Pumps
9	Installation of Screw Press
10	Installation of High Consistency Pulper
11	Installation of Pocket Ventilation System

6.2 TECHNO-ECONOMICS OF ENERGY SAVING MEASURES IDENTIFIED

Table 31: Techno-Economics of Energy Saving Measures Identified

Sr. No	Energy Conservation Measure	Annual Energy Saving Potential			Potential Saving ₹/year	Investment ₹	Payback Period Years	No. of Units may adopt technology	Total Saving Potential ₹
		Elec., kWh	Heat, mn kJ	Total, MTOE					
1	Boiler Efficiency Improvement	-	23,070	543.79	4,469,372	3,025,000	0.68	8	35,754,976
2	Boiler Feed Water Pump Efficiency Improvement	477,736	-	40.67	1,867,948	2,250,000	1.2	4	7,471,792
3	Boiler Feed Water Pressure Drop Reduction	260,794	-	39.47	1,019,705	1,150,000	1.13	2	2,039,410
4	Boiler Fans Efficiency Improvement	165,190	-	14.06	645,892	775,000	1.2	6	3,875,352
5	Flash Steam Recovery	-	9,403	221.64	1,821,614	1,100,000	0.6	6	10,929,684
6	Digester Blow Heat Recovery	-	8,314	197.95	1,610,685	2,050,000	1.27	8	12,885,480
7	Steam Consumption Reduction by Efficient Condensate Evacuation	-	8,785	295.83	1,702,011	1,390,000	0.82	4	6,808,044

8	Energy Efficiency Improvement in Process Pumps	277,828	-	7.33	1,086,307	651,000	0.6	12	13,035,684
9	Installation of Screw Press	528,800	-	84.1	2,067,608	4,555,000	2.2	3	6,202,824
10	Installation of High Consistency Pulper	144,000	-	23.22	563,040	2,000,000	3.55	2	1,126,080
11	Installation of Pocket Ventilation System	-	12,354	291.19	957,380	2,000,000	2.09	2	1,914,760
12	Installation of Pressurized Head Box	226,320	7,411	-	2,320,760	4,500,000	1.94	4	9,283,040
13	Total	2,080,668	69,337	1,829.79	20,132,322	25,446,000	1.26	61	111,327,126

6.3 SUMMARY OF LEVEL OF AWARENESS ON ENERGY EFFICIENCY AND ENERGY CONSERVATION POTENTIAL IN THE CLUSTER

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

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

Major energy sources being used in cluster are Coal, Biomass and Electrical energy. Annual energy consumption of above mentioned sources in different type of operations in Muzaffarnagar cluster is presented in table below:

Table 32: Annual energy consumption of various energy sources in Muzaffarnagar Paper cluster

S. No	Type of Unit	Electrical energy consumption (kWh/annum)	Fuel Consumption (GJ)	Gross (MTOE)
1	Agro Waste & Waste Paper	68,656,291	3,214,746	82,445
2	Waster Paper	109,046,952	454,599	20,200
3	Total	177,703,243	3,669,345	102,645

Total Annual energy consumption in the cluster is around 102,645 MTOE (Tonnes of Oil Equivalent). After implementation of proposed energy conservation measures will save the 9,537,288 kWh of electrical energy and 396,982 mn kJ of fuel. Annual energy saving potential identified in cluster is around 10,272 MTOE, which is around 10% of total energy consumption.

