सत्यमेव जयते
Ministry of Power
Government of India

Improving Energy Efficiency in

Pulp & Paper Sector

(Achievements and Way Forward)

Perform Achieve & Trade

September 2018

BUREAU OF ENERGY EFFICIENCY

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Published by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Published by BEE in Partnership with GIZ

Imprint

Bureau of Energy Efficiency (BEE), Ministry of Power, Govt. of India
4th Floor, Sewa Bhawan, Sector-1, R.K. Puram
New Delhi, 110066, India

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Registered offices: Bonn and Eschborn, Germany
Indo-German Energy Programme (IGEN)
C/o Bureau of Energy Efficiency
West Block-2, Sector-1, R.K. Puram, New Delhi, 110066, India

Responsible
Winfried Damm
E: winfried.damm@giz.de

Contributing Authors
Bureau of Energy Efficiency (BEE)
Abhay Bakre, Pankaj Kumar, Ashok Kumar, Sunil Khandare, Navin Kumar

Indo-German Energy Programme (IGEN)
Arvind Kumar Asthana, Rita Acharya, Nitin Jain, Piyush Sharma, Ravinder Kumar

Confederation of Indian Industry (CII)
K S Venkatagiri, P V Kiran Ananth, K Muralikrishnan, Balasubramanian M B and Team

Acknowledgement
JK Paper Mills, Seshasayee Paper and Boards Limited, B.P. Thapliyal, CPPRI, IPMA

Study by:
Confederation of Indian Industry (CII)
CII – Sohrabji Godrej Green Business Centre
Survey No. 64, Kothaguda Post,
Near Hi-tech City, Hyderabad, 500084, India

Version: New Delhi, September 2018

Dr. Winfried Damm

Head of Energy, GIZ India

Paper has become an essential part of our daily lives ever since its invention. Indian paper industry accounts for 3.7% of world's paper production. A number of processes and a variety of fuel input makes the sector one of the most diversified sector. The complex process along with several utilities paves way for tremendous energy efficiency potential in the sector. Use of biomass and byproduct as fuel sources could save the primary energy consumption in this sector quite significantly. The efficiency in some plants are at par with the world's best plants, but a good number of plants still have significant reduction potential.

Germany has been playing a very active role in promoting energy efficiency in not only its own land, but also supporting the other countries to adopt the same. Germany has been supporting India in various fields since last 60 years, with an aim of promoting cooperation and involving public-private sectors of both sides in the areas of energy, environment and sustainable economic development. The Indo-German Energy Programme (IGEN), works as a partner of Bureau of Energy Efficiency (BEE) in supporting policies and programmes envisaged under the Energy Conservation Act, 2001.

It has been a privilege to work with BEE, the organization spearheading activities on energy efficiency in India. IGEN has been involved with BEE in the Perform Achieve and Trade since its inception, and hence it is blissful to know that the outcome of this scheme led to a huge savings in terms of CO_2 emission reduction and coal.

However, the real outcome of PAT scheme is not only the savings in terms of toe and CO_2, but it is the change in behavior towards energy efficiency. It is astonishing to see the amount of resources and concepts the industries have put together in achieving the target. Some state-of-the-art projects implemented in PAT cycle-I are cross cutting and could have significant potential across the sectors. Some of the positive outcomes of this scheme were the utilization of waste heat in generation of steam and power, adoption of cogeneration, use of alternate fuel and raw material, etc. This report analyses the outcome of PAT scheme in Pulp and Paper sector in multidimensional ways and forecasts the future savings along with innovative case studies having high replication potential. The estimate suggests the cumulative energy savings from the sector till 2030 to be 7.81 million TOE, which is quite impressive.

We are delighted to be a part of this historic journey where India has been a forerunner in implementing an exceptional scheme, customized to the benefit of the industries as well as the nation. I personally feel that the deepening of this scheme in Pulp and Paper sectors including SME would prove a game changer in the times to come. This scheme has tremendous opportunities for regional synergies and its adaptation by other countries could lead to address the global climate issues.

Dr. Winfried Damm

अभय बाकरे, आईआरएसईई
महानिदेशक
ABHAY BAKRE, IRSEE
Director General

ऊर्जा दक्षता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)

FOREWORD

As we are embarking an ambitious path to provide electricity to all and raise the level of energy availability to the population across the country with limited resources at disposal; efficient use of primary energy resources is absolutely necessary.

Bureau of Energy Efficiency, under the Ministry of Power has been spearheading the promotion of energy efficiency in various aspects of the country's energy landscape, through programs such as Standards & Labelling for appliances, Energy Conservation Building Code (ECBC) for buildings and Demand Side Management (DSM) program for Agriculture and Municipality sectors.

One such flagship program for energy intensive industries namely Perform, Achieve and Trade (PAT) was launched under the National Mission for Enhanced Energy Efficiency (NMEEE). This scheme has demonstrated its value in its first cycle, in which 478 Designated Consumers have achieved 8.67 MTOE of energy savings against the target of 6.68 MTOE, exceeding by about 30 %.

With an objective to have further insight on the actions taken and other notable effects taken by these designated units in achieving the excellent results, a study has been taken up by BEE in partnership with GIZ. The report gives an in-depth analysis of the achievements, projections and success stories across various sectors covered in the first cycle of PAT scheme.

With the continued guidance of Ministry of Power, the Bureau of Energy Efficiency expresses its gratitude towards all the industries, associations and other stakeholders for their significant contribution to achieve the task of saving energy and adoption of energy efficiency measures. BEE intends to convey our congratulations to all who joined us on our collective endeavour of improving energy efficiency in the country.

Abhay Bakre.
(Abhay Bakre)

New Delhi: 19.09.2018

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ Save Energy for Benefit of Self and Nation

चौथा तल, सेवा भवन, आर.के.पुरम, नई दिल्ली–110 066 / 4th Floor, Sewa Bhawan, R.K. Puram, New Delhi-110 066
टेली / Tel.: 91 (11) 26178316 (सीधा / Direct) 26179699 (5 Lines) फैक्स / Fax: 91 (11) 26178328
ई–मेल / E-mail : dg-bee@nic.in, abhay.bakre@nic.in, वेबसाईट / Website : www.beeindia.gov.in

Sectoral Expert Committee Members			
S. No.	**Name**	**Designation**	**Organization**
PULP AND PAPER			
1	Dr. B.P. Thapliyal	Director	CPPRI
2	Mr. Pramod Agarwal	President	IARPMA
3	Mr. P.S. Patwari	President	INMA
4	Mr. Pavan Khaitan	Managing Director	Kuantum Papers Limited
5	Mr. Raghavendra Hebbar	GM (Development)	JK Papers Limited
6	Sh Rohit Pandit	Secretary	IPMA

Content

List of Figures

List of Tables

1.0 Executive Summary

In a bid to combat increasing energy consumption and related carbon emissions, the Government of India released the National Action Plan on Climate Change (NAPCC) in 2008 to promote and enable sustainable development of the country by promoting a low carbon and high resilience development path. Under the NAPCC, eight national missions were framed to focus on various aspects related to water, solar energy, sustainable habitat, agricultural, energy efficiency, ecosystems, etc. Perform Achieve and Trade scheme (PAT) is a component of the National Mission for Enhanced Energy Efficiency (NMEEE) which is one of the eight missions under the NAPCC.

PAT is a regulatory instrument to reduce specific energy consumption (SEC) in energy intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy savings, which could be traded. Energy Savings Certificate (ESCerts) are issued to the industries which reduce their SEC beyond their target. Those companies which fail to achieve their target are required to purchase ESCerts for compliance, or are liable to be penalised. Trading of ESCerts are conducted on existing power exchanges.

PAT Cycle 1, which was operationalized in April 2012, included 478 units, known as "Designated Consumers" (DCs), from eight energy-intensive sectors viz. Aluminium, Cement, Chlor-Alkali, Fertilizer, Iron &Steel, Pulp & Paper, Thermal Power Plant and Textile were included. The annual energy consumption of these DCs in eight sectors was around 164 million TOE. The overall SEC reduction target in the eight sectors was about 4.05% with an expected energy saving of 6.68 million TOE by the end of 2014-15.

With the completion of the PAT Cycle 1 in 2015, the reported overall achievement was 8.67 million TOE, exceeding the target for cycle 1 by almost 30%. The total energy saving of 8.67 million TOE is equivalent to saving of about 20 million tonnes of coal and avoided emissions of about 31 million tonnes of CO_2. In terms of monetary value, saving in energy consumption corresponds to Rs. 95,000 million.

PAT Cycle 1 has witnessed an exceptional performance from all the sectors in terms of reducing their energy consumption. The DCs have made commendable efforts to achieve energy efficiency targets by adopting various improvement measures in technology, operational and maintenance practices, and application of management techniques.

The paper plants having annual energy consumption greater than 30,000 million TOE were included under PAT Cycle 1. Based on the annual threshold 30,000 million TOE, 31 paper plants were included as DCs and their cumulative energy consumption was 2.09 million TOE. Based on their specific energy consumption level, these DCs were given SEC target reduction of an average of 5.69% resulting in 0.119 million TOE energy consumption reduction in absolute terms. The paper sector constituted 1.78% of the overall energy saving target under PAT Cycle 1. A brief achievement by the Paper sector in PAT-1 at a glance is mentioned in the Table 1.