Annexure 1

List of Paper Mills in Muzaffarnagar Paper Cluster

Table 33: List of Paper Mills in Cluster

Sr. No	Paper Mill	Product	Capacity		Raw Material
1	Parijat Paper Mills Ltd	Kraft Paper	14000	TPA	Waste Paper
2	Bindlas Duplex Ltd	MG Kraft Paper, Duplex Board	38000	TPA	Agrowaste & Waste Paper
3	Tehri Pulp and Paper Ltd	Kraft Paper	75000	TPA	Agrowaste & Waste Paper
4	Tirupati Balaji Fibres Limited	Writing & Printing Paper	13200	TPA	Waste Paper
5	Shree Sidhbali Paper Mills Ltd	Kraft Paper	18000	TPA	Agrowaste & Waste Paper
6	Meenu Paper Mills(P) Ltd	Media Kraft Paper	5000	TPA	Waste Paper
7	Silverton Papers Ltd	Kraft Paper	25000	TPA	Agrowaste & Waste Paper
8	Garg Duplex and Paper Mills (P) Ltd	Kraft Paper	15000	TPA	Agrowaste & Waste Paper
9	Silverton Pulp & Papers Pvt Ltd	Writing & Printing Paper	8250	TPA	Waste Paper
10	Rana Papers Ltd	Kraft Paper, Kraft Liner	49500	TPA	Agrowaste & Waste Paper
11	Shalimar Krafts & Tissues (P) Ltd	1st Grade Product	10000	TPA	Waste Paper
12	Shalimar Paper Mills (P) Ltd	Kraft Paper	3500	TPA	Waste Paper
13	Mahalxmi Crafts & Tissues Pvt Ltd	Kraft Paper	8000	TPA	Agrowaste & Waste Paper
14	Shakti Krafts & Tissues	Kraft Paper Super Media	3500	TPA	Waste Paper
15	KK Duplex & Paper Mills (P) Ltd	Duplex, Gray Board	3500	TPA	Waste Paper

16	Orient Board & Paper Miils Pvt Ltd	Super Media	3400	TPA	Waste Paper
17	Taj Paper Pvt Ltd	Kraft Paper	3500	TPA	Waste Paper
18	Suyash Kraft & Paper Ltd.	Kraft Paper	3600	TPA	Waste Paper
19	Maruti Papers Ltd	Kraft Paper	24000	TPA	Agrowaste & Waste Paper
20	Nikita Paper Ltd	Kraft Paper	21000	TPA	Agrowaste & Waste Paper
21	Bhageshwari paper mills (P) Ltd	Kraft Paper	10500	TPA	Agrowaste & Waste Paper
22	Sikka Papers Ltd	Writing Paper & Kraft Paper	35000	TPA	Agrowaste & Waste Paper
23	Bindal Papers Ltd	Writing Paper	87500	TPA	Agro waste
24	Aggarwal Duplex Board Mills (P) Ltd	Coated Duplex Board, Poster Paper & Hard Tissue Paper	28000	TPA	Waste Paper
25	Shakumbri Paper Mills(P) Ltd	Kraft Paper	7000	TPA	Agrowaste & Waste Paper
26	Polymer Paper Ltd	Filter Paper	1750	TPA	Waste Paper
27	Siddheshwari Paper Mills(P) Ltd	Kraft Paper	14000	TPA	Waste Paper
28	Galaxy Paper Mill	Gray Board	10500	TPA	Waste Paper
29	Aristo Paper Mill	Kraft Paper	3500	TPA	Waste Paper

Annexure 2

Detailed Technology Assessment Report

The detailed technology assessment report is provided for the boiler efficiency improvement Energy Conservation Measure. Maintaining an optimum air to fuel ratio in the boiler is key to improved boiler operating efficiency. A stable combustion condition requires the right amounts of fuels and oxygen. The combustion products are heat energy, carbon dioxide, water vapor, nitrogen, and other gases (excluding oxygen). In theory there is a specific amount of oxygen needed to completely burn a given amount of fuel. In practice, burning conditions are never ideal. Therefore, more air than ideal must be supplied to burn all fuel completely. The amount of air more than the theoretical requirement is referred to as excess air. Boilers normally run at about 10 to 20 percent excess air. Failing to maintain adequate excess air levels and supplying high air to fuel ratio in the boiler leads to tremendous energy losses in terms of heat generated by fuel being taken away with nitrogen and unused oxygen. The graph below represents the variation of boiler efficiency level with reference to the change in the oxygen level in flue gas, which directly corresponds to the excess air supplied.