Parameter	Units	Values
Number of DCs in the sector	nos	31
Total energy consumption of DCs in the sector	million TOE	2.09
Total energy saving target for pulp and Paper sector in PAT Cycle I		0.119
Total energy saving achieved by pulp and Paper in PAT Cycle I		0.289
Energy savings achieved in excess of the target		0.171
Reduction in GHG Emissions in Cycle I	million T CO_2	1.24
Cumulative energy savings with PAT Impact till 2030 over BAU[1]	million TOE	7.81

Table 1: Pulp and Paper sectoral achievement in PAT Cycle I

The key focus of Paper sectoral report is on the energy savings resulting from PAT scheme as compared to the business as usual scenario (BAU). The report also includes the impact of PAT on GDP of the country, sector specific data analysis, process trends, sectoral benchmarking of specific energy consumption, success stories implemented in plants, and list of key technologies which can be implemented in the sector. Analysis has been presented until the year 2030.

1. Difference of energy consumption between PAT and Business as Usual scenario (BAU)

2.0 Pulp & Paper sector in India

Paper sector is one of the fast-growing industrial sectors in India. Increasing population and literacy rate, growth in GDP, improvement in manufacturing sector and lifestyle of individuals account for the growth in the paper industry of India. Indian Paper industry plays a key role in the Indian economy, with a contribution of around Rs. 500 billion to the GDP and its contribution to the exchequer is around Rs. 45 billion . The paper production in India is likely to grow at 6% CAGR and the expected paper production in India by year 2030 will be around 39.18 million tonnes. The industry provides employment to more than 0.5 million people directly and 1.5 million people indirectly.

The Indian paper industry accounts for 3.7%of the world's paper production. Presently there are more than 600 mills with installed capacity of about 22 million tonnes with an average capacity utilization of 80%. The actual production of paper in 2014-15 year was 17.03 million tonnes (Paper & Paperboards segment) & 1.24 million tonnes (Newsprint segment), and the country's per capita consumption was around 13.2 kg3. The industry is broadly classified into three segments based on the raw material used, namely wood based, agro based and waste paper. Waste paper segment accounts for 68% of total paper production followed by wood based (23%) and agro based (9%). The industry is also categorized on paper grades, namely Writing & Printing, Industrial Packaging and Newsprint & Paperboard.

SECTOR HIGHLIGHTS...

- India's Paper sector contributes approx. Rs. 500 billion to its GDP
- Indian Paper industry accounts for 3.7% of worlds paper production
- Total installed capacity around 22 million tonnes
- Paper production in 2014-15 was approx. 15 million tonne
- Country's per capita paper consumption 13.2 kg

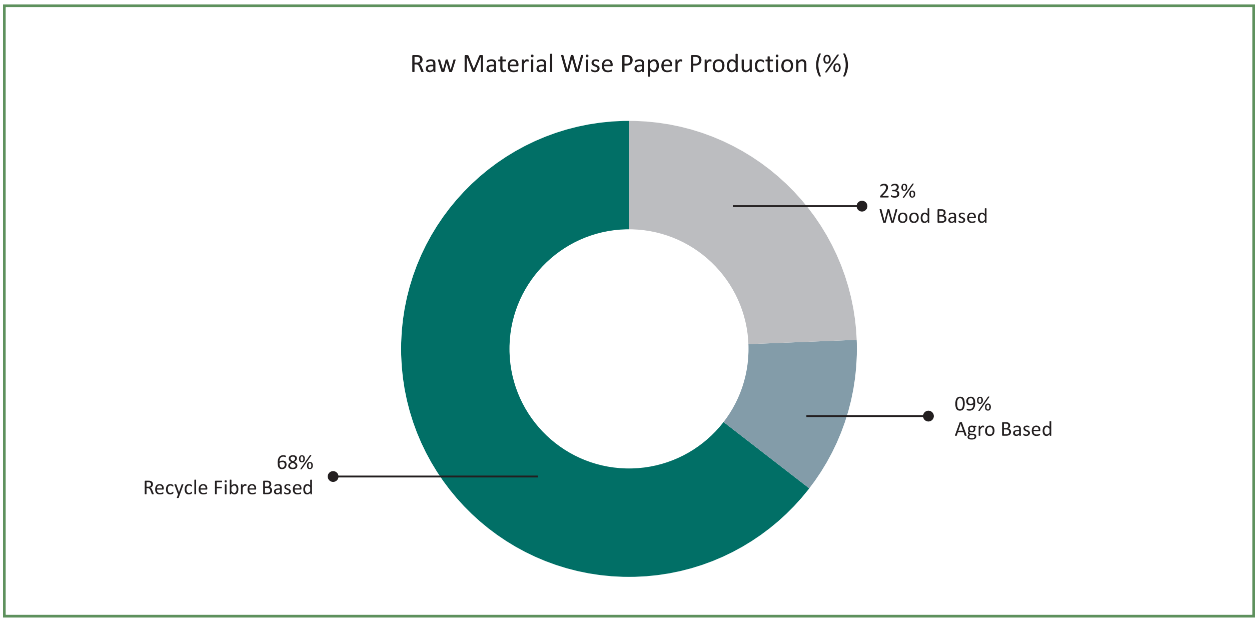

Figure 1: Raw Material Wise Paper Production[3]

3. Central Pulp & Paper Research Institute (CPPRI) Annual Report 2014-15

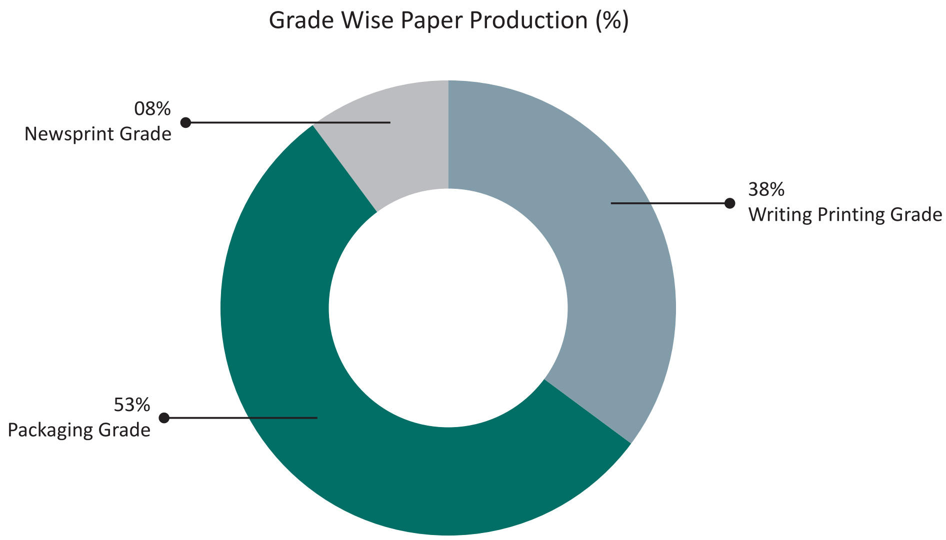

Figure 2: Grade Wise Paper Production[3]

2.1 Sectoral Contribution to Country's Energy Intensity

Year	FY12	FY13	FY14	FY15	FY20	FY25	FY30
Paper Production (million tonne)	10.90	11.80	13.00	17.03	21.88	29.28	39.18

Table 2: Growth of Paper Industry

The Energy intensity of the country is calculated in Table 33, and is on the basis of primary energy consumption and includes energy consumption of non-conventional sources of energy. The sectoral energy intensity for the paper sector DCs in PAT is mentioned in Table 4.

Financial Year	Total Energy Consumption of India	Gross Domestic Product (GDP)	Energy Intensity
	million TOE	Billion USD	toe/ million USD
2008	427	1,187	360
2009	453	1,324	342
2010	512	1,657	309
Average Baseline	464	1,389	334
2015	659	2,102[7]	313
2020	1018[8]	3,018	337
2025	1211[9]	4,233	286
2030	1440[8]	5,937[11]	243

Table 3: India's Energy Intensity

The contribution of DC's to overall energy intensity of India is 5.46% for the baseline year. Paper sector has achieved 0.289 million TOE savings under PAT cycle – I. The contribution of this energy savings to overall total energy consumption of India is 0.04% during the assessment year.

Financial Year	Total Production	Total Energy Consumption	Gross Domestic Product (GDP)	Energy Intensity
	million tonnes	million TOE	Billion USD	toe/ million USD
Average Baseline	7.38[12]	4.88	1,389	1.51
2015	17.03	10.65	2,102	2.03
2020	21.88	12.76	3,018	1.69
2025	29.28	16.02	4,233	1.51
2030	39.18	20.19	5,937	1.36

Table 4: Paper Sector Energy Intensity

Pulp & Paper sector Energy intensity contribution in baseline year and assessment year was **1.05%** and **1.61%** respectively.

4 Working group report 12th five year plan (CPPRI 2014-14 Annual report)
5 Energy consumption values are taken from Energy Statistics 2017 report
6 BP Statistical Review of World Energy 2016
7 GDP from World Bank GDP for India – Upto 2015
8 India Energy Outlook, Year 2015 - IEA
9 Estimated by calculating CAGR for 2020 and 2040 in India Energy Outlook, Year 2015 - IEA
11 GDP values calculated based on CAGR value of 7.5% till 2020 and 7% between 2020 and 2030. Same assumptions have been considered in India Energy Outlook, Year 2015 - IEA
12 Avg. production of paper in India during year 2007-2010

3.0 Process, Technologies and Energy Consumption Trend of the Sector

The Paper manufacturing process is complex, involving multiple steps that require specialized equipment. The major processes employed in the pulp and paper industry include raw materials preparation, pulping, bleaching, chemical recovery, pulp drying, and paper making.

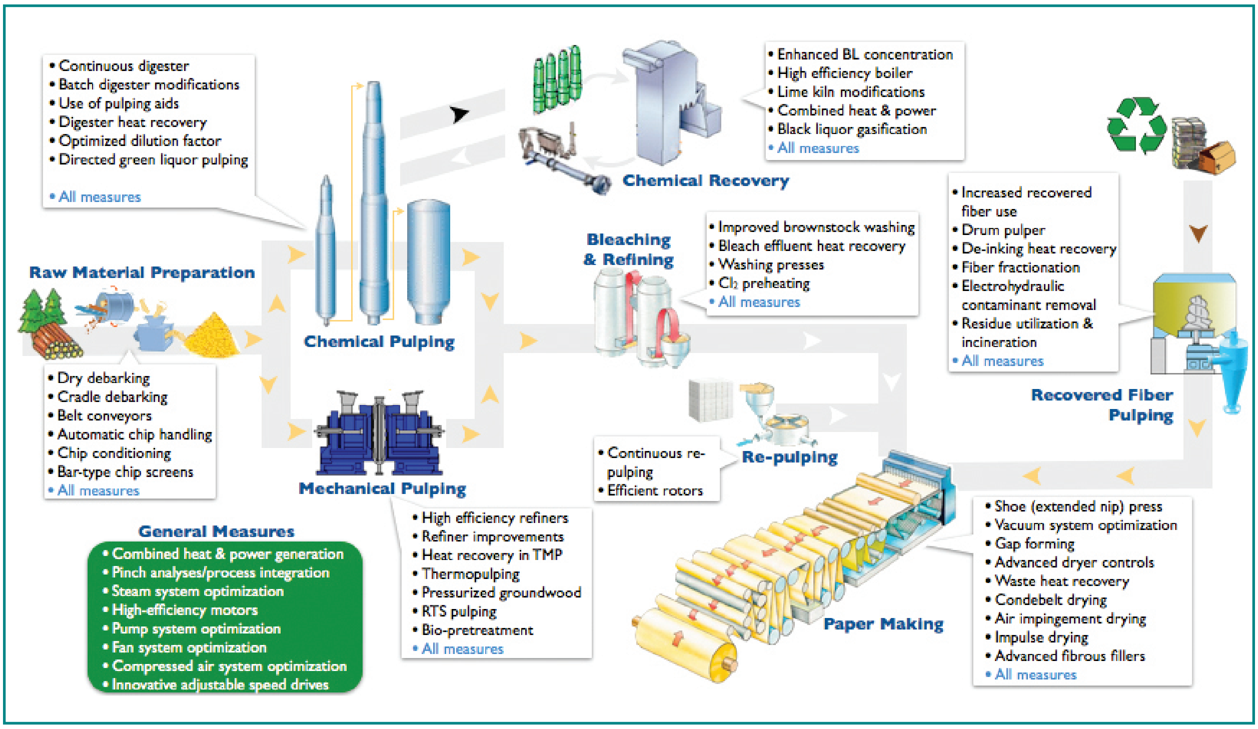

Figure 3: Paper Manufacturing Process flowchart

1. Raw material preparation

Logs typically arrive at the mill on trucks or rail cars. For ease of handling, large logs are sometimes sent to a slasher deck for size reduction prior to debarking. Debarkers are used to remove bark from logs prior to chipping, since bark is a contaminant in the pulping process. Commonly, bark is removed from logs by placing them in a large rotating steel drum, where the logs rub against one another and the bark is removed by friction. After debarking, the logs are sent to a chipping machine (most commonly a radial chipper).

These machines produce wood chips of a consistent size and shape to maximize the efficiency of the pulping process. Wood chips are then passed over a series of vibrating screens to remove chips that are either oversized or undersized. Chips that are too small—often called "fines"—are subsequently burned as hog fuel to generate steam. Chips that are too large are typically recovered fo further reduce them. The chips are then transported to the pulping stage using belt Conveyors.

2. Pulping

The primary goals of pulping are to free fibers in wood from the lignin that binds these fibers together, and then to suspend the fibers in water into a slurry suitable for paper making. The three main processes for producing wood pulp are mechanical pulping, chemical pulping, and semi-chemical pulping.

Mechanical Pulping

Mechanical pulping is the oldest form of pulping. The process employs mechanical energy to weaken and separate fibers from wood and waste paper feedstock via a grinding action.

Chemical Pulping

In the Kraft pulping process, wood chips are first steamed to soften them and to force out any trapped air. The wood chips are then combined with a highly alkaline solution – called white liquor – which contains sodium hydroxide (NaOH), and sodium sulfide (Na_2S). These ingredients are pressurized and cooked at 160-170°C in a digester over several hours, which allows the liquid to permeate the wood chips and dissolve most of the non-fibrous constituents in the wood.

Semi Chemical Pulping

Semi-chemical pulping uses a combination of chemical and mechanical pulping processes whereby wood chips are subjected to a mild chemical digestion process before they are mechanically pulped.

3. Chemical Recovery

The primary purpose of the chemical recovery process is to recover pulping chemicals from spent cooking liquor (i.e., black liquor) for reuse in subsequent pulping processes. The chemical recovery process for Kraft pulping consists of four key stages: (1) black liquor concentration, (2) black liquor combustion (recovery boiler), (3) recausticizing, and (4)calcining (lime burning).

Black liquor concentration is the process of evaporating water from black liquor to increase its solids content, which makes the recovery boiler combustion process far more efficient.

Most mills employ multiple effect evaporators to concentrate black liquor using indirect heat from steam. After concentration, black liquor will typically have a fuel value.

It is then combusted in a recovery boiler to produce steam for mill process heating applications and/or electricity generation. During combustion,organic constituents burn to generate useful heat while the inorganic process chemicals are reduced to a molten smelt. This smelt is removed from the bottom of the boiler for further refining in the recausticizing stage.

In the recausticizing process, the smelt from the recovery boiler is first mixed with weak white liquor to form an intermediate solution known as green liquor. This green liquor 19consists mostly of sodium carbonate (Na_2CO_3) and sodium sulfide (Na_2S). The green liquoris then recausticized by adding calcium hydroxide $Ca(OH)_2$ under controlled temperature and agitation. The recausticizing process converts the sodium carbonate in the green liquor into sodium hydroxide (NaOH) and a calcium carbonate ($CaCO_3$) precipitate. The calcium carbonate precipitate—also known as lime mud—is then removed, leaving behind whiteliquor (i.e., NaOH and Na_2S) that can be reused in the pulping process.

The lime mud is then sent to the calcining process, where it is heated in a kiln to produce lime (CaO) with carbon dioxide (CO_2) as a by-product. The lime is then dissolved in water to produce the calcium hydroxide $Ca(OH)_2$ that is used in the mill's recausticizing process.

4. Bleaching

Raw pulp can range in color from brown to crème due to the remaining lignin that was not removed during the pulping process. For paper products for which brightness and resistance to color reversion are important, such as office and printing paper, the pulp must be whitened by a bleaching process prior to the paper making phase.

5. Papermaking

The papermaking process can be divided into three basic stages: (1) stock preparation, (2) "wet end" processing where sheet formation occurs, and (3) "dry end" processing where sheets are dried and finished. The purpose of stock preparation is to process the pulp into a homogenous slurry with properties suitable for introduction into the paper machine. Stock preparation involves the following processes: mechanical homogenization of pulp, dispersion in water, fiberdeclustering, and introduction of wet additives, blending, and contaminant screening. The purpose of wet additives is to provide the final paper product with specific desirable properties (such as color and water repellence) and to improve the quality and efficiency of the paper making process. Dry end processes include drying, calendering, and reeling. In the drying section, steam heated rollers compress and further dry the sheet through evaporation, which facilitates additional bonding of fibers.

Refer Chapter 6 Benchmarking (National & Global) for energy consumption trends in the Indian Pulp & Paper Sector.

4.0 Methodology adopted for the project

The activities initiated with collection of sector specific data from Bureau of Energy Efficiency (BEE). In addition, other additional data was also collected through secondary research. The collected data were analysed to assess the impact of PAT Cycle 1 on energy intensity and Business as usual vs PAT scenario, GDP of the country, trend analysis for energy efficiency, quantification of energy saving in terms of toe and coal saving. Feedback was also collected from designated consumers on benefits and the challenges experienced through the PAT scheme.