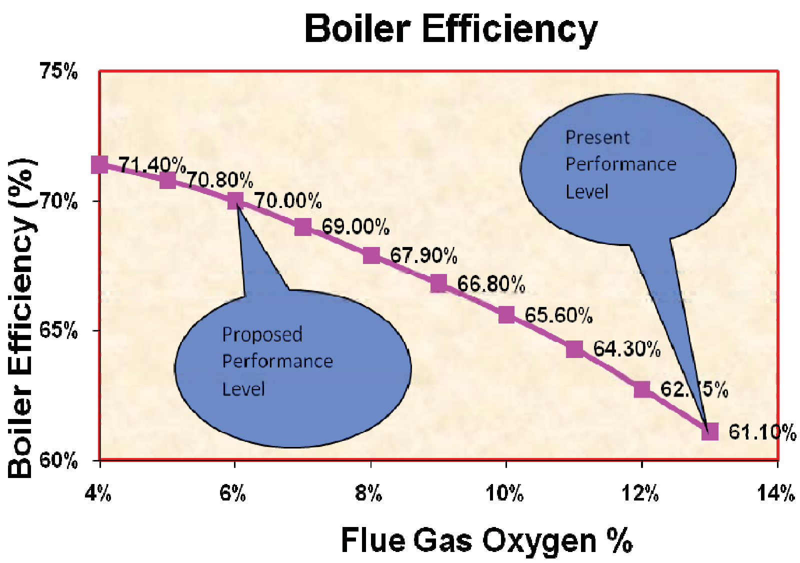

Figure 36: Variation of Boiler Efficiency with Oxygen Level in Flue Gas

Optimization of the air to fuel ratio in boiler will lead to intake of optimum amount of air required for complete combustion. This will lead to reduction in the amount of heat loss, which was being carried away with the surplus amount of air present in the flue gas. Reduction of heat loss in flue gas will lead to overall efficiency improvement of the boiler and consequently less amount of fuel will be required to generate an equivalent. In addition to the direct saving of fuel, installation of flue gas oxygen control will lead to reduced electricity consumption in the FD and ID fans of the boiler. This is merely because of the fact that less amount of air will be supplied by the ID fans and less amount of flue gas will be handled by ID fan. The detailed assessment is determined in the table below:

Table 34: Boiler Efficiency Improvement Technological Assessment

SN	Description	Value
1	Steam Flow (TPH)	5.00
2	Saturated Steam Pressure (kg/cm^2)	8.00
3	Steam Enthalpy (kCal/kg)	662.12
4	GCV of Fuel Used (kCal/kg)	3,338
5	Present Oxygen Level in Boiler	13%
6	Present Boiler Efficiency Level	61.1%
7	Present Fuel Consumption (TPH)	1.62
8	Proposed Operating Oxygen Level	6%
9	Proposed Boiler Efficiency Level	70.0%
10	Proposed Fuel Consumption (TPH)	1.42
11	Fuel Savings (TPH)	0.21
12	Annual Operating Hours	8,000
13	Energy savings (mn kJ/yr) @ GCV 3,338 kCal per kg	23,070
14	Monetary savings (₹/yr) @ ₹ 2,707 per Tonne	4,469,372
15	Estimated project cost (₹)	3,025,000
16	Payback Period (yrs)	0.68