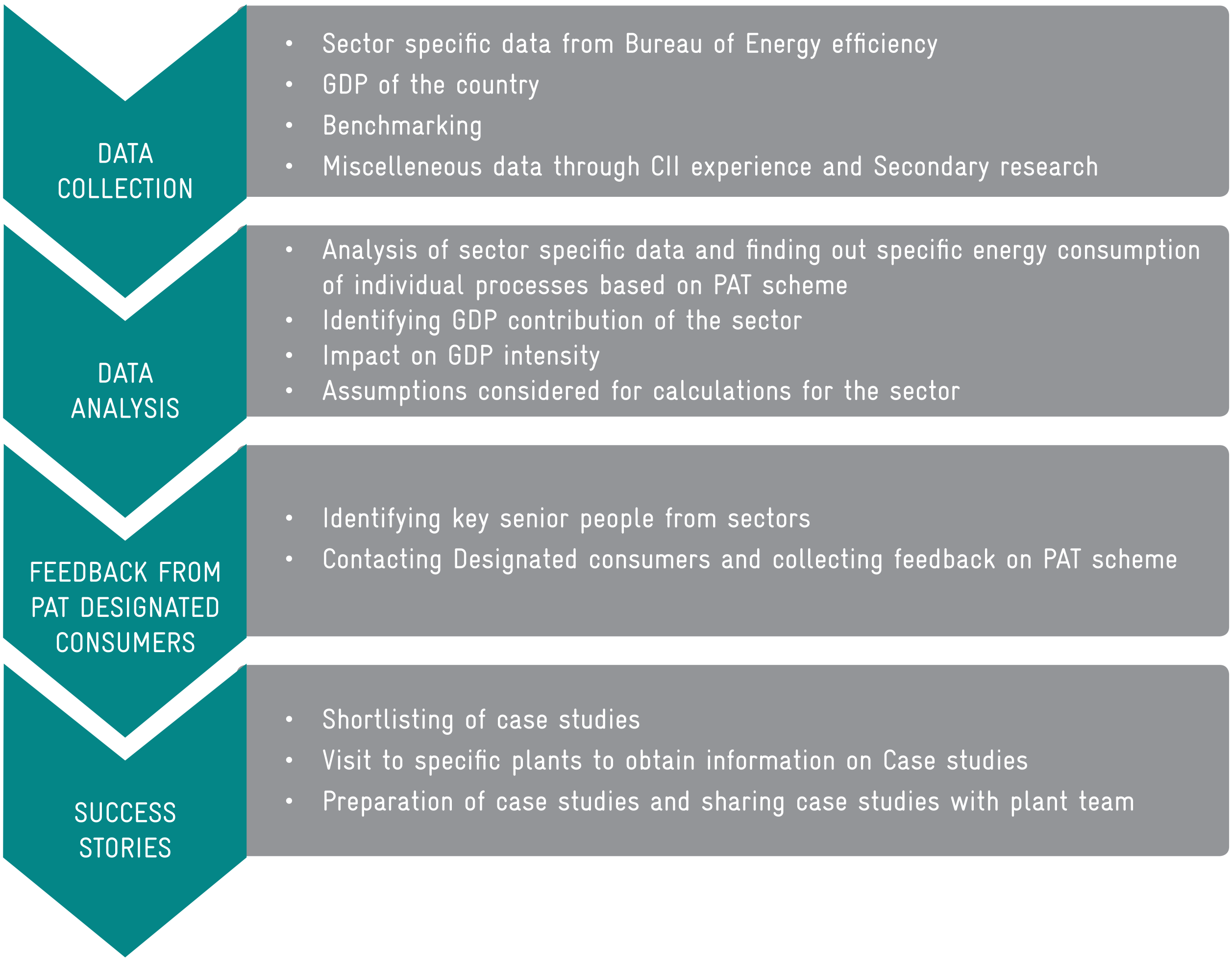

Figure 4: Methodology adopted for Impact assessment of PAT Cycle - 1

The case studies were shortlisted based on higher savings, low cost implementation, innovative and with high replication potential across the sector. With the assistance of BEE, GIZ, various plant visits were scheduled and conducted across various sectors to study the technical benefits and challenges of implementing the projects. Based on the feedback from the respective plant team, success stories were developed on the same.

5.0 PAT Cycle-1 and its Impact on Pulp & Paper Sector

PAT is a regulatory instrument to reduce specific energy consumption (SEC) in energy intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy savings, which could be traded. Energy Savings Certificate (ESCerts) are issued to the industries which reduces their SEC beyond the target. Plants who do not achieve the specified target will be obliged to purchase the certificate for compliance, or will be liable for penalisation. The existing power exchanges are platforms for trading of ESCerts.

PAT Cycle – I started from 2012, with its baseline from Financial years 2007 – 08 to 2009-10. The average value of specific energy consumed by the plant was taken for three years. The minimum threshold considered were based on the sectors. The minimum energy consumption of Pulp & Paper sector is 30,000 MTOE above which the plant is declared as a Designated Consumer (DC).

The total reported energy consumption of these designated consumers was about 2.09million TOE. These DCs were given a target of 0.119million TOE energy consumption reduction, which was around 1.8% of the total energy consumption reduction targets assigned for PAT Cycle 1.

5.1 PAT cycle-1 Impact

Pulp & Paper sector has achieved 0.289 million TOE in comparison to the target of 0.119 million TOE. This achievement has estimated GHG emission reduction of 1.24 million tonnes of CO_2 equivalent. The results of PAT Cycle – I is summarised in Figure 5.

Figure 5: PAT-1 Impact on Paper Sector

The savings are attributed to a number of measures adopted by the DCs. Some of the DCs have implemented short term measures with minimal investment, others have opted for medium and long-term measures requiring considerable investment. Investment of INR 18.84 billion was reported by 55% of DCs in the sector against implementation of energy conservation.

The emissions reduction for the sector due to energy savings achieved under PAT Cycle – I and contribution of these emissions to overall GHG reduction achieved are mentioned in Table 5. The emission reduction due to reduction in fossil fuel consumption only is considered for reduction in GHG emissions.

Parameter	Value
Reduction of CO_2 emission due to implementation of PAT Cycle 1(All sectors)	31 million Tonnes of CO_2 equivalent
Reduction of CO_2 emission due to implementation of PAT Cycle 1 Paper sector	1.24 million Tonnes of CO_2 equivalent
Contribution to CO_2 emission reduction in overall PAT Cycle-I	4%

Table 5: Reduction in CO_2 emissions from the PAT cycle

5.2 Energy Scenario: Business as Usual (BAU) vis-à-vis with PAT Impact

The section describes the impact of PAT and comparison with BAU scenario. A summary of the performance of the sector and its projection for 2030 is mentioned in the Table 6. The calculation of GHG emissions for PAT cycle – I has been done based on the fuel mix of the paper sector under PAT. The impact of PAT has been assessed for PAT Cycle – I and, with the current trend for energy reduction, has been estimated for the year 2030.

Particulars	Unit	Value
Number of plants in the sector	Nos.	31
Baseline Energy Consumption in PAT Cycle – I	million TOE	2.09
Energy reduction target for the sector	million TOE	0.119
Energy Savings achieved in PAT Cycle – I	million TOE	0.289
Energy Saving achieved in excess of target	million TOE	0.17
Reduction in GHG Emissions in Cycle I	million T CO_2	1.24
Cumulative energy savings with PAT Impact till 2030 over BAU[13]	million TOE	7.81

Table 6: Achievements of Pulp & Paper sector in PAT Cycle 1 and Projections till 2030

The energy saving of 8.67 million TOE declared for PAT Cycle 1 has been calculated based on notified production for the baseline period. It may be noted that the actual energy saving achieved will be higher since actual production would have been higher in the assessment year.

The reduction in specific energy consumption in the baseline year from 2007 – 08, 2008 – 09 and 2009 – 10, has been calculated and considered as Business as Usual scenario (BAU). This reduction in specific energy consumption is used to project the reduction by the sector till 2030.

The graphs in this section show specific energy consumption, energy consumption for business as usual and impact of PAT, projected till 2030. The reduction from baseline to assessment year with PAT scenario is the reduction in specific energy consumption based on PAT Cycle – I allotted target.

13. Difference of energy consumption between PAT and Business as Usual scenario(BAU)

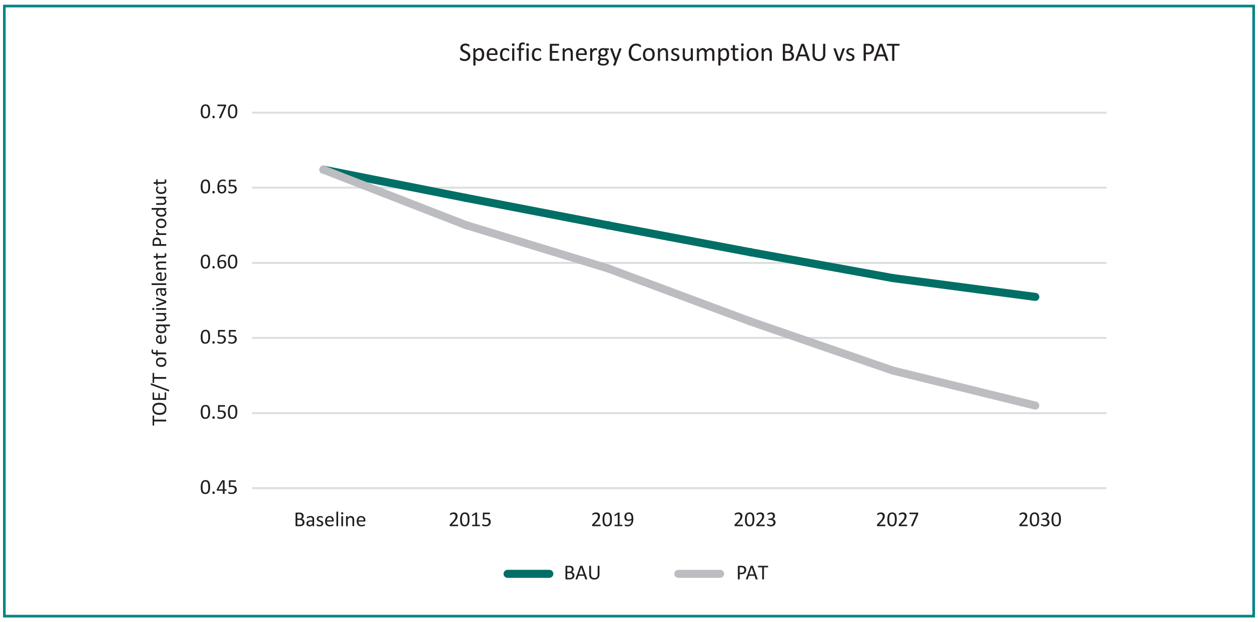

Figure 6: Specific Energy consumption of Pulp & Paper Sector BAU vs PAT

Figure 6 shows the specific energy consumption trend for the sector till 2030.

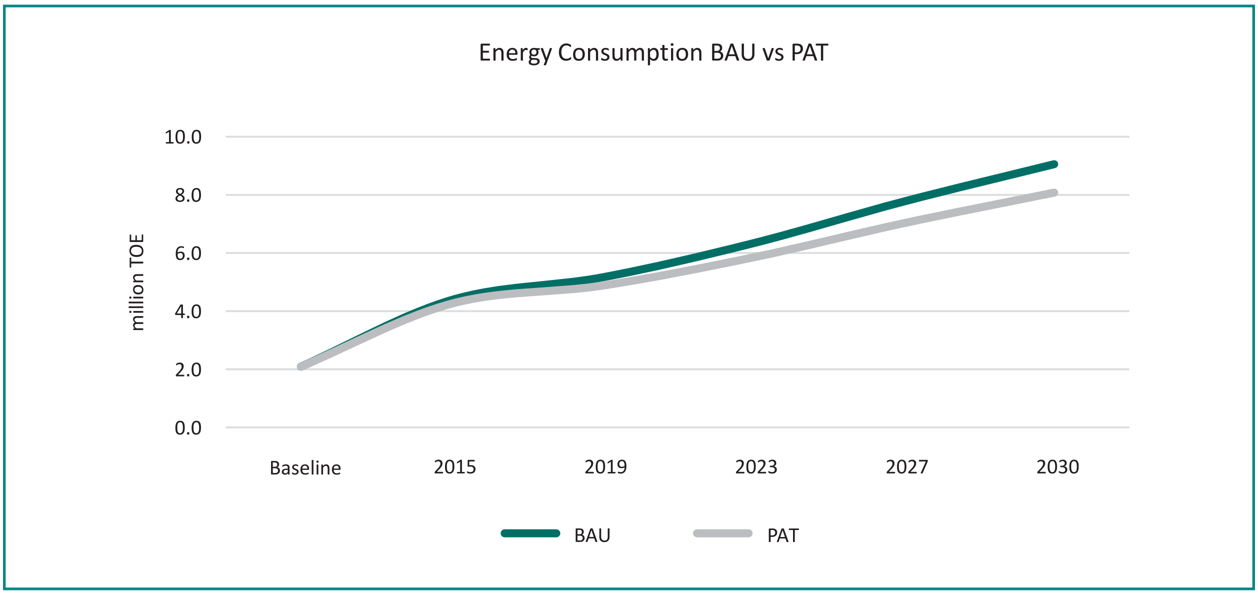

Figure 7: Energy Consumption of Pulp & Paper Sector BAU vs PAT

Figure 7 shows the energy consumption trend for the sector till 2030.The blue line indicates energy consumption of the sector (mTOE.) in business as usual scenario and the red line indicates energy consumption of the sector (mTOE) in PAT scenario.

The total energy consumption for Paper sector in the year 2030 without the impact of PAT is estimated to be **9.0 million** TOE, which may reduce to **8.1 million** TOE considering the impact of PAT.

Figure 8: A view of Paper mill

Year	GDP	Business as usual	With PAT
	Billion USD	Energy Intensity	Energy Intensity
		Toe/million USD	Toe/million USD
Baseline	1,389	1.51	1.51
2015	2,102	2.08	2.03
2020	3,018	1.80	1.69
2025	4,233	1.66	1.51
2030	5,937	1.52	1.36

Table 7: Energy Intensity with PAT and BAU for Paper Sector

Assumptions considered for BAU Vs PAT calculation till 2030

Specific Energy Consumption

- The SEC of the sector has been calculated by taking into account the total production of the sector and the total energy consumption in the sector, and hence may not represent the actual SEC of any particular sub-sector/ product/ process.

Business as usual scenario:

- The plant would have undertaken activities on energy efficiency on its own, even without the intervention of PAT scheme.
- The reduction in specific energy consumption in the baseline year from 2007 – 08, 2008 – 09 and 2009 – 10, has been calculated and the same reduction is projected till the year 2030 to get the BAU scenario.

With PAT scenario:

- The actual energy saving achieved in the PAT Cycle – I is taken for the assessment year 2014 – 15.
- It has been assumed that the plants meet the target allotted to them till the years 2030.
- The targets for the subsequent PAT cycles are calculated based on the current trend of reduction in percentage of target between PAT Cycle – I and II.
- It has been considered that the target will go on decreasing in the subsequent cycles owing to the diminishing potential in the plant as they go on implementing projects on energy efficiency.

5.3 Pulp & Paper Sector - Data Analysis of PAT Cycle - 1

Some of the key findings from the Proforma is listed below:

- Specific Steam Consumption reduces by 4.6% w.r.t Baseline year
- Specific Electricity Consumption reduces by 5.7% w.r.t. Baseline year
- Percentage share of renewable energy increased by 8% wrt Baseline year
- Percentage share of electricity from grid decreased by 6% wrt Baseline year
- Percentage share of electricity through own genration increased by 6% wrt Baseline year
- Capacity utilization of paper mills remains same in basline as well as in assessment year
- Consumption of Imported Pulp increased by 34% wrt Baseline year
- Quantity of Exported Pulp increased by 13% wrt Basline year