Annexure 3

Details of Technology / Service Providers in Muzaffarnagar Paper Cluster

Table 35: List of Technology/Service Providers

S. No	Name of company	Contact person	Address of company	Technology / service provider for
1.	R C Paper Machine	Chaitanya Nigaskar	F-23, Industrial Area Delhi Road, Saharanpur - 247001, Uttar Pradesh, India	Renowned manufacturer and exporter of Paper Machines, Paper Machine Equipments, Handmade Paper Machines, Sheet Cutters for Paper, Board Machines, Dryers, Rewinders for Paper, Craft Paper Machines, 3F Screens, and more
2	Annapurna Imports	Vishal Agarwal	179, Patel Nagar,New Mandi, Muzaffarnagar - 251001, Uttar Pradesh, India	Supply Paper Machines, Paper Machine Clothing, Pulp Mill Equipments, Pressurised Head Boxes, Heavy Press-Rolls, Suction Couch Rolls, C.I. Dryers, Calendars, Ceramics Suction Tops, Doctor Blades, Screw Press, Centricleaners, Ceramic Nozzles and other Accessories
3	Associated Pumps & Valves	Sunil Thakur	206, Vardhman, D-Block Central Market, Prashant Vihar, Delhi- 110085	Pumps and Valves
4	Cheema Boilers Ltd.	Navdeep Singh Bhatti	SCO 523-524, Sector 70, Mohali-160071	Boiler and Boiler Auxiliaries
5	Forbes Marshall	Raman Kumar	PB29, Mumbai Pune Road, Pune	Steam systems

Annexure 4

Techno Commercial Bids from Service/Technology Provider

DyanamicENGINEERS
Dyanamic Engineers Pvt. Ltd.
D-94, Sector-63, Noida-201301
Phone: 0120-4787400 (30 LINES)
Fax: 0120-4787504

Ref. No.:- 17342/10-11
Date: September 10, 2010.

M/s Deloitte Touche Tohmatsu India Private Ltd
7th Floor,Building 10,Tower B,DLF Cyber City Complex,
DLF City Phase-II, Gurgaon-122002, Haryana

Sub: - Offer for Screw Press-1200 & Hi-Con Pulper 15 m^3

Kind Attn: Mr.Puneet Sethi

Dear Sir,

We thank you for your enquiry thru e-mail dated 31/8/10 for above mentioned subject. We are pleased to quote our most competitive offer as under.

S. No.	Products	Price in INR
1	Boiler Flue Gas Control system	2,635,000.00
2	Boiler Feed Water Control System	1,001,500.00

1. **Terms and Conditions:-**

Price	:	**CIF New Delhi. India.**
Taxes & Duties	:	**Extra As Applicable**
Delivery	:	**2 Months**
Payment	:	**40% Advance & Balance before Despatch**
Site Supervision	:	**Will be charged at INR 5000 per Manday**

We hope the same is line with your requirement. Awaiting for your valued Order. In case of any query please contact the undersigned.

Yours Sincerely,

Deepak Chauhan

ANNAPURNA IMPORTS

Importer & Exporters of Paper Machinery & Machinery

C.I. Dryers, Press Rolls, Yankee, Calendar Rolls, Granite Rolls ,Screw Press, Combination roll, Paper Making Felt, Dryer Screen, Forming Wire, Ceramic Suction Tops, Ceramic Centricleaners, Doctor Blades, Slotted Screen Motor, Bearing, Valves, and complete Paper Machine.

Ref. No.:- AI/Mach./01
Date: September 7, 2010.

M/s Deloitte Touche Tohmatsu India Private Ltd
7th Floor,Building 10,Tower B,DLF Cyber City Complex,
DLF City Phase-II, Gurgaon-122002, Haryana

Sub: - Offer for Screw Press-1200 & Hi-Con Pulper 15 m^3

Kind Attn: Mr.Puneet Sethi

Dear Sir,

We thank you for your enquiry thru e-mail dated 31/8/10 for above mentioned subject. We are pleased to quote our most competitive offer as under.

S. No.	Products	Description	Price, ₹
1	Screw Press	1200 Dia	4,555,000.00
2	Hi Consistency Pulper	15m^3.	2,000,000.00
3	Kadant siphon	1 No.	63,140.00
4	Pressurized Head Box	1 No.	4,500,000.00
5	Pocket Ventilation System	1 No.	2,000,000.00

2. Terms and Conditions:-

Price	:	**CIF New Delhi. India.**
Taxes & Duties	:	**Included**
Delivery	:	**90 Days**
Payment	:	**30% Advance & Balance before Despatch**

We hope the same is line with your requirement. Awaiting for your valued Order. Any queries please feel free to talk to the undersigned.