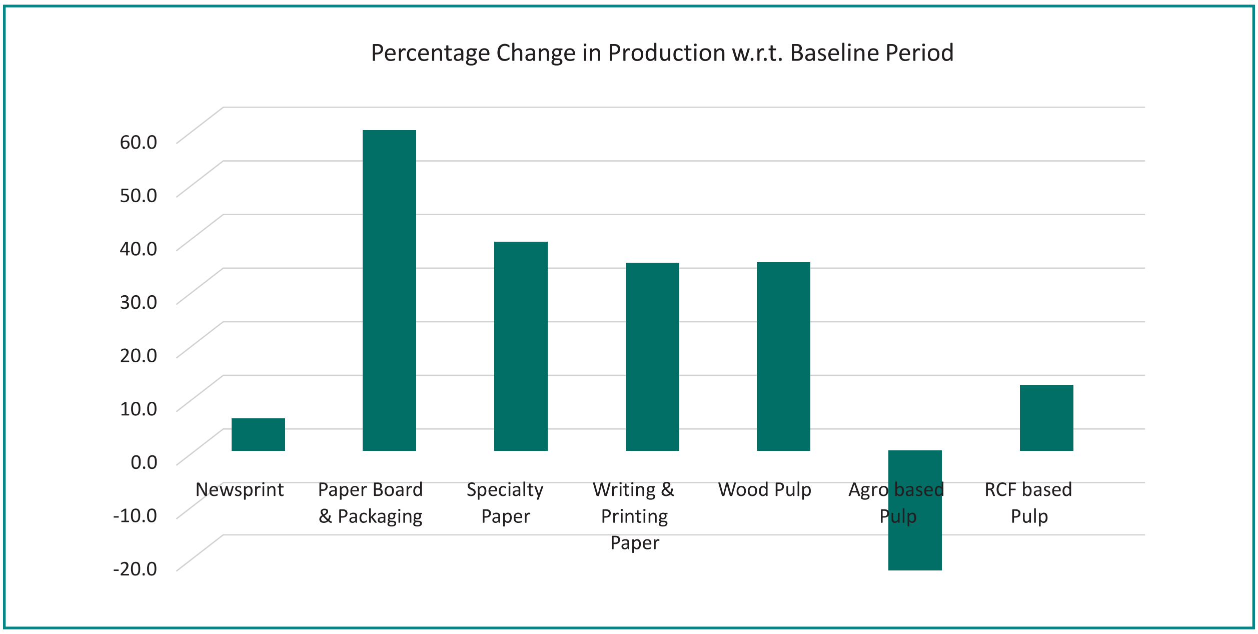

Figure 9: Percentage Change in Production w.r.t. Baseline period

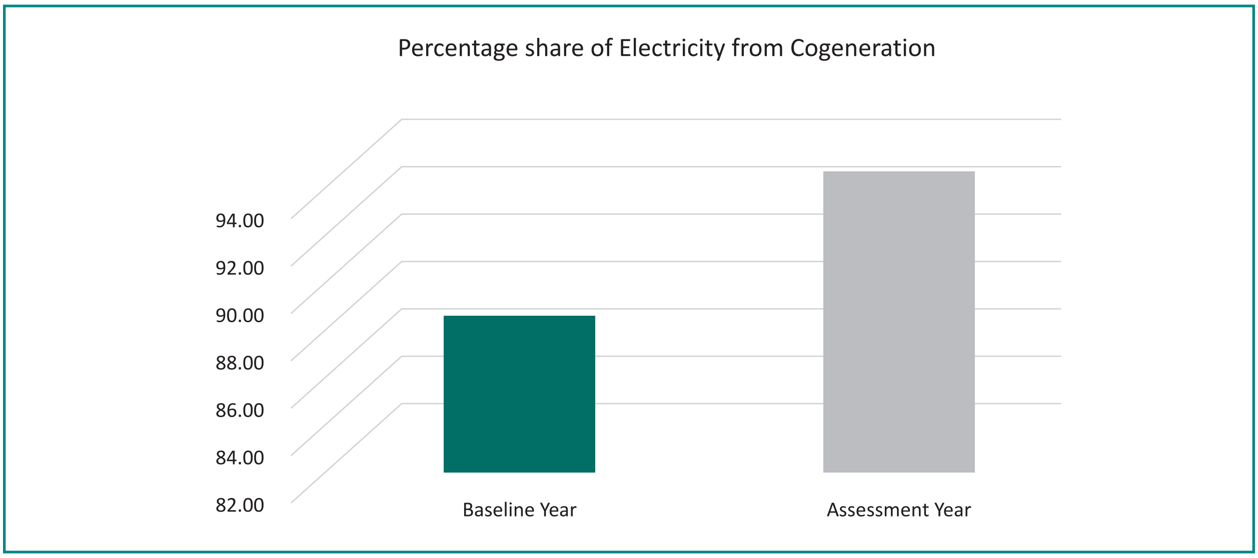

Figure 10: Percentage share of Electricity from Cogeneration

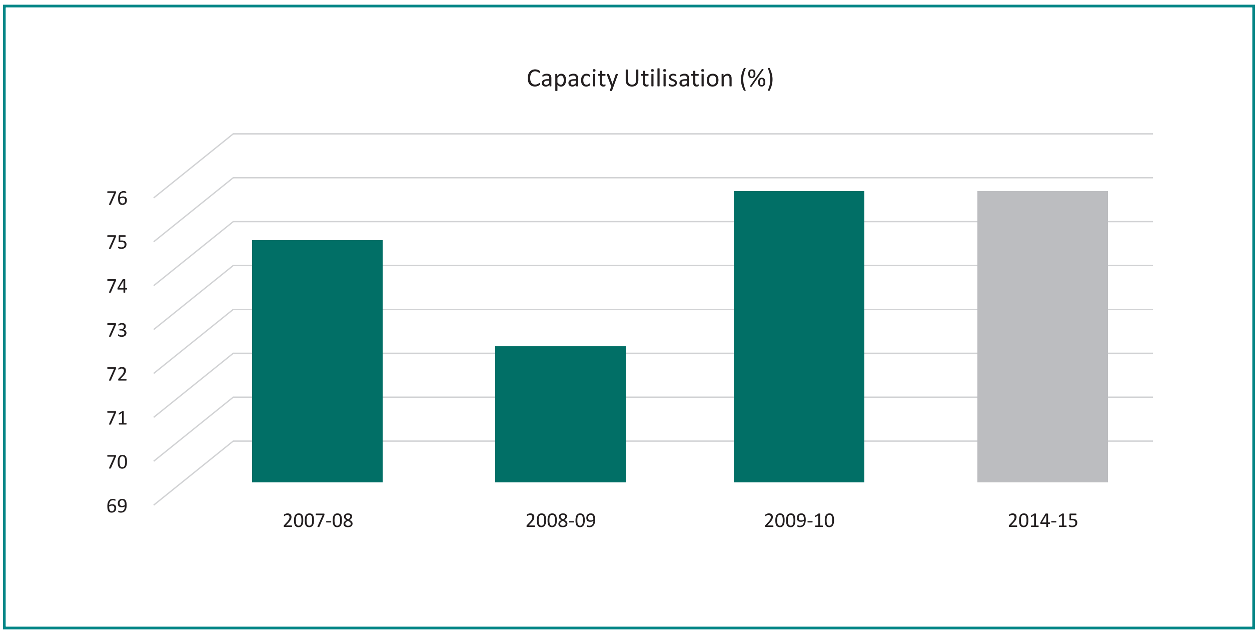

Figure 11: Capacity Utilization Paper Plants

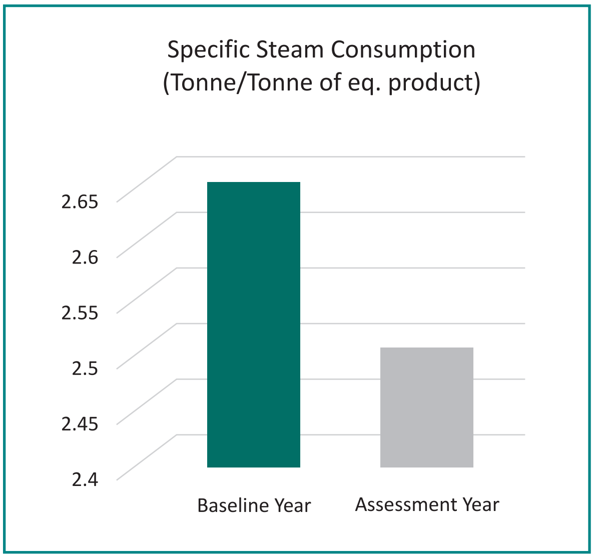

Figure 12: Specific Steam Consumption

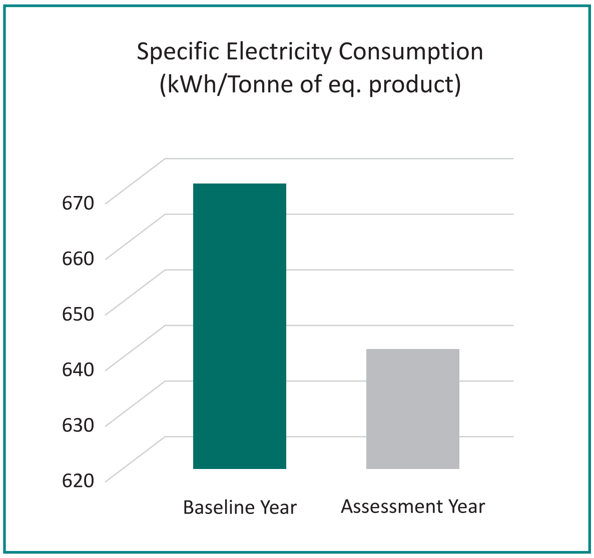

Figure 13: Specific Electricity Consumption

6.0 Benchmarking (National & Global)

Benchmarking is an important tool to establish how one is performing and what avenues can be adopted to achieve the highest level in energy efficiency. Following section provides the comparison of India's Aluminium sector performance with the best efficiency levels in the world.

Table 8 indicates the Electrical & Thermal energy consumption of Paper sector (Raw Material Wise) Global & Indian trend.

Industry Group	Particulars	Units	Global Avg.	India Avg.	Industry Benchmark
Wood Based Mills	Specific Electrical Energy Consumption	kWh/tonne of paper	1000-1100	1400-1500	1200
	Specific Steam Consumption	Tonne of steam/ tonne of paper	7.0-9.0	12.0-13.0	9.0
Agro Based Mills	Specific Electrical Energy Consumption	kWh/tonne of paper	-	1200-1400	1000
	Specific Steam Consumption	Tonne of steam/ tonne of paper	-	12.0-14.0	10.0
Recycled Fiber Based Mills producing unbleached grades	Specific Electrical Energy Consumption	kWh/tonne of paper	500	450-550	400
	Specific Steam Consumption	Tonne of steam/ tonne of paper	2.5	4.0-5.0	3.5
Recycled Fiber Based Mills producing bleached grades	Specific Electrical Energy Consumption	kWh/tonne of paper	600-650	680-800	570
	Specific Steam Consumption	Tonne of steam/ tonne of paper	4-4.5	6.0-7.0	5.0

Table 8: Specific Energy Consumption (Global Vs India)[14]

The level of technology used in the three segments of industry (in terms of the raw material used: wood, agro and recycled fibre-based) varies. The agro and recycled paper mills still use conventional processes which are obsolete by international standards, and have not attempted to improve their methods. However, the wood-based mills have upgraded the technology used to improve paper quality and reduce pollution load. In order to solve many problems the industry faces, it is necessary to modernize the processes involved in paper manufacture; the technology currently in use lags behind that used in the rest of the world by about 30 years.

Steps aimed at filling the gaps in technology should be taken up in wood, agro- and recycled fibre-based paper mills through a structured technology support programme. The programme should aim to improve the competitiveness of

14. Knowledge Exchange Platform (KEP) Newsletter – Issue 6 Special Edition – ENMS 2016

industry by acquiring state-of-art technologies. This can be achieved by:

- Identifying and marketing appropriate technologies
- Acquiring proven technology of UK origin/ design and drawing.
- Contractual R&D activities leading to technology upgradation of the units.

The aspects that such a scheme should cover are:

- Raw material upgradation
- Resource conservation
- Product quality
- Process improvement
- Energy conservation
- Environmental compliance
- Research and development for adoption of technologies in Indian mills.

Specific steam & electricity consumption section-wise, based on the raw material use, is mentioned in Table 9, Table 10 and Table 11.

Section	Power Consumption (kWh/ Tonne Paper)	Steam Consumption (Tonne Steam/ Tonne Paper)
Pulp Mill (Raw Material Preparation, Digester, Screening & Washing, Bleach Plant)	300-325	1.2-2.5
Recovery Section	250-300	3.0-3.5
Stock Preparation & Paper Machine	350-450	2.5-4.0
Effluent Treatment Plant	75-100	-
Power Generation Plant	150-200	-
Total	**1125-1300**	**3.7-6.5***

*Without considering the steam consumption in recovery section

Table 9: Section wise Energy Consumption Trend (Wood Based)[15]

Section	Power Consumption (kWh/ Tonne Paper)	Steam Consumption (Tonne Steam/ Tonne Paper)
Pulp Mill (Raw Material Preparation, Digester, Screening & Washing, Bleach Plant)	300-325	1.2-2.5
Recovery Section	75-100	1.0-1.7
Stock Preparation & Paper Machine	350-450	2.5-3.5
Effluent Treatment Plant	75-90	-
Power Generation Plant	125-200	-
Total	**925-1165**	**3.7-6.0***

*Without considering the steam consumption in recovery section

Table 10: Section wise Energy Consumption Trend (Agro Based)[16]

15. Technology Gap Assessment of India Pulp & paper Sector & Technologies Available to Bridge the GAP to Achieve Targets Set Under PAT-2 Presentation by Dr B P Thapliyal - CPPRI
16. Technology Gap Assessment of India Pulp & paper Sector & Technologies Available to Bridge the GAP to Achieve Targets Set Under PAT-2 Presentation by Dr B P Thapliyal - CPPRI

Section	Power Consumption (kWh/ Tonne Paper)	Steam Consumption (Tonne Steam/Tonne Paper)
Pulper & Pulp Cleaning (HD Cleaner, Centricleaner, De-Inking & Bleaching)	300-350	0.5-0.7
Stock Preparation & Paper Machine	350-450	2.1-3.0
Effluent Treatment Plant	40-45	-
Power Generation Plant	100-110	-
Total	**790-950**	**2.6-3.7**

Table 11: Section wise Energy Consumption Trend (RCF Based)[17]

17. Technology Gap Assessment of India Pulp & paper Sector & Technologies Available to Bridge the GAP to Achieve Targets Set Under PAT-2 Presentation by Dr B P Thapliyal - CPPRI

7.0 List of Major Energy Saving Opportunities in the Sector

A list of major energy saving opportunities in the sector have been identified and listed below. The projects are listed based on readiness level, co-benefits obtained by installing the system and expected payback range by implementing the project.

Technology Readiness Level (TRL):	Co-Benefits: PQCDSME	Payback Horizon (PB)
TRL 1 – Research (Basic or Advanced)	Productivity (P)	PB 1 – less than 1 year
TRL 2- Proof of concept	Quality (Q)	PB 3 – 1 year to 3 years
TRL 3- Demonstration(Pilot)	Cost(C)	PB 5 – 3 to under 5 years
TRL 4- First of a Kind	Delivery (D)	PB 8 – 5 to under 8 years
TRL 5- Fully Commercial	Safety (S)	PB 12 – 8 to under 12 years
	Moral (M)	PB >12 – over 12 years
	Ethics, Environment (E)	

S No	Energy Saving Opportunities	Co-Benefits	Technology Readiness Level	Payback Band
1	Advanced process control systems	P,Q,C,D,S,M,E	TRL - 5	PB 1
2	Extended Delignification system for wood cooking	Q,C,M,E	TRL - 5	PB 3, PB 5
3	High pressure cogeneration systems	P,C,E	TRL - 5	PB 8, PB 12
4	Optimising blow through steam consumption	P,C,E	TRL - 5	PB 1, PB 3
5	Oxy-fuel combustion technology-lime kiln & black liquor boilers	P,Q,C,M,E	TRL - 5	PB 8, PB 12
6	Ultra-low intensity refining	P,Q,C,M,E	TRL - 5	PB 3
7	Installing shoe press in paper machines	P,Q,C,M,E	TRL - 5	PB 3
8	Firing of black Liquor at higher concentration	P,Q,C	TRL - 5	PB 5
9	Energy efficient vacuum blowers & pumps	P,Q,C	TRL - 5	PB 3
10	Installation of Centrifugal compressors	C	TRL - 5	PB 3, PB 5
11	Bio-methanation (For Agro based pulp mill)	P,C,M,E	TRL - 5	PB 3, PB 5

Table 12: List of key technologies in the sector

8.0 Success Stories – Case Studies in Pulp & Paper Sector

8.1 Recovery of Waste Heat from Pulp mill Effluent for Warm Water Generation and to Reduce Heat Load on ETP Cooling Tower

Introduction of the plant

JK Paper Ltd. has two large integrated paper manufacturing units – JK Paper Mills, Rayagada, Odisha and Central Pulp Mills, Songadh, Gujarat with a combined capacity of 4,55,000 TPA. It is the market leader in Branded Copier paper segment and among the top two players in Coated Paper and high-end Packaging Boards.

JKPM was commissioned in 1962 with an integrated pulp and paper plant with 18000 TPA installed capacity. Over the years, production capacity been enhanced with the addition of 4 more paper machines. It manufactures a diversified product range from 58 GSM to 300 GSM of different grades of paper & boards.

About the Project

Acid and alkali bleach plant effluents at a temperature of 75-80°C are generated and discharged to effluent streams from pulp mill. This effluent is cooled in ETP cooling towers for further processing in ETP; which indicates significant amount of heat energy loosed to the surrounding.

Under mill development plan with new state of art pulp mill, JKPM discussed with technology providers for installing suitable heat recovery system to recover some of this waste heat for effective beneficial uses in the mill.

Plate type heat exchanger were selected due to its better overall heat transfer coefficient, small approach temperature (2-3°C), feasibility to increase heat transfer area by increasing number of plates, compared to other types of heat exchangers and it was installed after justification of project.

Control valve is provided to control fresh water flow to heat exchanger to maintain outlet temperature of effluent to ETP. There are no significant problems faced while implementing this project.

The generated warm water at 46-48°C is used in pulp mill and in DM plant as feed water, hence resulted into reduction in steam consumption in pulp mill hot water heaters and in Deaerators of chemical recovery boiler.

Overall pulp mill specific steam consumption reduced by 25% with this project.

Figure 14: Photograph of Acid Effluent Cooler

Figure 15: Photograph of Alkaline Effluent Cooler

Savings achieved after installation of plate type of heat exchanger are given below.

Description	UOM	Technology Readiness Level	Payback Band
Inlet Temperature	°C	75	80
Outlet Temperature	°C	50	52
Temperature drop	°C	25	28
Flow	m3/day	6000	3000
Heat gained by Fresh water	Million Kcal/day	150	84
Heat gained by Fresh water	Million Kcal/year	49,500	27,720
GCV of Coal	Kcal/Kg	4200	
Coal Saving	Ton/Year	18,386	
Cost of Coal	Rs./ Ton	4200	
Achieved Energy Saving	Rs. Million/Year	77	
Total Investment	Rs. Million	20	
Payback	months	3	
GHG emission reduction	MT CO_2/Year	31,037	
Replication Potential	This project can be replicable in all the pulp mills by installing heat exchangers after consideration of bleach effluent characteristics.		

Table 13: Saving Potential of the Project Implemented

This project can be replicable in all the pulp mills by installing heat exchangers after consideration of bleach effluent characteristics. Also it requires frequent cleaning within 2 to 3 months for removal of scaling.

Plant Contact Details

Plant Name	J K Paper Limited Unit – Rayagada
Contact Person	Mr P K Suri
Designation	Executive Vice President
Email ID	pksuri@jkpm.jkmail.com
Website	www.jkpaper.com

8.2 Performance Upgradation through Conversion of Atmospheric Fluidized Bed to Spouted Bed Combustor with Increased Heating Surface

Introduction of the plant

Seshasayee Paper and Boards Limited (SPB), the flagship company belonging to 'ESVIN GROUP', operates an integrated pulp, paper and paper board Mill at Pallipalayam, Erode-638 007, District Namakkal, Tamilnadu, India.

SPB, incorporated in June 1960, was promoted by Seshasayee Brothers (Pvt) Limited in association with a foreign collaborator M/s Parsons and Whittemore, South East Asia Inc., USA. After commencement of commercial production, having fulfilled their performance guarantee obligations, the foreign collaborators withdrew in 1969. Main promoters of the Company as on date are a group of companies belonging to the ESVIN group headed by Mr. N Gopalaratnam.

SPB commenced commercial production in December 1962, on commissioning a 20000 tpa integrated facility, comprising a Pulp Mill and two Paper Machines (PM-1 and PM-2), capable of producing, writing, printing, kraft and poster varieties of paper.

The Plant capacity was expanded to 35000 tpa in 1967-68, by modification of PM-2 and addition of a third Paper Machine (PM-3). The cost of the expansion scheme, at Rs 34 Million, was part financed by All India Financial Institutions (Rs 31 Million).

In the second stage of expansion, undertaken in 1976, capacity was enhanced to 55000 tpa, through addition of a 60 tpd new Paper Machine (PM-4). Cost of the project, including cost of a Chemical Recovery Boiler and other facilities for enhanced requirement of utilities, was estimated at Rs. 176 Millions. The same was part financed by term loans from Institutions and Banks to the extent of Rs. 145 Millions and the balance out of internal generation.

SPB undertook various equipment balancing and modernisation programmes, since then, for improving its operating efficiency, captive power generation capacity, etc., upto 1992-93.

About the Project

To cater to the steam & power requirements, SPB Erode unit had installed High pressure AFBC boiler #10 along with two medium pressure boilers #6 & #7 & HP chemical recovery boiler #11. Extra power demand of plant was met through importing the power from grid.

High pressure AFBC boiler #10 was designed by Mitsui Babcock, UK & supplied by Enmas Andritz Ltd. having rated capacity of 117 TPH (MCR). Steam generation could not be raised beyond 85 TPH due to limitation in furnace footprint (bed coil heating surface) which had resulted in shortfall both in steam generation and consequently lowered power generation in 21 MW double extraction condensing steam turbine generator (~14 MW as against 20 MW rated capacity).

In order to enhance HP steam generation to rated capacity, combustor was modified to spouted fluidized bed with increased bed coil depth (Double header pin row hairpin arrangement) and additional heating surface relating to enhanced volumetric heat absorption in bed.