Yours Sincerely,
Pankaj Kinder
#91-9368331100

ADD: 179, Patel Nagar, New Mandi, Muzaffarnagar-251 001 (U.P.) INDIA
Tel:- +919837022374, 9837923000 Email: bindals@hotmail.com, ,
Web: www.annapurnaimports.com

ASSOCIATED PUMPS & VALVES

KSB Authorised Dealer

To

M/s. Deloitte Touche Tohmatsu India Pvt Ltd , Gurgaon

Offer No. 10439/2010, 9/9/2010

Kind Attn. Mr Puneet Sethi

Sub: Your requirement of KSB pumps

Dear Sir,

Please refer your enquiry, we are pleased to submit our offer as under.

No.	PUMP	PUMP MODEL	CAP (M3/HR)	SUC TION PRESSURE (KG/CM2)	DISCHARGE PR (KG/CM2)	QTY	EFF%	BKW	MK W	RPM	UNIT PRICE(Rs)
1	FAN PUMP PM1	MEGA-G-50-160	58.63	1.1	3.5	1	77.07	4.93	7.5	2870	50077.00
2	FAN PUMP PM2	MEGA-G-150-315	395.83	1.2	3.5	1	83.46	29.47	37	1470	233006.00
3	SUBMERSIBLE WATER PUMP	SUB	180	-	5	1	77.23	31.86	40	1440	68324.00
4	CHEST PUMP 3	MEGA-G-80-315	120	0.3	3	1	76.61	11.43	15	1455	109035.00
5	HIGH PR PUMP	MOVITE C VCF 10/16	8	0.2	13.8	1	60	4.94	5.5	2900	95523.00
6	BFW PUMP	HAD 80/11	60	1.2	90	1	68	207	250	2980	1956521.00

Terms and conditions

Price for Delhi

Payment 100% against performa invoice.

Delivery within 4 weeks from the date of your po.

Sales tax/vat/ed extra as applicable at the time of despatch.

Warranty as per warranty card of manufacturer.

Hope you will find our offer in line with your requirement and shall look forward to receive your valued order.

Thanking you,

SUNIL THAKUR

ASSOCIATED PUMPS & VALVES

206, VARDHMAN, D- BLOCK CENTRAL MARKET,

PRASHANT VIHAR - DELHI- 110085

CELL : +91 9818642009, PHONE : 01127867035/01127550030, TELEFAX – 01127867035

CBL

AN ISO 9001 2000 COMPANY

CHEEMA BOILERS LIMITED
SCO 523-524, SECTOR 70
MOHALI, CHANDIGARH
160 071 INDIA
PHONES: 91 172 5091790, 5090487
FAX : 91-172-5090486
mail@cheemaboilers.com
www.cheemaboilers.com

Ref: CBL161/SP: 2010-11

September 8, 2010

M/s Deloitte Touche Tohmatsu India Pvt. Ltd., Gurgaon, Haryana

Kind Attention: Mr. Puneet Sethi

Ref: Your email dated August 30, 2010

Sub: Offer for FD Fans

Dear Sir,

We acknowledge with thanks the receipt of your enquiry and pleased to submit our prices as per below:

Scope of Supply

S No.	Description	Unit Price (Rs.)	Qty. (Nos.)	Total Price (Rs.)
1	FD Fan with motor	675,000	3	2,025,000
Total Price (Rs. Twenty Lac Twenty Five Thousand Only)				2,025,000/-

Commercial Terms & Conditions

S No.	Description	
1	Price Basis	Ex works Kurali
2	Packing & Forwarding	Extra @ 2.5%
3	Freight & Insurance	Extra
4	Taxes & Duties	Extra
5	Payment Terms	50% advance and balance against performa invoice before dispatch
6	Delivery	2.5 -3 months from receipt of advance & techno-commercial clear order, whichever is later
7	Exclusions	Dismantling, Erection, Ducting, Control Panel Cabling, Commissioning, VFD, Inlet Silencer, Any approval at site is in your scope (As applicable)
8	Inspection of material	We invite you to inspect the material & testing facilities during any stage of manufacturing prior to dispatch at your works.

Hope the above is as per your requirement. We now look forward the pleasure of receiving your valuable order.

Sincerely yours,

For CHEEMA BOILERS LIMITED,

Navdeep Singh Bhatti

Asst. Engineer (Mktg.)

Cell: 09781297242

ENERGY IS LIFE BEE CONSERVE IT

Registered Office:
P B # 29, Mumbai-Pune Road,
Kasarwadi, Pune 411 034, INDIA
TEL: 91 (0) 20-27145595
DID: 91 (0) 20-27149012
FAX: 91 (0) 20-27147413
URL: http:\\www.forbesmarshall.com

Ref: RKK/10-11/47

M/s Deloitte Touche Tohmatsu India Pvt. Ltd., Gurgaon

Kind Attn: Mr. Charu Gupta

Subject: SPIRAX MAKE CONDENSATE RECOVERY SYSTEM

Dear Sir,

As per discussion and Refer to mail on dated 1st September 2010, please find attached techno-commercial offer for steam operated condensate and flash steam recovery system along with the system to capture heat from Digester Blow down flash steam. We take this opportunity to thank you for the interest shown in our products which will help you to save energy in your plant, hence increase productivity and reduce fuel bills.

If you require any clarifications, then do get in touch with us.

Warm Regards,

For Spirax Marshall Pvt Ltd.

Raman Kumar Khunger

9953325727

Techno-Commercial Offer

S No.	ITEM	Total Price (Rs.)
1	CONDENSATE RECOVERY SYSTEM Pressure Powered Pump Package Unit With insulation jacket and CRM	640,000/-
2	Flash Vessel FV 8 with all accessories to return flash steam to Feed Water Tank (like IJ , FT , SG , SV and Gauge etc.)	120,000/-
3	De – Aerator Head Size 200 NB	120,000/-
4	Digester Flash stem heat recovery system (By pass system & plate heat exchanger)	1,780,000/-

Terms & Conditions

Prices : Ex- Works Pune, taxes and duties extra.
Terms : 30% advance balance 70 % Against Performa Invoice.
CED : Extra as applicable at the time of dispatch (Presently 10.3%)
CST : 2% against form "C".
Delivery : 3 – 4 Weeks from date of receipt clear techno-commercial P.O., Advance and road Permit.
Validity : 30 days

P & F : 2.5%

Annexure 5

Financial schemes available for improving energy efficiency in cluster

1. Credit linked capital Subsidy scheme(CLCSS)

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

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

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

The Japan International Corporation Agency (JICA) has extended a line of credit to SIDBI for financing Energy Saving projects in Micro, Small and Medium Enterprises (MSMEs). This project is expected to encourage MSME units to undertake energy saving investment in plant and machinery to reduce energy consumption, enhance energy efficiency, reduce CO_2 emissions, and improve the profitability of units in the long run.

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

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

Financial parameters:

The financial parameters for appraising the project are:

Parameter	Norms
Minimum Assistance	Rs. 10 lakh
Minimum promoters contribution	25% for existing units; 33% for new units
Interest rate	The project expenditure eligible for coverage under the line will carry a rate of interest rate of 9.5-10% p.a
Upfront fee	Nonrefundable upfront fee of 1% of sanctioned loan plus applicable service tax
Repayment period	Need based. Normally the repayment period does not extend beyond 7 years. However, a longer repayment period of more than 7 years can be considered under the line if necessary

Eligibility criteria for units (Direct assistance):

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

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

3. Scheme for Financing Energy Efficiency Projects

PURPOSE:

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

ELIGIBILITY

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

LIMIT:

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

Project cost may include the following:

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

RATE OF INTEREST:

- Bank's BPLR from time to time.

REPAYMENT :

- Maximum 5 years, including moratorium, if any.

SECURITY :

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

Grant from IREDA:

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

Bureau of Energy Efficiency (BEE)
(Ministry of Power, Government of India)
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066
Ph.: +91 – 11 – 26179699 (5 Lines), Fax: +91 – 11 – 26178352
Websites: www.bee-india.nic.in, www.energymanagertraining.com