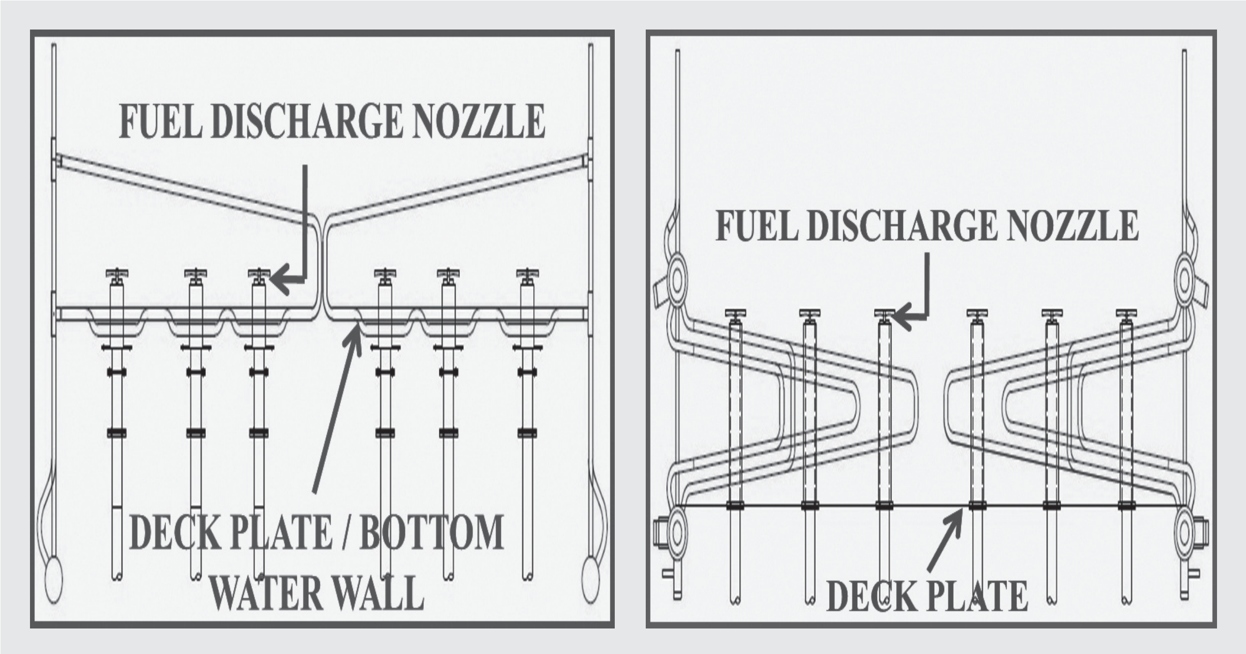

Figure 16: Schematic Representation of Nozzle

In addition to the above, newly designed vertical super heater coil bank was installed in the existing vacant space between PSH1B & PSH1C resulting in steam temperature being maintained at rated 510°C compared to earlier 490-495°C prior to the installation of the newly designed coil.

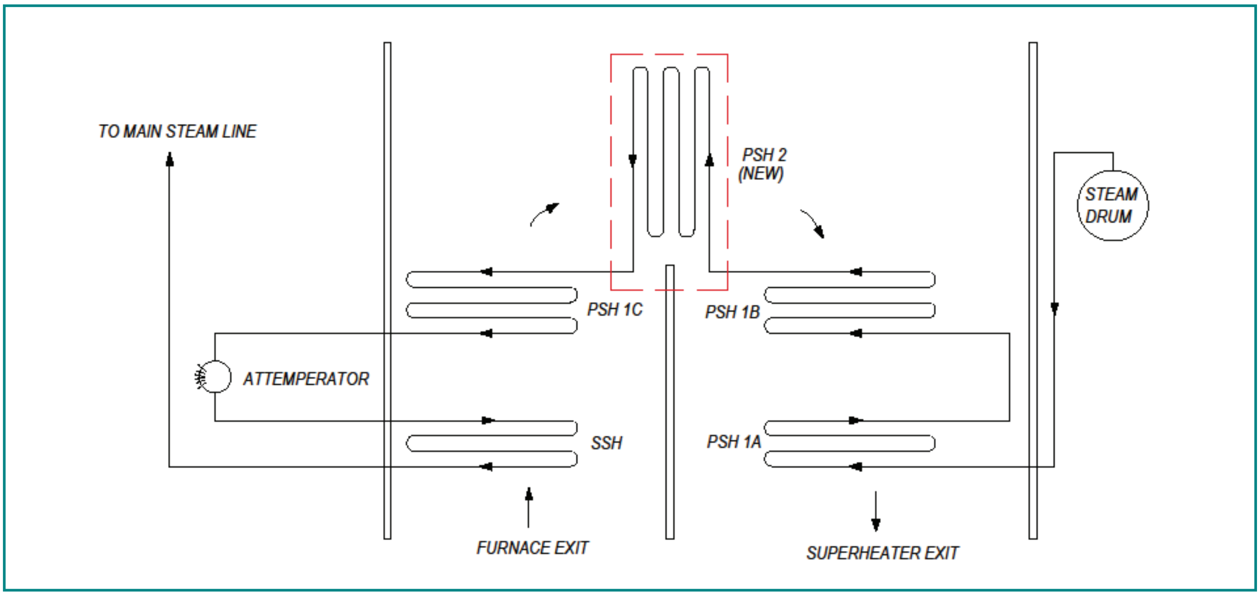

Figure 17: Schematic Representation of Super heater Coil

With this modification, HP steam generation in AFBC boiler has increased to ~110 TPH which resulted in stoppage of the two old inefficient MP Boilers # 6 & # 7. Also 21 MW steam turbine generator was loaded near to rated capacity resulting in surplus power generation sent for power export. In addition, PA fan could be stopped (due to reduction in bed coil resistance), resulting in power saving of ~2,000 units/day

Description	UOM	Earlier	Present
Increase in Steam Generation	TPH	85	105
Increase in Power Generation	MW	13.5	19
Overall Station power consumption reduction	kWh/day	Base	7,000
Power Export	MW	Nil	~3
Power Import	MW	1.2	Nil
Energy Saving	Rs. Million	123	
MTOE equivalent saving	TOE	3,670	
Investment	Rs. Million	100	
Payback	Months	10	
GHG emission reduction	tCO_2 equivalent	35,000	
Financing mode	Capex		
Replication Potential	This Energy Saving Scheme is applicable for all operating with AFBC boilers		

Table 14: Saving Potential of the Project Implemented

Challenges faced during Implementation

- Boiler #10 Shutdown required: 7 Weeks
- For meeting the steam and power demands of the plant, both Boiler #6 & #7 along with 3 MW STG had to be run continuously with increase in Grid Power drawl. This had resulted in High Energy (Power & Fuel) costs.
- There was practically no change in operational practices; to go further, we were able to stop the PA fan which had further resulted in lowered power consumption.

Other Benefits

- Ease of Operation – With running only Boiler #10 and stopping the inefficient MP Boilers (#6 & #7), operation of the Boiler House as a whole had completely eased (as also advanced DCS automation-control); the reduction in skilled man-power had been gainfully used elsewhere.
- Reduction in rejects – With efficient coal combustion & stoppage of PA fan, LOI in bottom ash discharge had marginally reduced (<9 % for low ash imported coal) leading to very high combustion efficiency (99.5%).
- Reduction in carbon content (unburnt) in bottom ash had made it saleable to nearby cement plant, thus effecting avoidance of discharge of solid rejects.
- With stoppage of old MP boilers & with increased quality of boiler feed water to HP Boiler # 10, blow down water rejection had significantly reduced, resulting in marginal reduction in DM water intake.

Plant Contact Details

Plant Name	Seshasayee Paper & Boards Limited
Contact Person	Dr T.G. Sundararaman
Designation	General Manager (E&I)
Email ID	drram@spbltd.com
Website	www.spbltd.com

9.0 List of Technology suppliers

A list of major energy saving opportunities in the sector have been identified and listed in Table 15. The projects are listed based on readiness level, co – benefits obtained by installing the system and based on expected payback range by implementing the project.

S No	Company Name	Technology	Website link
1	VOITH Paper Fabrics India Limited	Technologies & Services for entire paper production process	www.voith.com
2	Valmet India	Technology, Services & Automation for entire paper plant	www.valmet.com
3	ANDRITZ India	Technologies & Services for entire paper production process	www.andritz.com
4	GL&V India Private Limited	Technologies & Services for entire paper production process	www.glv.com
5	Forbes Marshall	Boiler, Steam & Condensate System	www.forbesmarshall.com
6	Thermax India	Boiler, Steam & Condensate System, Absorption Chiller, Water & Waste Management, Air Pollution Control System	www.thermaxglobal.com
7	Paques Environmental Technology India Pvt. Ltd.	Water & Waste Management Technologies	En.paques.nl
8	Ion Exchange (India) Ltd.	Water & Waste Management Technologies	www.ionindia.com
9	Flakt India Private Limited	Axial Fan, Centrifugal Fan, Air Handling Unit	www.flaktwoods.com
10	REITZ INDIA LTD	Design, Engineering & Manufacturing of Industrial Fans	www.reitzindia.com
11	Atlas Copco	Industrial Compressor, Air & Gas Treatment Equipment	www.atlascopco.com
12	Elgi Equipments Limtied	Centrifugal, Reciprocating & Screw Compressors	www.elgi.com
13	Godrej & Boyce Mfg. Co. Ltd.	Compressed Air System, Air Treatment Equipment, Automation	www.godrej.com
14	KSB PUMPS LTD	Centrifugal Pump, Multistage Pressure Pump, Submersible Pump	www.ksb.com
15	Grundfos Pumps India Pvt. Ltd.	Industrial Pumps Design, Engineering & Manufacturing	www.grundfos.com
16	Alfa Laval	Process Heat Exchanger	www.alfalaval.in
17	Tranter	Process Heat Exchanger	www.tranter.com
18	Enmas GB Power Ltd.	Industrial Boiler	www.enmasgb.com

Table 15: List of key technology suppliers in Paper Sector

Abbreviations

Bureau of Energy Efficiency

Ministry of Power, Government of India
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066 (INDIA)
T: +91 11 26766700 I F: +91 11 26178352
Email: admin@beenet.in I www.beeindia.gov.in
Follow us on @BEEIndiaDigital on Facebook & Twitter

Leading Towards Energy Efficiency Economy

Confederation of Indian Industry

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Published by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH