

An initiative supported by



Technology Compendium

On

Energy saving Opportunities

Pulp & Paper Sector

August 2013

Disclaimer

This report is part of Shakti Sustainable Energy Foundation (SSEF) and Confederation of Indian Industry, CII – Godrej GBC's effort to assist the Indian industry achieve greater energy efficiency levels and to facilitate designated consumers meet their Perform, Achieve & Trade (PAT) targets set by Bureau of Energy Efficiency (BEE), Government of India.

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Foreword by Director General – Bureau of Energy Efficiency



With the growth of economy, the demand for energy has grown substantially. Further, the high level of energy intensity in certain major industrial sectors, and more so, the variation between the most & least efficient facility within them is a matter of concern. In such scenario, efficient use of energy resources and their conservation assume tremendous significance and become imperative for sustainable growth of the industrial economy and the country at large.

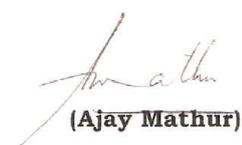
The efficient use of energy and its conservation is the best option to meet the increasing energy demand, Government of India has enacted the Energy Conservation Act, 2001. The Act provides for institutionalizing and strengthening delivery mechanism for energy efficiency services in the country and provides the much-needed coordination between the various entities.

The Ministry of Power and Bureau of Energy Efficiency (BEE) are entrusted with the task of preparing the implementation for the National Mission on Enhanced Energy Efficiency (NMEEE) under National Action Plan on Climate Change (NAPCC). This mission has a component which deals with the market based mechanism to improve the energy efficiency in energy intensive large industries and facilities by certification of energy savings which could be traded.

This scheme known as Perform, Achieve and Trade (PAT) is expected to save about 6.686 million metric tonne of oil equivalent (mMtoe) by 2014-15. Eight industrial sectors namely Power, Iron & Steel, Fertilizer, Cement, Aluminium, Pulp & Paper, Textile and Chlor-alkali have been included in this scheme where in about 478 industries (known as Designated Consumers (DCs)) are covered. In the ensuing PAT scheme, all the DCs will be required to achieve a reduction of Specific Energy Consumption (SEC) from their baseline SEC within 3 years time (2012-13 to 2014-15).

These industry specific technology compendiums will provide ready-to-use information on national & international energy conservation opportunities, Best Operating Practices (BOP), Best Available Technologies (BAT), with their techno-economic considerations. These compendiums will be helpful for DCs to prepare their energy efficiency action plans and to achieve their SEC reduction targets set by BEE.

I am sure that this Technology Compendium manual will receive an overwhelming response from the cross section of the industry. I take this opportunity to thank Shakti Sustainable Energy Foundation (a part of Climate Works Foundation) for supporting this initiative.


(Ajay Mathur)

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EXECUTIVE SUMMARY:

Paper sector is one of the fast growing industrial sectors in India. The paper industry in India is one of the 35 high priority industries having a bearing on the socio-economic development of the country. One of the key social objectives of the Indian Government, namely, eradication of illiteracy through compulsory primary education, bears a direct relation with the paper industry.

Indian Paper industry plays a key role in the Indian economy, with a contribution of Rs. 3000 million (USD 7 billion) approximately to the GDP and its contribution to the exchequer is around Rs. 300 million (USD 0.7 billion). The industry provides employment to more than 0.12 million people directly and 0.34 million people indirectly. The Indian paper industry plays a pivotal role in the overall industrial growth and provides the necessary medium to propel the knowledge based economy forward in the new millennium.

The Indian Paper sector accounts for about 1.7¹% of the world's production of paper and paperboard. The global paper industry is highly concentrated in the United States, China, Japan, Scandinavian² and Canada, which together account for 60% of the total paper production.

The demand of paper in India has been in the trend line of 8% for some time. So far, the growth in paper industry has reflected the growth in GDP and has grown on an average of 6-7 per cent over the last few years. India is the fastest growing market for paper globally and it presents an exciting scenario; paper consumption is poised for a big leap forward in future years with the economic growth and is estimated to touch 20 million tons by 2020³.

Pulp & Paper industry is an energy intensive industry. The consumption of steam and electricity per tonne of paper production in India is about 11-15 tonne and 1,500-1,700 kWh. The average specific energy is placed at 52 GJ per tonne of paper.

Out of eight sectors under the Perform, Achieve and Trade (PAT) mechanism, the energy consumption of pulp and paper industry is 1.4 million MTOE. This is 0.6% of total energy consumption (230 million MTOE) of all eight sectors and totally 31 pulp and paper industries have been included in the PAT mechanism. The overall target given to the pulp and paper industry is 117704.4 MTOE of energy savings.

The Indian Pulp & Paper sector is facing some developmental challenges to increase the global competitiveness on the following fronts - Capital expenditure, Energy Cost, Availability of raw materials, Green technologies & Quality improvement. With this background, this Technology Compendium, which comprises of various technologies and best practices to save energy, has been prepared. This compendium is expected to assist the designated consumers to improve their energy efficiency levels and finally to achieve the targets under PAT scheme. This research reveals that, by implementing the Best Available Technologies & practices, the Paper sector can easily achieve its PAT target.

¹ Indian Pulp & Paper Technical Association

² Scandinavian – Denmark, Norway & Sweden

³ IPMA

METHODOLOGY

I. Formation of technology advisory group:

A group consisting of key industrial experts from paper sector has been identified to guide and advise the CII team in preparation of the technology compendium. They include the following;

1. Mr K S Kasi Viswanathan, Chairman, Paper working group, CII – Godrej GBC and Dy Managing Director, Seshasayee Paper & Boards Limited
2. Mr D P Chandarana, Director, Ojas Securities Private Limited
3. Dr A R K Rao, Former CMD of Hindustan Paper Corporation & Technical consultant for Hindustan Mudranalaya
4. T G S Ram, Vice President, Seshasayee Paper & Boards Limited

The Technology advisory group (TAG) has reviewed the project methodology and approach during the inception phase and while project implementation stage, the TAG reviewed the findings of the project.

II. Secondary Research:

Secondary research process was an important activity through which project had received several inputs. Project inputs were collected from several secondary sources, as below;

1. National / International best practices manuals of CII
2. Paper & pulp sector journals
3. Identification of clean technologies by interacting with international association like International Energy Agency, Swedish Energy Agency, IVL, Sweden, etc.,
4. Stakeholder interactions – Industry experts, Technology service providers, Funding Agency, etc.,
5. Energy Audits of CII
6. Proceedings of Papertech conferences of CII and IPPTA conferences

III. Stakeholder Interactions:

Extensive stakeholder consultations were organized during the course of execution of this project and the details are as under:

1. Interactions with Godrej GBC's paper working group members to understand the Indian Paper sector's present levels of technology competence and usage, processes and sub-processes, energy efficiency commitments, etc.

2. Interaction with several technology service providers to get inputs on - best available existing technologies and 'in-development technologies', as well as their utility and cost benefits.
3. Informal exchanges were also undertaken during the "Papertech 2012" conference organized by CII in association with IPMA.

IV. Review and Analysis:

The inputs received from the Technology Advisory Group, Secondary research & Stakeholder interactions have been collated, reviewed and analysed to arrive at the following;

- ❖ Mapping of Technologies/Process and sub-processes in the paper sector
- ❖ Understanding of energy trends from the past and technology adoption and its influence on energy performance in the paper sector
- ❖ Identification of clean technologies available in paper sector
- ❖ Identification of best operating practices in paper sector which includes
 - Energy saving and Environmental benefits
 - Investment required and payback period
 - Technology providers

Subsequently the draft Paper Technology compendium was prepared, circulated to the various stakeholders and inputs were sought from them on the draft compendium.

V. Stakeholder consultation workshop:

A stakeholder consultation workshop was conducted on 7th July 2012 during "Papertech Conference 2012" at Hyderabad to seek inputs from the various Paper sector experts on the technology compendium.

The Objective of this workshop was to have inputs from industry experts on the following;

1. Contents of the Technology compendium for the Indian Pulp & paper industry
2. Technologies listed in the compendium on suitability in the current scenario

Representatives from leading paper companies participated in the workshop. The leading paper manufacturers such as Seshasayee Paper & Boards Limited, Hindustan Paper Corporation, TamilNadu Newsprint & Papers Limited, ITC – PSPD, West Coast Paper Mills BILT, etc. participated in the discussions.

Multiple suggestions have been received from stakeholders group during consultation workshop.

VI. Preparation of final compendium:

This final compendium has been prepared taking into account all the suggestions which have been received at the stakeholder workshop as well as the multiple stakeholder consultations which were held earlier.

1.0 OVERVIEW OF INDIAN PULP & PAPER INDUSTRY

Background of Indian Paper Industry

Pulp & Paper industry in India is quite old; the first hand made paper was manufactured in the year 1159 AD. The first paper mill was set - up at Serampur, West Bengal in the year 1812 which was based on the grass and jute as raw material. Since then the paper industry has come a long way with present installed capacity of about 10 million tonnes per year with an average capacity utilization of 80%. The per capita consumption of paper in the country is 9.30 kg.

The initial development & growth of industry in the 19th century was affected by shortage of wood (soft wood) in the country. In 1914 the development of pulp making processes based on bamboo lead to rapid growth of the industry and by the end of the 1950's installed capacity increased to 137,000 tonnes. In the 1970s excise concessions were given to small agro based mills, which resulted in a rapid increase of small mills and capacity. In the late 1980s the industry was in a severe oversupply situation, capacity utilization rates being around 60 %. In early 1990s the government reversed the policy, making large units more competitive (e.g. by removing excise concessions for agro based mills).

Capacity

India has about 715 industrial units engaged in the manufacture of pulp, paper and paperboards. The industry is highly fragmented, with capacities ranging from 2 to 800 tonnes per day. A majority of the pulp & paper mills (551) are recycled fibre-based mills, while agro-based (139) comes second, followed by wood based (25) mills⁴.

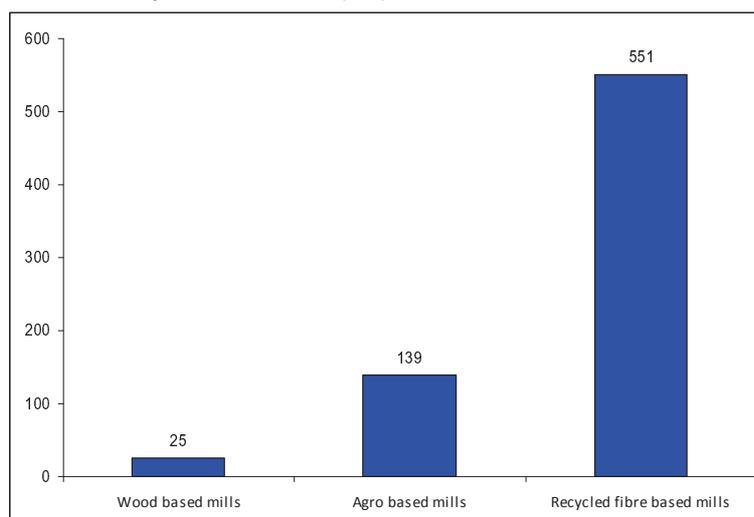


Figure 1: Categorization of the Mills Based on Cellulosic Raw Materials

⁴ PAT Document – Ministry of Power

The Indian paper industry uses wood, agricultural residues and waste paper as raw materials. In the early 70's, the share of waste paper used as raw material was only 7%, whereas now it constitutes the major raw material base for paper industry with 47% share in total production.

Table 1: Raw material percentage share in paper production

Year	% Share ⁵		
	Wood	Agro residue	Waste Paper
1970	84	9	7
2000	39	31	30
2011	31	22	47

There are currently around 715 paper mills operating, most of which are family-owned operations. The majority of the paper mills have a capacity of less than 50,000 tons per annum (TPA). Only 56 mills have capacity of more than 50,000 TPA. The average-sized paper mill has a capacity of 20,000 TPA. Paper mills provide employment to 0.12 million people directly and 0.34 million people indirectly.

India paper industry is broadly classified into three segments – namely Writing & Printing (W&P), Newsprint and Paperboard & Industrial Packaging (Paperboard). Paperboard is the largest segment, accounting for 45% of total domestic paper demand, followed by W & P (35%) and Newsprint (20%). Indian paper industries use a variety of raw materials, including non-wood materials such as rice straw, wheat straw, bagasse, sabai grass and bamboo. Other raw materials are hard woods, such as eucalyptus and casuarinas, and recycled papers. The industry is further categorized on the basis of raw-material used for manufacturing paper into forest based (with a share of 31%), agro-based (22%) and recycled fibre-based paper (47%)⁶.

Despite the fact that the Indian Paper Industry holds its importance to the national economy, it stands fragmented. Paper sector is dominated by small and medium size units; Less than half a dozen mills account for almost 90% production of newsprint in the country. There is a growing need to modernize the Indian mills, improve productivity and build new capacities.

⁵ DIPP, Govt. of India

⁶ DIPP, Govt. of India

Table 2: Indian Paper Mills Production capacity by Category-wise⁷

Category	Capacity Range	Number of units	Capacity (TPA)
Small	Up to 10000	299	12,90,382
	<2000	69	75,522
	2000–5000	107	2,96,980
	5000–10000	123	9,17,880
Medium	10000–20000	116	16,69,460
Large	>20000	70	38,93,048

According to the CPPRI, there are about 720 units which manufacture pulp, paper, paper board and newsprint, out of which 621 are currently in operation. The total installed capacity is 11.57 million tonnes, out of which 1.3 million tonnes are lying idle due to the closure of 99 units. The Indian paper industry consists of small, medium and large paper mills, having capacities ranging from 5 to 800 tonnes per day (TPD).

Table 3: Indian Paper Mills Production Share by Type of Raw Material used⁸

Type of Raw material for paper industry	Scale of Operation (tpd)	No of Mills	Production Share, %
Large integrated wood based	100 - 800	85	36
Medium agro based	50 - 100	115	29
Small waste paper based	5 – 50	520	35
	Total	720	100

Although per capita paper consumption in India is very low compared to other countries the paper industry holds a considerable share in manufacturing production. Today more than 380 small and big paper mills produce a variety of different paper, paperboard as well as newsprint products. Cultural paper constitutes the biggest share in production with 41%, followed by kraftpaper with a share of 27%, paperboard with 17%, newsprint with 12% and specialty paper at 3%. India's installed production capacity increased substantially from 0.77 million tonnes in 1970-71 to 3.95 million tonnes in 1994-95.

However, production has not increased accordingly. While in 1970-71 production ran at almost full capacity, in 1994-95, only 2.51 million tonnes of paper and paper board were produced. The capacity utilization had decreased from 99% in 1970-71 to a low of 60% in 1992-93 and slightly increased again to 64% in 1994-95.

The performance of the Indian pulp & paper industry has been constrained due to high cost of production caused by inadequate availability and high cost of raw materials, high energy cost, etc.

⁷ Research India 2008

⁸ Central pulp & paper research institute data, as on December 2010

Several policy measures have been initiated in recent years to remove the bottlenecks of availability of raw materials and infrastructure development. To bridge the gap due to shortage of raw materials, duty on pulp and waste paper and wood logs/chips have been reduced. The capacity utilization of the industry is 79% approximately as about 98 paper mills, particularly small mills, are sick and /or closed. On the policy front, the Government has delicensed the paper industry w.e.f. 17th July, 1997 and several fiscal incentives have also been provided to the paper industry, particularly to those mills, which are based on non-conventional raw material.

As on 2010 – 2011, the installed capacity of the pulp & paper mills in India is 12.7 million tons and the actual production is about 10.11 million tons. This makes the overall capacity utilization to be around 80%. The consumption of Paper in India is around 11.15 million tons during the same year. The capacity utilization details (for the year 2010- 11) of some major paper producers in India is summarised in the table below.

Table 4: Capacity utilization of some major paper producers

Sl.no	Company	Capacity (Tones)	Production (Tones)	Capacity utilization (%)
1	ABC PAPER	105000	60553	57.7
2	ABHISHEK INDUSTRIES	175000	123639	70.7
3	ANDHRA PAPER MILLS	175000	176452	100.8
4	BILT	800000	796718	99.6
5	EMAMI PAPER MILLS LTD	145000	142494	98.3
6	HINDUSTAN NEWSPRINT LTD	100000	100546	100.5
7	ITC - PSPD	550000	547931	99.6
8	JK PAPER LTD	240000	273755	114.1
9	N R AGARWAL INDUSTRIES LTD	170000	158031	93.0
10	RAINBOW PAPERS LTD	159500	109054.9	68.4
11	RAMA PAPER MILLS LTD	61000	48627.9	79.7
12	STAR PAPER MILLS	75000	68592	91.5
13	TNPL	275575	245008	88.9
14	WESTCOAST PAPER	320000	173638	54.3
15	YASH PAPER MILLS	39960	26598	66.6

The Indian Paper Industry accounts for about 1.6% of the world's production of paper and paperboard. The global paper industry is highly concentrated in the China, United States, Japan, Germany, Canada, Finland, Sweden & Indonesia which together accounted for more than 65% of total paper production.

1.1 GEOGRAPHICAL SPREAD OF INDIAN PULP AND PAPER INDUSTRY

Regional Distribution of Paper Mills in the Country

In terms of regional distribution of paper mills in the country, Gujarat leads the tally with the maximum number of mills (127), followed by Uttar Pradesh with 115 mills. However, the major players are located in the southern and central parts of the country⁹.

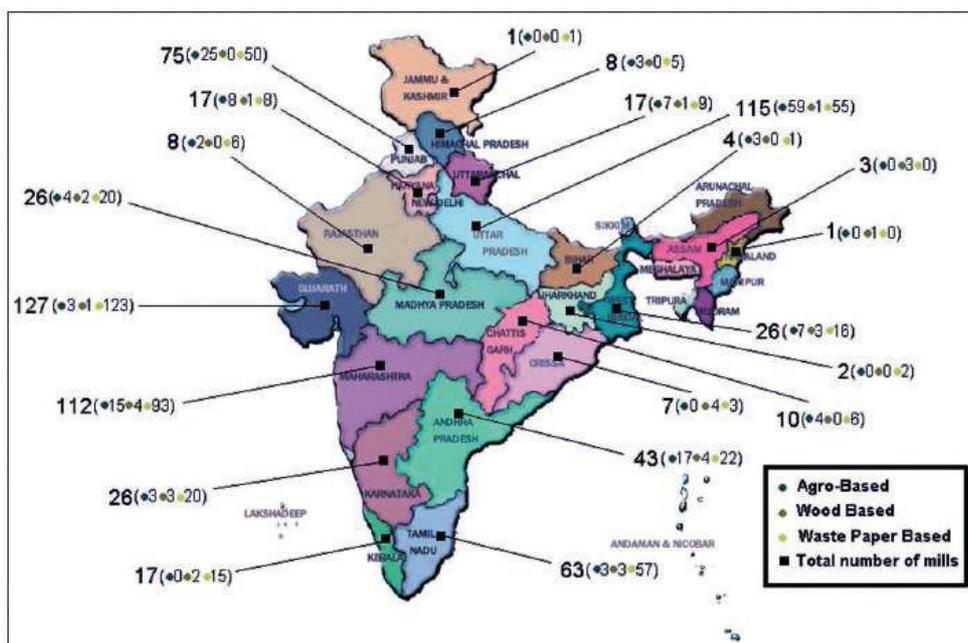


Figure 2: Paper Mills in India – Regional Distribution

⁹ DIPP Annual report 2010 -11

Distribution of registered pulp and paper plants state wise is shown below.

Table 5: State-wise distribution of Paper & pulp plants

State / UT	Agro based	Wood based	RCF based	Total
Andhra Pradesh	17	4	22	43
Chhattisgarh	4	0	6	10
Gujarat	3	1	123	127
Haryana	8	1	8	17
Karnataka	3	3	20	26
Kerala	0	2	15	17
Madhya Pradesh	4	2	20	26
Maharashtra	15	4	93	112
Paschim Banga	7	3	16	26
Punjab	25	0	50	75
Rajasthan	2	0	8	10
Tamil Nadu	3	3	57	63
Uttar Pradesh	59	1	55	115
Uttaranchal	7	1	9	17

1.2 MAJOR PLAYERS IN INDIAN PULP AND PAPER SECTOR

The number of paper mills has increased from just 17 mills in 1951 to around 715 units in 2010, out of which nearly 568 were in operation.

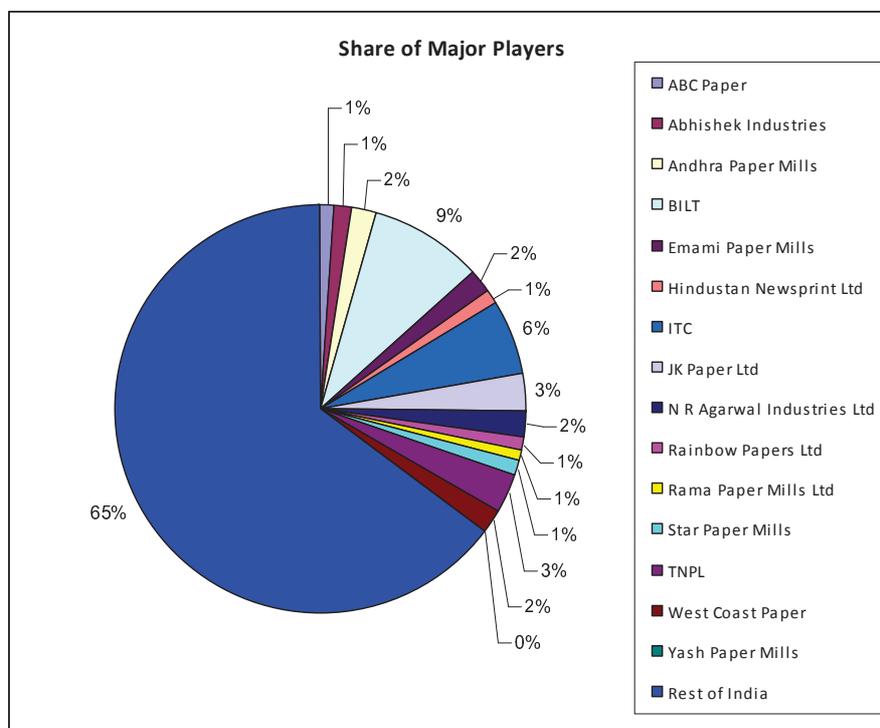


Figure 3: Share of major players (in percentage)

As it can be seen from the above chart, the top 16 pulp & paper companies in India account for 35% of the production and the rest of the sector accounts for 65% of the Indian paper production in 2010.

1.3 Breakup of Manufacturing Cost

The mapping of the input costs, showing the share of various inputs like raw material, energy, labour etc are shown below. The share of various inputs is based on the analysis of six large sized paper mills in India.

Table 6: Cost breakup for Newsprint Paper & uncoated Paper

Sl. No	Rs./Ton	Newsprint	Uncoated paper
1.	Fibre	9750	11750
2.	Chemicals	1000	2600
3.	Energy	3750	2700
4.	Personnel	500	500
5.	Other manufacturing costs	1950	3050
6.	Capital	4550	6550
7.	Total	21500	27150

The various manufacturing cost breakup for newsprint and uncoated paper is show in the graphs given below.

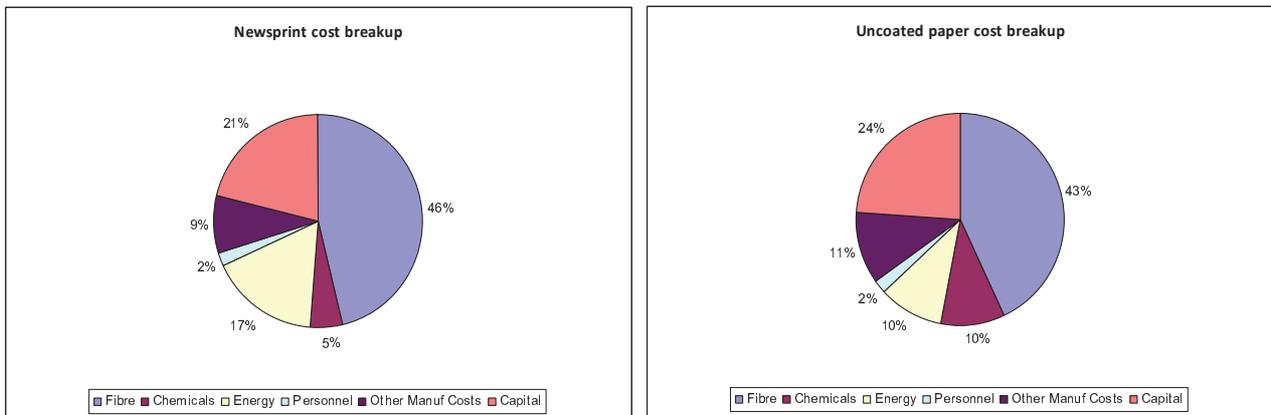


Figure 4: Manufacturing Cost Breakup for Coated & Uncoated Paper

2.0 ENERGY CONSUMPTION IN INDIAN PULP & PAPER INDUSTRY

Pulp & Paper industry is an energy intensive industry. The consumption of steam and electricity per tonne of paper production in India is about 11-15 tonnes and 1,500-1,700 kWh. The average specific energy is placed at 52 GJ per tonne of paper, which are nearly twice the North American and Scandinavian standards.

The following schematic shows a typical Sankey diagram of the primary and secondary forms of energy consumption in an integrated pulp & paper plant.

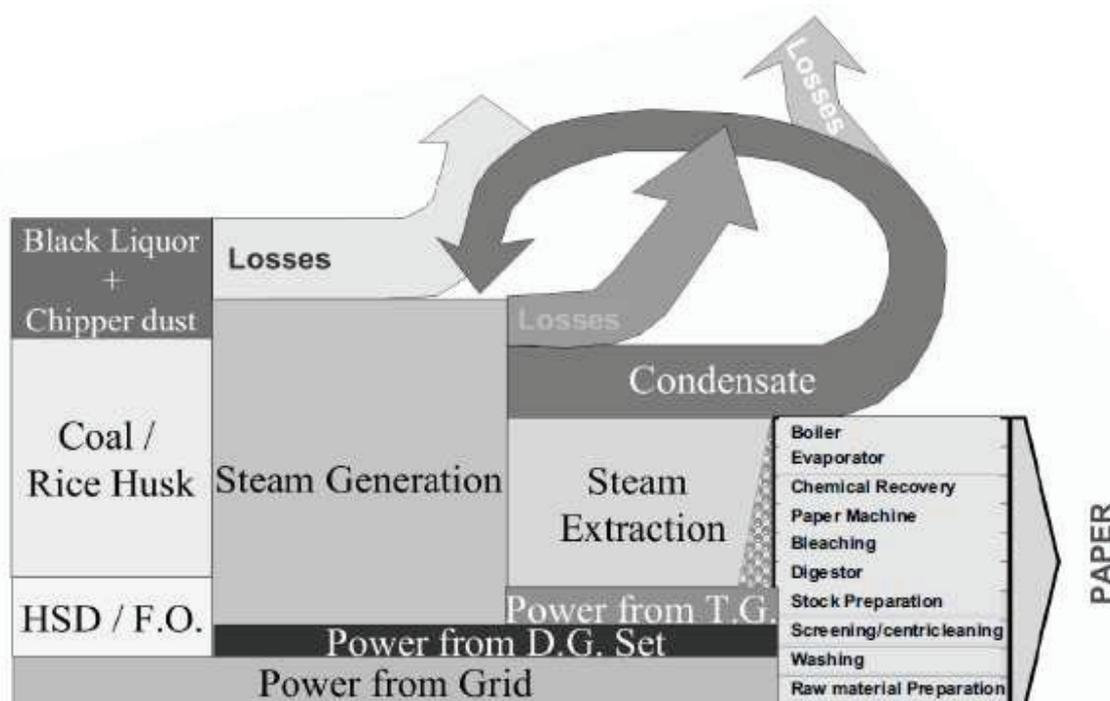


Figure 5: Typical Sankey diagram of the primary and secondary forms of energy

Major factors that affect energy consumption in the Indian Pulp & Paper Industry are:

- Low level of capacity utilization
- Quality and type of paper produced
- Number and multiplicity of machinery
- Paper machine runnability and down time
- Finishing losses
- Boiler type & pressure levels
- Level of cogeneration
- Power generation

The energy cost component has been pegged at 16-25% of the total production cost of paper, and this is expected to increase over other inputs in the near future. Energy consumption in paper plants varies according to the type of raw material and the technology. Major sources of energy used in paper production are coal and electricity, but other fuels such as low sulphur heavy stock (LSHS) and furnace oil (FO) for boiler firing, and light diesel oil (LDO) and high speed diesel (HDO) for captive power generation are also used.

The Pulp & Paper Sector is expected to consume approximately 730 PJ per annum of energy in the year 2020 and 1702 PJ per annum in 2030, it is expected to contribute 76 million tCO₂ per annum and 164 million tCO₂ per annum of GHG emissions in the years 2020 and 2030, respectively.

The following table summarizes the performance of integrated wood based paper mills in India and abroad.

Table 7: Performance comparison of integrated wood based paper mills in India & Abroad

Input Norms	Mills in India (Wood Based)	Mills Abroad
Raw material, tones	2.0–2.4	1.8–2.0
Energy, GJ	23-37	18-22
Water, m3	120-200	20-60
Chemical Recovery, %	85-95	95-98
Manpower, no.	14-20	5-7
Technical manpower, no.	2	4
Fibre Recovery, %	15	40

Typical energy consumption of an Indian paper mills is shown in the following table and is based on the energy efficiency studies done by CII.

Table 8: Typical energy consumption details of Indian Paper Mills

S. No.	Type of Mill	Electrical Energy KWH/T	Thermal Energy GJ / T
1	Integrated Wood / Bamboo based	1400 – 1500	27.3
2	Agro based mill without recovery	1200 – 1300	27.3
3	Waste Paper based	600 – 850	11.3

2.1 PRODUCTION CAPACITY AND CONSUMPTION TRENDS

Distribution of pulp & paper mills based on products manufactured¹⁰

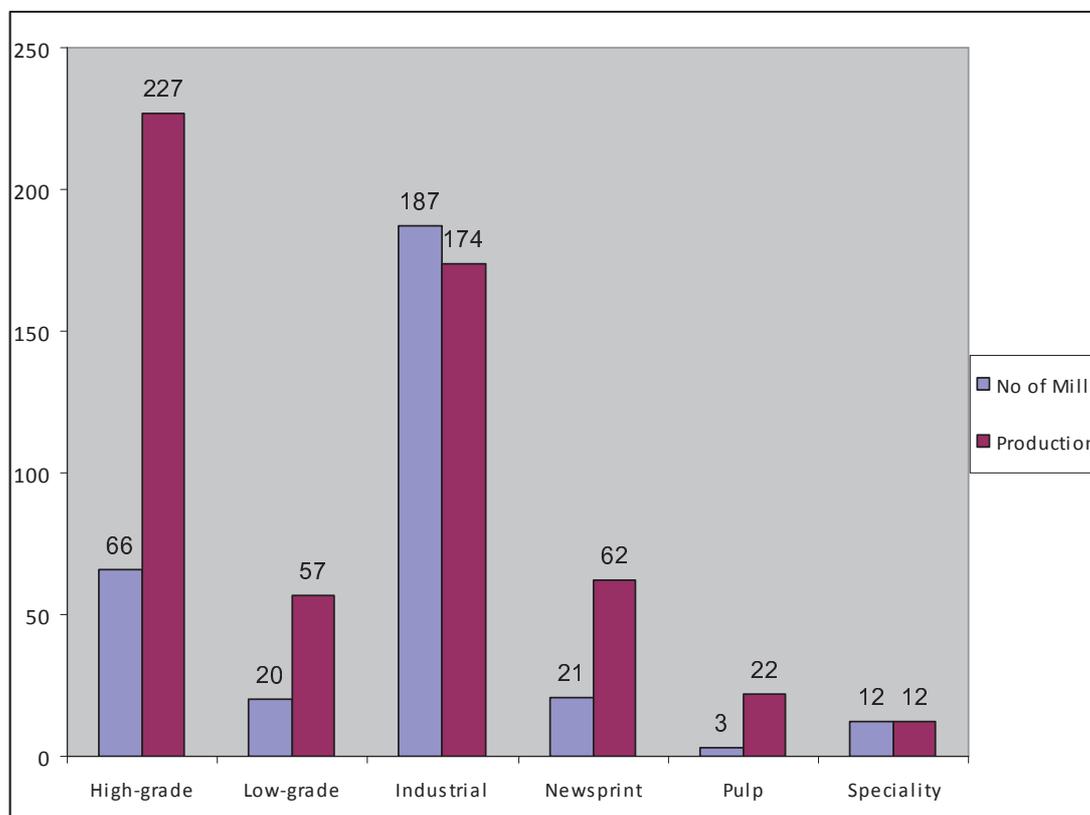


Figure 6: Distribution of pulp & paper mills based on products manufactured¹⁰

Over the years, the Indian Paper industry has been a marginal importer of finished Paper but a significant importer of Recycled fibre to be used as raw material. Newsprint accounts for a majority of the paper import in India. In 2009 -10, for example, the news print import was at 0.99 million tons (51% of the Newsprint consumption), while the Paper & Paper board import was 0.42 million tons (6% of the consumption). The Paper and paper boards account for a major portion of the total paper production in the country. In 2009 -10, the production of paper and Paper boards rose to 7.07 million tons while the news print production was at 0.96 million tons.

¹⁰ NPC / CPCB, March 2006

Table 9: Details of Export, Import and Consumption of Finished Paper (in Millions Tons)

	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Production	0.91	1.03	1.04	1.10	0.96	1.09
Export	0.008	0.004	0.004	0.006	0.007	0.007
Import	0.70	0.79	0.89	0.99	0.99	1.05
Consumption	1.60	1.82	1.92	2.08	1.94	2.14

2.2 FUTURE GROWTH OPPORTUNITIES

India is the fastest growing paper market in the world, growing at a CAGR of 6.7% over FY 06-11. Indian paper industry demand is closely linked to economic activity as demand has grown at an average 0.9x multiple of GDP in the past 5 years. Indian Paper industry demand recovered strongly in FY11 compared to weak previous corresponding period (impacted by financial crisis) mainly due to government favorable excise policy, increased government spending on education and improved activity from service, print media, FMCG, consumer durables and pharmaceutical sector¹¹.

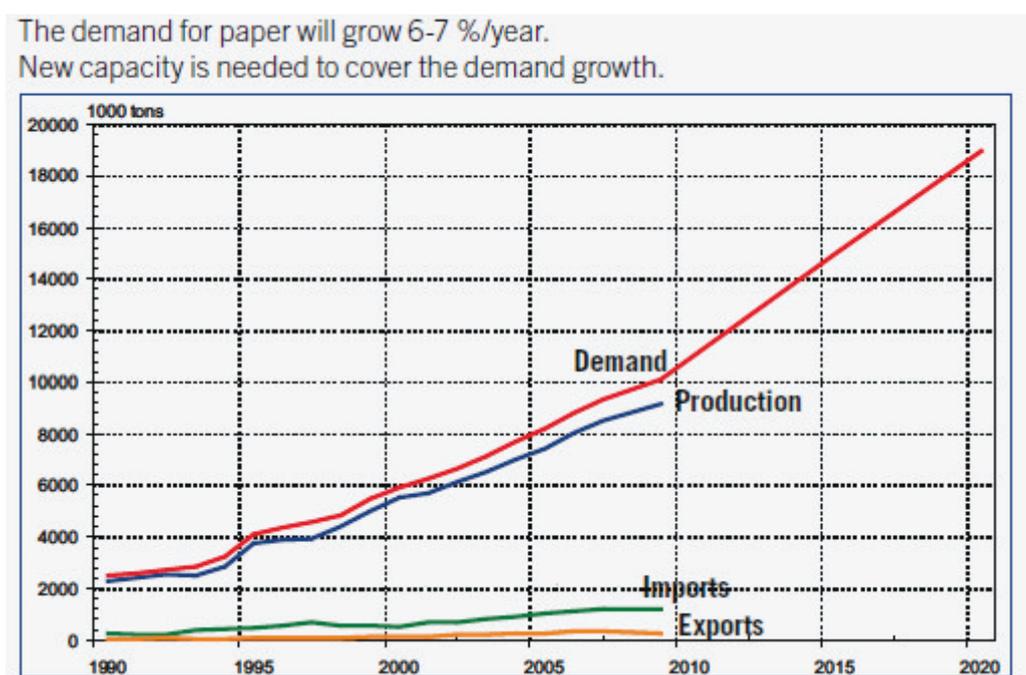


Figure 7: India Paper Outlook 2011¹²

The current demand for paper and paperboard is around 10.05 million tons and is forecasted to reach 19 million tons by 2020. The pulp and paper industry is forecasted to grow at 6–7 per cent each year. Paper production is likely to grow at 8.4 per cent, while the consumption of paper will grow at 9 per cent. Thus, new capacity is needed to cover the demand growth. As it stands, the gap between production and consumption will be met through the import of pulp and paper from other countries¹³.

Predictions of the demand and supply growth until 2020 by Poyry and Financial express suggest that the extent of imports of Paper and Paper boards and Newsprint is not going to reduce. The following charts based on research by CPPRI confirm this aspect.

¹¹ CARE Research: August 2011

¹² India Paper Outlook

¹³ Poyry

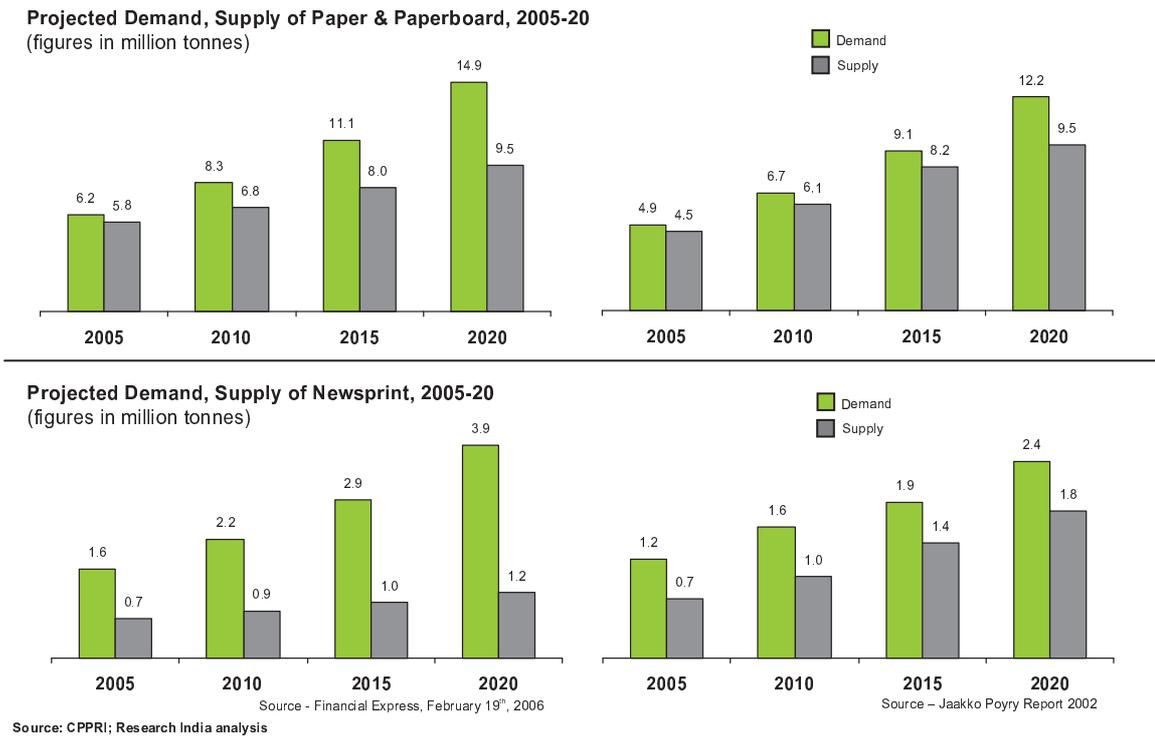


Figure 8: Projected Demand, Supply of Paper & Paperboard, 2005-20 (figures in million tonnes)

3.0 ENVIRONMENTAL ISSUES BEING FACED BY THE INDIAN PULP & PAPER SECTOR

The problem of the environment is quite predominant in both large as well as small scale category of pulp & paper industry. In large scale mills, despite adequate infrastructure and technical manpower, there is a need to further improve the environmental performance of the mill.

The environmental problems are more serious in small scale pulp & paper mills which lacks in infrastructure, technical manpower, research & development facilities and resource crunch. The major problem from small pulp & paper agro-based mills is from discharge of black liquor which contains highly polluting constituents in the form of lignin and cooking chemicals which are not recovered through chemical recovery prior to its discharge into the surface water or on land. Its discharge deteriorates the precious resource, like river water or land.

The major environmental issues faced by the pulp & paper industry are:

- Control of color and AOX discharge
- Control of release of Non Condensable Gases (NCG's).
- Disposal of Solid waste viz. Lime Sludge/Fly ash

The Ministry of Environment & Forest (MoEF) has launched the Charter on "Corporate Responsibility for Environmental Protection (CREP)" in March 2003 with the purpose to go beyond the compliance of regulatory norms for prevention & control of pollution through various measures including waste minimization, in-plant process control & adoption of clean technologies. The Charter has set targets concerning conservation of water, energy, recovery of chemicals, reduction in pollution, elimination of toxic pollutants, process & management of residues that are required to be disposed off in an environmentally sound manner. The Charter enlists the action points for pollution control for various categories of highly polluting industries. A Task Force was constituted for monitoring the progress of implementation of CREP recommendations/ action points. The CREP for Paper Industry was introduced in the year 2003 by MoEF and had to be complied with by the entire industry between 2005 to 2008. The industry took this challenge and significant improvements in terms of waste water discharge, air pollution and solid waste disposal was achieved.

Fibre Security

Presently fibre shortage is the main problem and the industry is abating the risk of fibre shortage by focusing on

- Fast growing plantations
- Recycled paper collection
- Utilization of non-wood material (including developing of new technologies)

3.1 POLICY / REGULATIONS AND INDIAN PULP & PAPER SECTOR

India is promoting the addition of other renewable power sources into its generation mix and had an installed capacity of 17 GW of renewable energy sources on 30 June 2010. Under its National Action Plan on Climate Change, India plans to install 20 GW of solar power by 2020. With an installed wind capacity of 12 GW in June 2010, India has the world's fifth-largest installed capacity of wind power.

The Paper sector has been a major participant in the renewable energy initiatives of the country and is one of the large installers of the wind energy generation in the states of Tamil Nadu, Gujarat and Maharashtra. This has to some extent reduced the energy cost component for some of the mills.

The Ministry of New and Renewable Energy has recently introduced Renewable Energy Purchase obligations and the Paper sector is one of the sectors which is affected by this obligation. However the Ministry also has made the power generation through black liquor firing as a renewable source of power, which will significantly benefit the large integrated plants. This will also benefit the medium size agro based plants to install recovery boilers and avoid discharging of black liquor.

Energy Conservation Act and PAT (Perform Achieve and Trade)

The Energy Conservation Act (ECA) of 2001 provided for the establishment of the Bureau of Energy Efficiency (BEE), the development of energy efficiency standards by industrial product/process, and the requirement to have energy audits carried out by an accredited energy auditor and assign a certified energy manager in energy-intensive and other larger energy consumers (known as "Designated Consumers").

The overall objective of the PAT scheme is to save 6.6 million metric tonnes of oil equivalent (mMtoe) in the first PAT cycle until 2015. The individual company targets have been announced by the Bureau of Energy Efficiency.

The pulp & paper sector contributes to the PAT scheme with 31 units clearing the eligibility criteria of 30,000 MTOE/year consumption. Specific energy consumption varies from 0.202 toe/t to 0.878 toe/t. The total reported energy consumption of these designated consumers is about 2.08 million ton of oil equivalent, out of which Pulp & paper sector has to achieve energy savings of 0.119 million ton of oil equivalent/year during first PAT cycle.

In 2011, India also introduced a range of financing mechanisms administered by the India Renewable Energy Development Agency (IREDA) and preferential loans, venture capital funds and guarantees (Partial Risk Guarantee fund) administered by the Energy Efficiency Services Limited (EESL) under the Framework for Energy Efficiency Economic Development (FEEED).

Plausible leasing out of degraded forest land to private entrepreneurs

Indian paper industry, for quite a long time, has been arguing for a share of the existing degraded forest land on lease, which they may use for producing their requirement of pulp wood at a price

that will add to their global competitiveness. Such a measure, it feels, will reduce the present state of uncertainties in supply of fibres as well. The Working Group constituted by the Planning Commission in June 1997 on the 'Prospects of Leasing out Degraded Forest Land to the Private Entrepreneurs / Forest Corporations' argued against acceding to the demands by the paper industry. An in depth scrutiny of the arguments of the group in the light of surveys undertaken in the states of Orissa and Andhra Pradesh, reveals a different situation.

However, to enhance their credibility, it is imperative that the Industry requires some 'code of conduct' which will ensure that they will not compromise with the faith the Nation has put on them by leasing out a good amount of land, still constitutionally remaining under the ownership and management of the Government.

Other issues faced by Indian pulp & paper sector

The other issues with regard to Technology, fiber availability and security are highlighted below.

Technological issues

The technological issues faced by the Indian Pulp & paper industry can be summarized as follows.

- Obsolescence of technology in most cases.
- Lack of eco friendly state of the art processing technologies.
- Uneconomic scale of operation.
- In an international comparison, even the largest machines are medium-size
 - The average capacity of paper machines is about 14000 tones per annum
 - Most of Indian paper machines have a trim width from 1.5 to 3.5 m
 - There are only 9 paper machines with trim width of 5 m or more
 - Only 14 machines have capacities 50000 tones per annum or more
- It is not possible to have very high speed paper machine, i.e. >1500 mpm for the type of raw material available in India
- Similarly for adoption of new papermaking technology, quality of raw material and mill size are the major limitations.
- Except the wood based integrated mills and few agro/RCF mills the level of automation and process control is very low in most of the mills

Fibre Security

In India, the paper industry is primarily rural based with close linkages with farming community. Over the years it has evolved into an agro-based industry from its earlier character of a forest-based industry.

Wood requirement of paper industry: Currently, Indian paper industry is consuming only about 7 million MT or about 3% of the total wood consumed in India; about 90% is consumed as fuel wood.

Additional raw material requirement in 2012-13 is anticipated to be about 8 million tons of wood which will be about 6% of total consumption of the country. This would require afforesting 2 million Ha of land mass to maintain proper ecological balance. Availability of agricultural residues is good (as shown in the figure), but there are many limitations to their use.

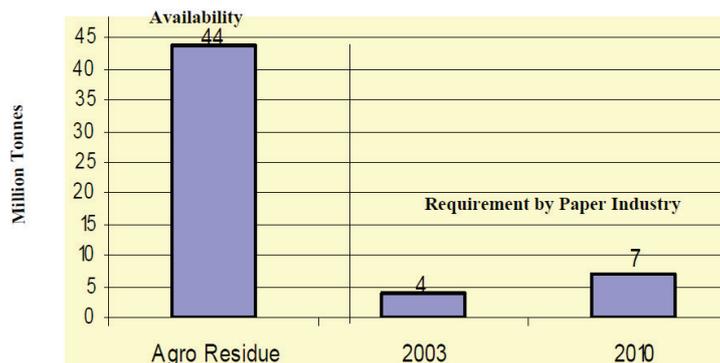


Figure 9: Usage of Agro residue by paper industry during 2003 & 2010 (in million Tons)

Import of Recycled fibre paper is continuously increasing. At present more than 75% of consumption (of recycled fibre) is met through imports.

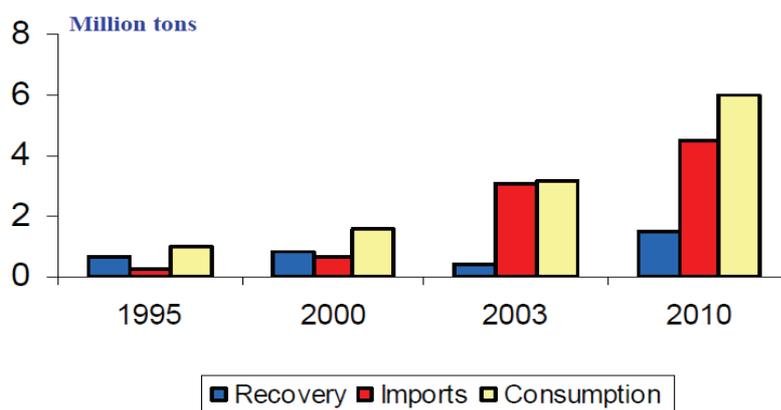


Figure 10: Consumption of Recycled Fibre

3.2 ENERGY TRENDS IN INDIAN PULP & PAPER INDUSTRY

While developing the PAT (Perform Achieve & Trade scheme), BEE had conducted a survey of energy consumption pattern of the Indian Pulp & Paper Industry. The survey revealed the energy consumption of an Indian Paper mill is ranging between 25.3 – 121 kJ/Ton of paper. This translates to a GHG intensity range of 2.46 – 11.8 Tons of CO₂/ Ton of paper produced and reinforces the diversity of operating conditions in the Indian Pulp & Paper Mill.

Specific energy consumption in Pulp and Paper industry may vary because of the following aspects.

- 1) Type/grade of product (Eg: Tissue paper is more energy/GHG intensive than paper board)
- 2) Type of raw material used (virgin fibre or recycled fibre)
- 3) Installation of chemical recovery system (and heat generation) from black liquor in virgin fibre based mills
- 4) Installation of CHP system; Extent of cogeneration practiced in the CHP system (CHP – Combined heat & Power production)
- 5) Specific energy consumption in manufacturing pulp & paper (or level of energy efficiency in the mill involving implementation of advanced technologies and operational proficiency)
- 6) Installation and operation of pollution control equipment
- 7) Size of the mill and its capacity utilization

Decline in energy consumption & GHG emission intensity for Indian integrated pulp & paper mills

Energy intensity data compiled from different sources show an interesting reduction trend in the energy consumption / GHG emission intensity for producing paper in an Indian integrated pulp & paper mill. The values given in the following table summarizes the decreasing trend in energy intensity which was achieved inspite of incurring additional energy consumption for commissioning and operation of pollution prevention/ reduction equipment in the later years.

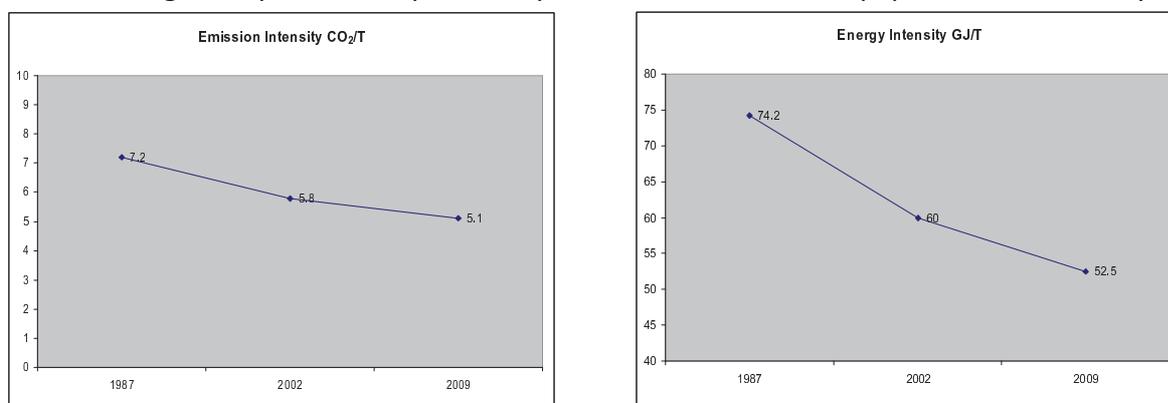


Figure 11: Energy & GHG Intensity during 1987, 2002 & 2009

The reduction in energy and GHG emission intensity can be credited to the adoption of energy efficiency measures in the Indian pulp & paper industry and also for migrating to advanced technologies in the process areas.

4.0 ENERGY EFFICIENCY IMPROVEMENT OPPORTUNITIES

TECHNOLOGY - 1

OXYFUEL BURNING IN LIME KILN AND BLACK LIQUOR BOILERS

Background

Combustion takes place in lime kilns and black liquor boilers when the respective fuel reacts with oxygen from air above the auto ignition temperature. This reaction being exothermic liberated heat which is used for creating an environment for certain desired reactions to occur or for generation of steam.

Air contains less than 21% oxygen by volume which is useful for combustion process. The bulk of the rest of the gaseous mixture, is nitrogen which does not take part significantly in the combustion or other processes.

When a fuel is burnt, oxygen in the combustion air chemically combines with the hydrogen and carbon in the fuel to form water and carbon dioxide, releasing heat in the process. Air is made up of 21% oxygen, 78% nitrogen, and 1% other gases. During air–fuel combustion, the chemically inert nitrogen in the air dilutes the reactive oxygen and carries away some of the energy in the hot combustion exhaust gas. An increase in oxygen in the combustion air can reduce the energy loss in the exhaust gases and increase heating system efficiency.

Brief about the of best practice / technology

Most industrial furnaces that use oxygen or oxygen-enriched air use either liquid oxygen to increase the oxygen concentration in the combustion air or vacuum pressure swing adsorption units to remove some of the nitrogen and increase the oxygen content. Some systems use almost 100% oxygen in the main combustion header; others blend in oxygen to increase the oxygen in the incoming combustion air (see Figure). Some systems use auxiliary oxy-fuel burners in conjunction with standard burners. Other systems use staged combustion and vary the oxygen concentration during different stages of combustion. Still others “lance” oxygen by strategically injecting it beside, beneath, or through the air–fuel flame.

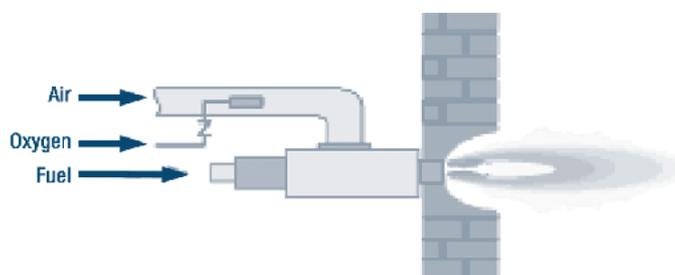


Figure 12: Potential fuel / energy savings for the model plant

Potential fuel / energy savings for the model plant

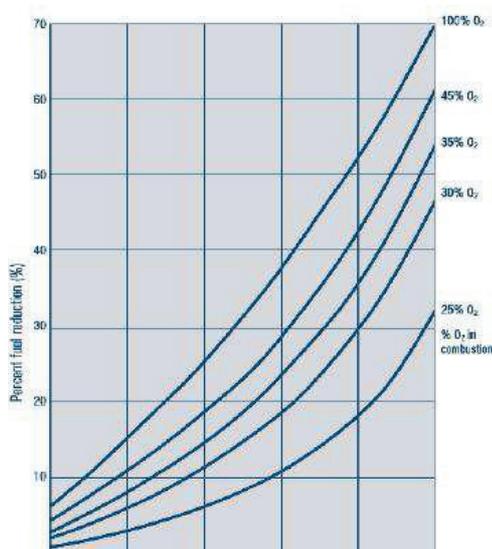
Oxygen-enriched combustion can:

Increase efficiency. The flue gas heat losses are reduced because the flue gas mass decreases as it leave the furnace. There is less nitrogen to carry heat from the furnace.

Increase productivity. When a furnace has been converted to be oxygen enriched, throughput can be increased for the same fuel input because of higher flame temperature, increased heat transfer to the load, and reduced flue gas.

Also, using oxygen enhancement allows higher kiln temperatures that increase kiln capacity. If a mill is short of calcining capacity then this technology can address that shortfall.

Using oxygen-enriched combustion for specific applications may improve efficiency, depending on the exhaust gas temperature and percentage of oxygen in the combustion air. Figure 2 shown can be used to calculate energy savings for commonly used process heating applications. The Process Heating Assessment and Survey Tool (PHAST) developed by USDOE under the Industrial technologies Program (ITP) can also be used to estimate the amount of energy that can be saved by switching to oxygen-enriched combustion. (The PHAST tool is available for free download from the site:



Conversion to oxygen-enriched combustion is followed by an increase in furnace temperature and a simultaneous decrease in furnace gas flow around the product. Unless there is a sufficient increase in the heat transfer to product, the flue gas temperature will rise above the pre-conversion level and little or no energy will be saved. In radiant heat-governed furnaces, the conversion could increase the radiant heat transfer substantially. Consequently, the flue gas temperature could drop to or below the pre-conversion level. In convective heat-governed furnaces, the furnace gas velocity may drop because the convective heat transfer coefficient may decrease in a larger proportion than the increase in gas temperature. If this happens, the conversion would do little to increase the overall heat transfer, so reducing flue gas temperature to pre-conversion level may not be possible.

Figure 13: Percentage Fuel reduction Vs. % O₂ in combustion

By adopting oxyfuel firing technology in lime kiln, efficient combustion can be achieved and thus reducing the amount of fuel to be fired. For an example, a typical 200 TPD integrated pulp & paper mill processes lime sludge and generates about 80 TPD of lime at a FO consumption of 145 liter/ton of lime. By adopting oxyfuel firing, FO consumption reduction can be achieved and will be in the range of 7 – 12%.

Cost Benefits Analysis:

	Without PAT	With PAT benefit
Energy savings	Rs. 4.5 million	Rs. 4.5 million
MTOE equivalent		291
PAT benefit ¹⁴	--	Rs. 2.9 million
Total benefit	Rs. 4.5 million	Rs. 7.4 million
Investment	Rs. 30 million	Rs. 30 million
Payback period	80 Months	49 Months
Replication Potential		
Number of plants	60% of the plants	
MTOE savings	3300	

¹⁴ PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation

TECHNOLOGY - 2

INSTALLATION OF SHOE PRESS IN PAPER MACHINES

Brief about the of best practice / technology

Commercial use of shoe presses has now passed the quarter-century mark. In that time, shoe press applications have grown from being limited to linerboard and corrugating medium, to virtually all grades of paper and board. Shoe presses are capable of creating high dryness for all grades and usually this dryness level translates to increased production. The sheet property benefits of shoe pressing are grade-dependent and, on a few grades, improving all of the important properties is mutually exclusive.

A quarter of a century ago, the first shoe press started up making linerboard. The thinking at that time was that the return on investment would come entirely from the steam savings that resulted from the dryness improvement. As it turned out, the profits from increased production and the reduction in furnish costs far outweighed the steam savings per ton. The shoe press created a 5-point dryness improvement over the roll presses it replaced, and this allowed the dryer-limited machine to increase production by 20%. The linerboard strength improvement made it possible to substitute recycled fibres for virgin Kraft pulp, decrease refining energy, and eliminate wet-end starch. This same basic scenario describes hundreds of shoe press installations (internationally) on linerboard and fluting that have taken place since then and similar results have been realized in the rest of the paper and board grades as well.

The vast majority of press rebuilds and new machines include one or more shoe presses to take advantage of one of the two fundamental benefits of shoe presses:

1. Shoe presses are able to press the sheet to very high dryness levels. Typically this means 4 to 7 points of dryness higher than the roll press it replaces. This results in production increases on existing drying-limited machines and shortened dryer sections and machine halls on new machines.
2. Shoe presses are able to preserve sheet bulk while pressing to high dryness values. Depending on the grade and press configuration, a shoe press can create dryness values 2 to 5 points higher than typical roll press configurations while maintaining bulk.

Shoe pressing for all grades

One way to think of tissue, paper and board is to regroup them into three classifications -- density grades, bulk grades, and mutually exclusive grades. Linerboard and corrugating medium make up the density grades because any pressing process that increases the sheet density increases all of the valuable physical properties. These properties include burst, internal bond, short-span compression and ring crush. At nip loads of 700 to 1400 kN/m, the shoe-pressed sheet will have higher dryness and density and hence better sheet properties than a roll-pressed sheet. Since most liner and medium machines run dryer-limited, any press rebuild and all new machines

should include shoe pressing for maximum sheet strength, production, and minimum drying energy.

The bulk grades include fine paper, folding boxboard, white lined chip board and others. These grades require bulk to maximize opacity and bending stiffness. As a general rule, increased pressing decreases bulk and therefore one would think that the high nip loading capability of a shoe press would be inappropriate. However, shoe presses have the unique feature of being able to shift the sheet bulk vs. press dryness relationship relative to roll presses, which is illustrated in Figure 17. How much the shift in the press dryness versus bulk curve is, depends on the basis weight, furnish, and press section configuration.

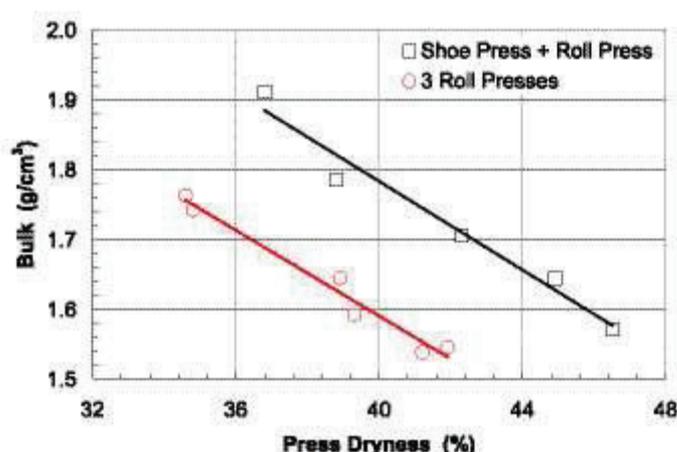


Figure 14: Press dryness vs. sheet bulk – 57 g/m² fine paper

Press dryness vs. sheet bulk - 57 g/m² fine paper

This shift in the dryness versus bulk curve creates several ways to turn a shoe press installation into revenue. The shoe press section can be loaded to create high bulk and equal dryness compared to a roll press section. This bulk can then be used to reduce basis weight and therefore fibre savings. If the shoe press section is loaded further, it will create 2 to 5 points of dryness improvement over a roll press section and still have the same bulk. Typically this higher dryness is used to increase production or shorten dryer sections on new machines.

The mutually exclusive grades include tissue, news, SC, and LWC. These grades all have some kind of strength or porosity requirement which is enhanced through press densification, and some kind of absorption, tear or opacity requirement that is maintained by minimizing press densification. Fortunately, the furnish for these grades consists of high percentages of mechanical pulp and filler, neither of which densifies much in the press section regardless of how much the sheet is pressed.

For news, SC, and LWC, the high nip load of the shoe press may cause the sheet to be denser than its roll pressed counterpart, but the difference is so slight, that the small losses in tear and opacity are deemed acceptable in light of the tensile, burst, porosity and, of course, high dryness benefits.

Nip saturation

Fortunately, the vast majority of shoe presses are installed in correct configurations and are operated correctly. However, every so often, an opportunity to further optimize a pressing situation presents itself. These usually occur when there is too little understanding of the pressing fundamentals at the time of installation or press clothing selection.

One area of pressing that needs more understanding is the concept of water handling capacity in the nip. Clothing suppliers commonly claim 'sufficient water handling capacity' in their felt and shoe press belt designs and later papermakers find out otherwise. An example of this is shown in the shoe press data in Figure 18.

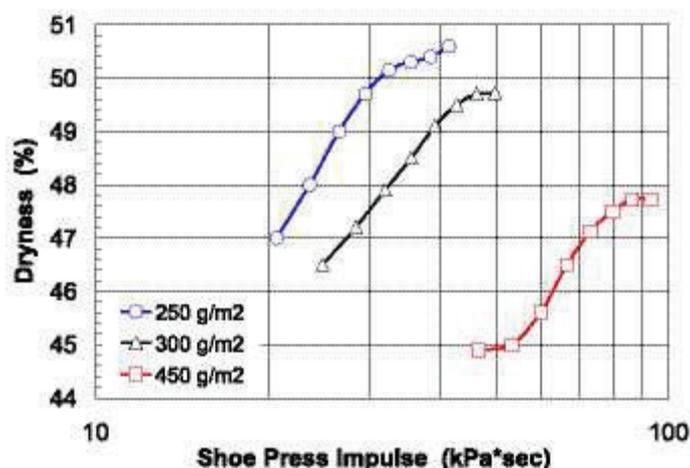


Figure 15: Press impulse vs. dryness for folding box board

Press impulse vs. dryness for folding box board

In this example, a single felted shoe press replaced an existing roll press in the third press of a folding box board machine. After the start-up, an on-machine trial was conducted to determine the dryness benefit of new shoe press produced. The shoe press nip load was varied from 350 to 700 kN/m, creating a 3.5% dryness advantage at equal sheet bulk. This was the expected dryness benefit and the project justification was fulfilled. A surprise came at the very high nip loads, however. When the sheet dryness data was plotted against the nip parameter Press Impulse, the non-logarithmic result indicated some fault in the nip.

The data in figure 2 should have fallen into straight lines for each basis weight, but this was not the case at loads above 600 kN/m. At the highest nip loads, the rate of dryness increase per nip load decreased. This indicates that a saturation condition had formed in the nip. For whatever reason, there wasn't enough functional void volume in the felt and/or shoe press belt to accept all of the water the sheet wanted to give up.

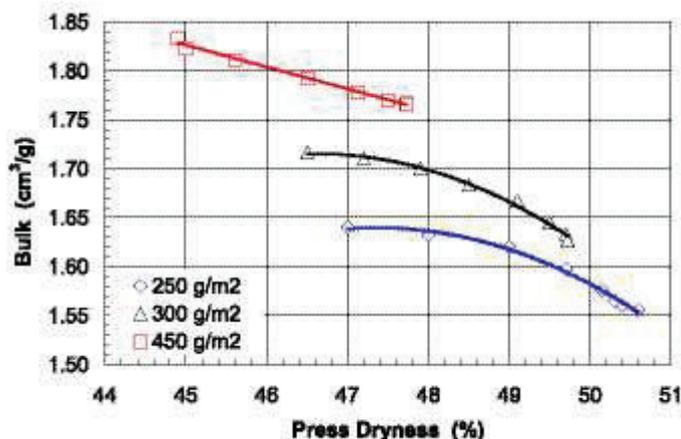


Figure 16: Press dryness vs. dryness for bulk folding box board

Press dryness vs. bulk for folding boxboard

Figure 18 shows the dryness versus finished sheet bulk. These data points should also form straight lines if the nip has sufficient usable void volume. The fact that the rate of bulk loss increases with press dryness indicates there is some form of crushing occurring. The fact that no portion of the 250 and 300 g/m² data is linear suggests that excessive densification can occur long before 'nip saturation.' The conventional wisdom is that there is some precise value at which nip saturation occurs, and up to that point there is no fault in the nip. This dryness versus bulk data is evidence that saturation is not a single point, but a continuum.

It is interesting to note that this single felted nip includes a blind drilled shoe press belt with ~400 g/m² of theoretical void volume. The water given up by the sheet is significantly less than this void volume and yet the data shows there is somehow too much water in the nip based on the dryness relationship and even more so on the sheet bulk relationship. Additionally, the saturation effect on dryness and excessive bulk loss increases with lighter basis weights, even though there is much less sheet water removed in the nip.

The reason for the dryness and bulk problem is not so much related to the lighter basis weight as it is to the higher machine speed that goes with the lighter weight. In the speed range this machine operates, increasing machine speed means more water remains in the felt and in the blind drilled holes in the belt. The increased speed of the 250 g/m² grade means the dwell time over the felt vacuum boxes is reduced, so the average felt moisture goes up. It also means there is less time for water to wick out of the blind-drilled holes and back into the felt. At the higher machine speeds, felt water that goes into the blind drilled holes of the belt remains in the holes and causes the belt to function as if there were no holes at all. Both of these contribute to the loss of usable void volume in the nip, which in turn creates nip saturation. This water that never leaves the felt or blind drilled holes is responsible for the excessive bulk loss in the sheet and loss of maximum dryness potential.

Although there are several interventions that can be taken to optimize this situation, the point is, the need to eliminate nip saturation would not even have been known had it not been for this on-machine trial and the subsequent evaluation of the data.

Bulk optimization

Figure 19 shows the Dryness versus Bulk relationship for a nip load matrix trial conducted on a machine making 435 g/m² laminating board. The press section includes a double felted roll press in the first press position and a double felted shoe press in the second press.

One of the fundamentals that came out of this trial was that shoe pressing causes the least bulk loss per unit of dryness improvement. The steeper slopes of the roll press loading curve data confirms that the excessive bulk loss is attributable to roll pressing. This excessive bulk loss is due to the high peak pressure and rate of compression of the roll press, and not the nip saturation concept mentioned above. There will always be bulk loss with wet pressing, but roll pressing causes excessive bulk loss compared to shoe pressing. Therefore, if the press section contains both roll and shoe presses, it is important to use the appropriate combination of loadings if bulk optimization is the objective.

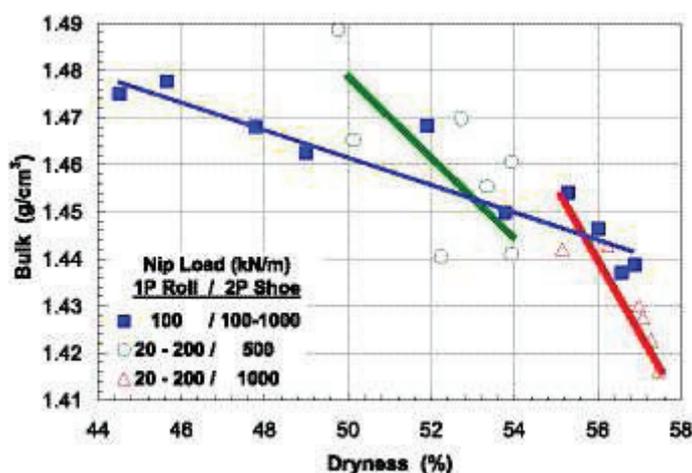


Figure 17: Press dryness vs. bulk for 435 g/m² board

Sheet smoothness optimization

The need to create sheet surface smoothness also enters into the pressing picture. As a rule, felts create roughness in the sheet surface, while plain rolls or belts create smoothness. The more dewatering that takes place in a nip, the more the sheet surface replicates the surface it is pressed against. The sheet surface roughness is also a function of formation and the ability of the furnish to replicate the topography that is presented to it. Bleached Kraft is a conformable pulp and easily replicates whatever it is pressed against, while mechanical pulps and unrefined waste pulps of all kinds do not replicate press nip surfaces so easily.

A caveat to the "felts make roughness" rule is that in multiple nip press sections, the next felt smooths out the high spots from the preceding felt (or former) and then, depending on the nip load or pressure, imparts its own roughness. This is the reason for the parabolic shape to the Dryness versus Bendtsen lines in Figure 20. The result of this 435 g/m² laminating board trial is that for any given press dryness, the sheet surface roughness can vary as much as 200 ml/min depending on the nip load sequence through the press section.

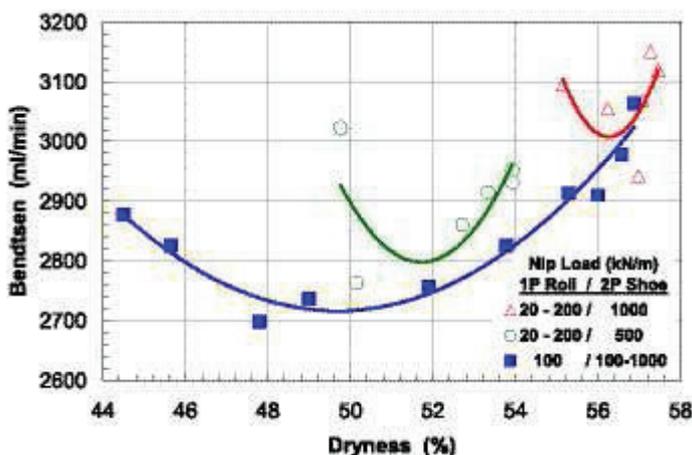


Figure 18: Press dryness vs. roughness for 435 g/m2 board

Press dryness vs. roughness for 435 g/m2 board

As we saw in the dryness verses bulk example, obtaining the best possible smoothness is a matter of discovering the optimum press load sequence, and the smoothest sheet comes from the shoe press nip where, even though the total dewatering may be high, the dewatering rate and peak pressure are quite low.

Potential fuel / energy savings for the model plant

For a 200 TPD paper mill operating with a roll press, the change to the shoe press will improve the dryness of paper by 5 basis points or 5%. This will reduce steam consumption by about 20%.

Table 10: Potential energy savings comparison for Roll press & Shoe Press

	Paper machine with Roll press	Paper machine with Shoe press
After press dryness	40%	45%
Pope reel moisture	4.5%	4.5%
Water evaporated per ton of paper	1.45	1.18
Steam needed per ton of water evaporated	1.8	1.8
Steam consumed per ton of paper	2.62	2.12

Reduction in steam consumption in the case of Shoe press over that of roll press is about 200 TPD. This corresponds to approximately **1423 MTOE** with the following assumptions.

1. One ton of saving LP steam results in reduction of 0.5 tons of HP steam
2. Boiler efficiency is 80%
3. HP steam generated from the boiler is of 44 bar and 440 °C and feed water temperature 100°C.

Other benefits

The profits from increased production and the reduction in furnish costs far outweighed the steam savings per ton. The shoe press created a 5-point dryness improvement over the roll presses it replaced, and this allowed the dryer-limited machine to increase production by 20%. The linerboard strength improvement made it possible to substitute recycled fibres for virgin Kraft pulp, decrease refining energy, and eliminate wet-end starch.

Cost Benefits Analysis:

	Without PAT	With PAT benefit
Energy savings	Rs. 9.9 million	Rs. 9.9 million
MTOE Equivalent	--	1423
PAT benefit ¹⁵	--	Rs. 14.4 million
Total benefit	Rs. 9.9 million	Rs. 24.3 million
Investment	Rs. 100 million	Rs. 100 million
Payback period	121 Months	49 Months
Replication Potential		
Number of plants	60% of the plants	
MTOE Savings	32280	

¹⁵ PAT benefits calculated based on the MTOE savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation

TECHNOLOGY - 3

OPTIMIZE DISPERSION ENERGY ACCORDING TO THE REQUIREMENT

Brief about the of best practice / technology

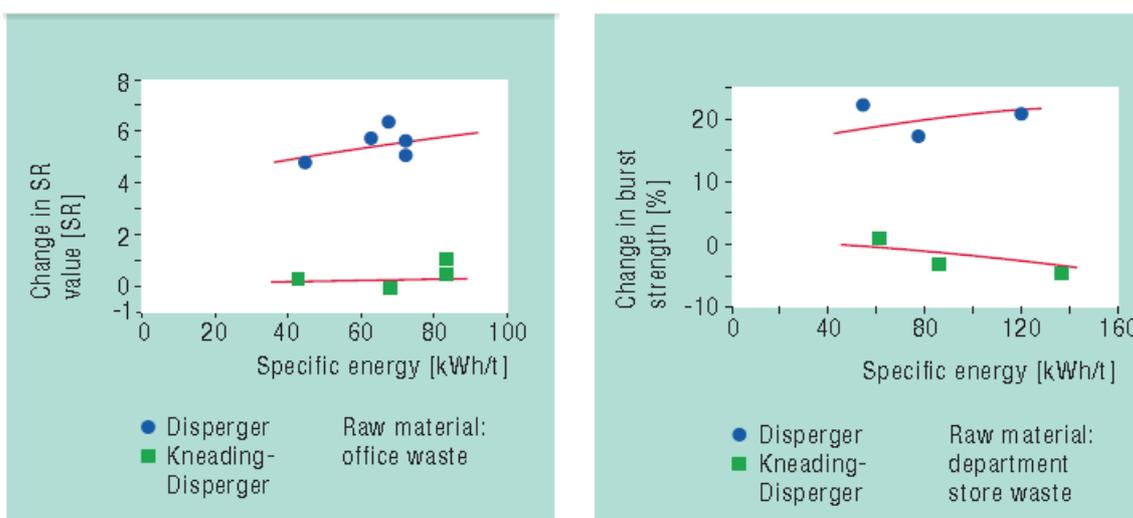
The fillings in a kneading disperger are much coarser than the fillings in a disk disperger. The rotor/stator spacing is about 10 mm, the peripheral speed is 5 – 15 m/s. The design may be 1 – shaft or 2 – shaft. Energy input for kneading dispergers is usually between 30 and 80 kW/ton, in special cases up to 120 kW/ton.

Control of the transferred dispersing energy for the kneading disperger is by adjusting the entering stock consistency. For the disk disperger energy control is by adjusting the spacing of the rotor/stator elements.

The effects of the two disperger types in general are very similar with some differing tendencies.

- The disk disperger may be advantageous when good sticky and dirt speck reduction is required
- The kneading disperger is recommended when high porosity and bulk of the finished product are a priority

Dispergers and other equipment in a Deinking plant are generally designed for a wide range of energy input to cater to a variety of raw materials and product quality. Typically the sticky count designed for is “< 200 mm²/kg”. Most Deinking plants in India have a smaller range of quality for furnish and final product. This provides an opportunity to optimize the energy input in disperger system. Some of the properties affected by the energy input for disperger system are quantitatively plotted in the following graphs



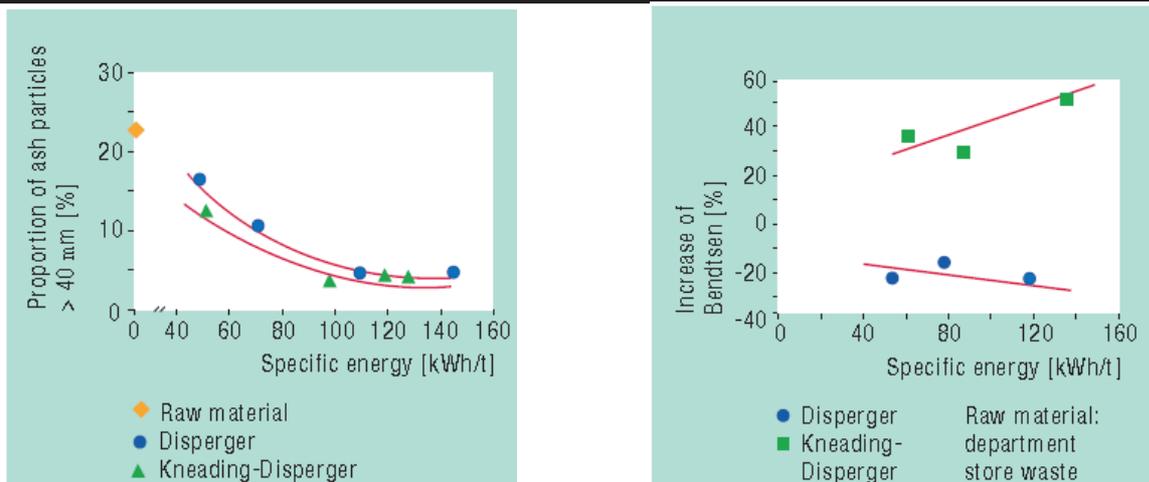


Figure 19: Metso Analysis

Emami paper mills, Balasore have reduced the energy input in the dispergers by installing disperger disks of less intensity.

Table 11: Comparison on energy levels before and after installing disperger disks

	Before change	After change
No. of teeth in disperger disk	2936	2040
Cost of tackle	Rs. 0.6 million	Rs. 0.6 million
Life of tackle	3 – 6 months	3 – 6 months
Energy input at disperger	90±10 kWh/ton	60±10 kWh/ton
Energy consumption in Deinking Plant	330 kWh/ton	300 kWh/ton

Potential fuel / energy savings for the model plant (also in terms of MTOE)

For plant of 200 TPD deinking plant, the energy savings is about 250 kW equivalent to **544 MTOE/yr.**

Cost Benefits Analysis:

	Without PAT	With PAT benefit
Energy savings	Rs. 7 million	Rs. 7 million
MTOE equivalent	--	544
PAT benefit	--	Rs. 5.2 million
Total benefit	Rs. 13.2 million	Rs. 13.2 million
Investment ¹⁶	--	--
Replication Potential		
Number of plants	60% of the plants	
MTOE savings	5141	

¹⁶ There is no additional significant expenditure that needs to be incurred as the disk design can be changed while ordering the next set of disks

TECHNOLOGY - 4

INSTALLATION OF EXTENDED DELIGNIFICATION SYSTEM FOR COOKING OF WOOD

Brief about Technology/Practice:

The latest technological advancements in pulping have led to the adoption of extended delignification pulping process.

The extended delignification pulping process is not only energy efficient, but also environment friendly. The system has the following features:

- Majority of heat is recycled in the system. The recycled heat is stored in the form of hot black liquor and white liquor
- Pulp is blown at lower temperature, resulting in lower heat loss from the system
- Alkali rich white liquor addition takes place only at 115°C. This makes it more reactive with alkali and aids in making the cook more selective leading to extended delignification.
- After cooking is over, the final displacement is performed with washer filtrate, eliminating the need for one stage of washing

The installation of extended delignification pulping process can result in substantial benefits, especially among large integrated paper plants.

Potential Fuel/Energy Savings (if Implemented):

For a plant having digester capacity of 200 Tons of BD pulp/ day the operating parameters before and after delignification are as given below:

Other Benefits

The conventional vertical digesters were replaced with extended delignification pulping process. The major advantages of the project are:

- Up to 75% reduction in steam demand
- Higher brightness levels can be achieved due to low Kappa numbers
- Considerable saving in bleaching chemicals
- Uniform and better pulp quality (15-20% increase in tear/ tensile strength), resulting in better machine runnability and efficiency
- Increased yield – yield up to 46% possible
- Reduction in washing loss leading to reduction of make-up chemicals
- Reduced load on effluent treatment plant

- Due to in-digester washing, one stage of washing gets eliminated
- Low screen rejects due to uniform cooking
- Lower black liquor viscosity allows feeding the boiler at 75+% solids
- Reduction of steam demand in evaporators

The reduction in chemical consumption was about 50%.

Table 12: Comparison on Conventional cooking and extended delignification

Operating Parameter	Conventional cooking	Extended delignification
Steam consumption (tons/ ton of pulp)	1.42	0.70
Average batch time (hrs)	6	4
Kappa number	21-22	12-13
Yield (%)	45.3	46
Washing loss (kg/ton of pulp as sodium sulphate)	16	10
Black liquor concentration (%)	14.2	16
Ash retention (%)	7	10
Paper breakage (%)	3.3	1.5

Financial analysis

The total annual savings achieved was Rs.112 millions. This required an investment of Rs.400 million, which had a simple payback period of 43 months.

Steam consumption before delignification = 1.42 tons/ton of pulp

Steam consumption after delignification = 0.7 tons/ton of pulp

Difference in steam consumption = 0.72 tons/ ton of pulp

For a plant of 200 TPD capacity, LP steam consumption difference = 144 TPD

Typically the HP steam generates 220 units/ton in condensing mode and LP steam extraction generates only 110 units/ton. Following this, for the same power generated from turbine, reducing one ton of LP steam means that we reduce one ton of HP steam inlet to the turbine but also increase the condensing steam by 0.5 tons to compensate for the power generation reduction. Thus saving one ton of LP steam results in saving half-a-ton reduction of HP steam.

Thus, assuming HP steam reduction as 50% of LP steam consumption reduction in a cogeneration system, the HP steam consumption will be 72 TPD.

Assuming HP steam conditions as 44 bar and 400°C and boiler efficiency as 80%, the savings in fuel that can be achieved **2520 MTOE**

Cost Benefits Analysis:

	Without PAT	With PAT benefit
Energy savings	Rs. 112 million	Rs. 112 million
MTOE Equivalent		2520
PAT benefit	--	Rs. 25.6 million
Total benefit	Rs. 112 million	Rs. 137.5 million
Investment	Rs. 400 million	Rs. 400 million
Payback period	43 months	35 months
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	28583	

TECHNOLOGY - 5

INSTALLATION OF CENTRALIZED COMPRESSED AIR GENERATION SYSTEM

Background

Compressed air systems are one of the most expensive of all plant utilities. Most systems typically have efficiencies in the range of 15 to 25 percent. One of the ways of improving this efficiency is by the proper selection of the compressor for a particular application. Reciprocating, rotary screw, and centrifugal compressors are the most common types of compressors used in industrial and commercial facilities.

Reciprocating compressors work like bicycle pumps. A piston, driven by an electric motor, through a crankshaft and connecting rod, reduces the air volume in the cylinder, compressing it to a higher pressure. The most common type of rotary compressor is the helical twin screw-type, also known as rotary screw or helical lobe. Meshing male and female screw-rotors rotate in opposite directions and trap air reducing the volume of the air along the rotors to the air discharge point.

TNPL (TamilNadu Newsprint and Papers Limited, Kaghitapuram) had seven reciprocating (six working + one stand-by) compressors each of 2000 m³/hr at 7 kg/cm² (g) caters to compressed air needs of the mill. Out of 7 reciprocating compressors, four numbers are 24 years old, two of them were 15 years old and the remaining one is 11 years old.

Reciprocating compressors have lot of moving parts and consume more electrical energy to overcome the frictional force. It required regular maintenance such as piston rings , gland packing and valve plates Hence it resulted in high operational & maintenance cost and significant machine down time.

Centrifugal compressors are dynamic compressors, which raise the pressure of air by imparting velocity energy, using a rotating impeller, and converting it to pressure energy.

Brief about Technology/Practice:

The centrifugal compressors is a state of art source of oil free air, simple but rugged mechanical design which combines the best features of aerodynamic technology to achieve optimum energy efficiency and also it delivers lower horsepower to cubic feet per minute. Considering the above, TNPL decided to phase out reciprocating compressors with centrifugal air compressors. During the mill development plan in the year 2006-07, two (2) centrifugal air compressors each of 4500 m³/hr were installed.

Potential Fuel/Energy Savings:

The operational data for 31 days operation between Reciprocating compressors and centrifugal compressors at TNPL are as below:

From the above table an energy savings of 5,700 kWh per day (around 17%) is evident (for 700 TPD plant). In addition to this, the maintenance cost for the centrifugal compressors is lower and occupies less built up area.

Other Benefits:

Savings of about 565 MTOE can be achieved by replacing reciprocating compressors with centrifugal compressors for a plant of 700 TPD capacity.

Cost Benefits Analysis:

For a model plant of 200 TPD, savings of about **162 MTOE** can be achieved by replacing reciprocating compressors with centrifugal compressors.

	Without PAT	With PAT benefit
Energy savings	Rs. 7.8 million	Rs. 7.8 million
MTOE equivalent	--	162
PAT benefit	--	Rs. 1.6 million
Total benefit	Rs. 7.8 million	Rs. 9.4 million
Investment	Rs. 2.5 million	Rs. 2.5 million
Payback period	4 months	3.3 months
Replication Potential		
Number of plants	60% of the plants	
MTOE savings	1837	

TECHNOLOGY - 6

INSTALLATION OF ADVANCED PROCESS CONTROL SYSTEMS

Brief about Technology/Practice

To avoid the limitations of single loop design and to provide more flexible and sophisticated process operating logic than can be implemented by human operators, an approach called “*multivariable control*” is used. A multivariable control or APC, is one that has the built-in intelligence to look simultaneously at two or more process variables and to choose, in a given situation, the best of several programmed strategies (algorithms) for manipulating one or more control valves (or other final control elements). APC can be defined as “*Use of logic, predictive algorithms, thermodynamics, calculations, real-time control models and other control techniques to achieve economically related plant operating targets*”.

APC technology is to be used in conjunction with the existing DCS (Distributed control system) by allowing it to vary multiple parameters to achieve the desired outputs of increased productivity and enhanced energy efficiency.

In ITC PSPD, Bhadrachalam, after having successfully installed APC systems for their DCS of the pulp mill, the advanced process controllers have been given a go for the limekiln, Soda recovery boiler and the power block.

Lime Kiln

- Long dead time process can be effectively handled by model based Advanced Process Controller
- Multivariable control problems can be addressed
- Control is based on models which derived from actual plant test
- Have the advantage of predictability (Feed Forward)
- APC responds to disturbances in the plant and takes corrective action typically every minute around the clock

Soda Recovery Boiler

- APC addresses the multivariable control problem to maintain both air ratios and excess oxygen in flue gas
- APC takes corrective actions every 30 seconds for disturbances in the unit to maintain excess oxygen close to the minimum allowable limit

Power Block

- Any mismatch between supply and demand is taken care by changing load on CFB-6 & CFB-7 by APC.
- APC responds to supply/demand imbalance promptly and takes corrective action every 15 seconds round the clock.
- Optimization of TGs can be achieved by inbuilt LP technology in APC.
- Loading the most efficient TG to improve overall efficiency (Implementation going on)

Potential Fuel/Energy Savings:**Benefits of APC for Lime Kiln application:****Table 13: Benefits of APC Application for Lime Kiln**

Benefits of APC Application for Lime Kiln	
Oil per Ton of product APC Case (Liters)	131
Oil per Ton of product Base Case (Liters)	140
FO Reduction per Ton of Product (Liters)	9
Average Production Tons/Hr	6
Price of FO per KL Rs	20000
Saving per 8000 annual operating hours with 90% online Rs.	8640000

Savings of FO that can be achieved = 426 MTOE

Benefits of APC for Soda Recovery Boiler application:**Table 14: Benefits of APC Application for SRB-3**

Benefits of APC Application for SRB-3	
APC Case Steam per ton of Black Liquor solids	2.8
Base Case Steam per ton of Black Liquor Solids	2.7
Improvement in steam per ton of Black Liquor solids	0.06
Average Black Liquor firing, TPH	35.7
Average Solids in Black Liquor, %	78.2
Steam Production improvement, TPH	1.68
Price for Steam per ton, Rs	350
Saving per 8000 annual operating hours with 90% online Rs	4217280

Savings in fuel that can be achieved = 1106 MTOE (Assuming steam enthalpy of 767.32 kCal/kg and boiler efficiency of 80%)

Benefits of APC for Power block application:

Table 15: Benefits of APC for Power block application

Description	APC OFF	APC ON
Steam/MW	7.564	7.395
Difference	0.169	T/MW
Avg. Power demand	56	MW
Steam Saving/hr	9.464	TPH
Savings/annum	23849280	INR

Other Benefits

The advantages of implementing Advance process control techniques are manifold, few of which are as follows:

- The advance control techniques push the processes to their constraints and extract the maximum from the process unit without compromising on product quality and safety.
- The advanced control algorithm balances performance and robustness objectives against process economics to minimize costly process movement.
- Advanced control techniques allow tailoring of control performance to meet process needs.
- Advanced control algorithms provide optimum control performance for changes in both control targets and process disturbances.
- Advanced control implementation reduces stabilization time during furnish change, which in turn results in minimum off-quality product.
- The feed forward action of the advance control algorithms helps to save the plant from possible damage by adjusting the operating parameters before the disturbance actually reaches downstream.
- Advanced control algorithms allow applying dead time compensation techniques to compensate for long delays in process response, permitting tighter control.

Cost Benefits Analysis:

For a model plant of 200 TPD, the savings that can be achieved are **1947 MTOE**.

	Without PAT	With PAT benefit
Energy savings	Rs. 9.08 million	Rs. 9.08 million
MTOE equivalent	--	1947
PAT benefit	--	Rs. 19.76 million
Total benefit	Rs. 9.08 million	Rs. 28.84 million
Investment	Rs. 1.5 million	Rs. 1.5 million
Payback period	2 months	1 month
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	18403	

TECHNOLOGY - 7

FIRING OF BLACK LIQUOR AT HIGH CONCENTRATION

Background

Andhra Pradesh Paper Mills (APPM) has three chemical recovery boilers of 127 TPD, 270 TPD and 170 TPD black liquor solids firing capacity. These are designed for firing concentrated black liquor of 50% total solids from evaporation plant. The boilers are provided with direct contact evaporators to concentrate the liquor further to 65% and then fire in the boilers. This results in increased sulphur compounds emission into atmosphere. Also average steam generation was 2.6 T/ T of BL solids at 32 kg/cm² pressure and 420° C temperature. The boilers are provided with low efficiency ESPs with stack emission of around 100 mg/Nm³.

Brief about Technology/Practice:

Under a Mill Development Project (MDP), a high efficiency and low odor chemical recovery boiler was installed. The following are some of its features.

- Single drum boiler capable of firing black liquor at 75% solids concentration, which helps in improved running ability.
- Steam generation of 3.4 T/T of BL solids there by increase in self power generation.
- Steam generation at higher pressure of 64 kg/cm² and temperature of 460° C temperature also helps in increased power generation.
- No direct contact evaporator, which avoids sulphur compounds emission in to atmosphere.
- High efficiency ESPs with reduced stack emission of less than 50 mg/ Nm³ minimize air pollution.
- Chain less soot blowers are provided for improved operational convenience and reduced maintenance.
- HVLC NCG from black liquor tanks of pulp mill and evaporation plant are incinerated in Recovery Boiler for environment management.

Potential Fuel/Energy Savings

Increase of the firing BL concentration from 65% to 75% will reduce the amount of moisture vapourised in the combustion chamber. This results in additional heat availability for generating more steam. This is one of the factors that increase the steam generation from 2.6 tons/ton of BL fired to 3.4 tons/ton of BL fired.

Increasing the steam generation rate from 2.6 T/T to 3.4 T/T in 400 TPD plant (assuming 1100 TPD of solid fired, generation of 220 KWh/ton of steam and cost is Rs. 4/KWh) the savings will be 24224 MTOE & generation of revenue will be Rs.259 million

Revenue generation = $0.8 \text{ T/T} * 1100 \text{ T/D} * 330 \text{ days of operation} * 220 \text{ KWh/Ton} * \text{Rs. } 4/\text{KWh}$
= Rs.255.5 million for 400 TPD plant (Rs.127.7 million for 200 TPD plant)

MTOE calculation = $0.8 \text{ T/T} * 1100 \text{ T/D} * 330 \text{ days of operation} * 1000 \text{ Kgs/Ton} * 767.32$
= 22282.9 MTOE for 400 TPD plant (11141.4 MTOE for 200 TPD plant)

Cost Benefit Analysis

Savings in fuel that can be achieved for a model plant of 200 TPD are 11141.4 MTOE

	Without PAT	With PAT benefit
Energy savings	Rs. 127.7 million	Rs. 127.7 million
MTOE equivalent	--	11141.4
PAT benefit	--	Rs. 114.8 million
Total benefit	Rs. 127.7 million	Rs. 242.5 million
Investment	Rs. 311 million	Rs. 311 million
Payback period	29 months	15 months
Replication Potential		
Number of plants	40% of the plants	
MTOE savings	84247	

TECHNOLOGY - 8

INSTALLATION OF HIGH PRESSURE COGENERATION SYSTEMS

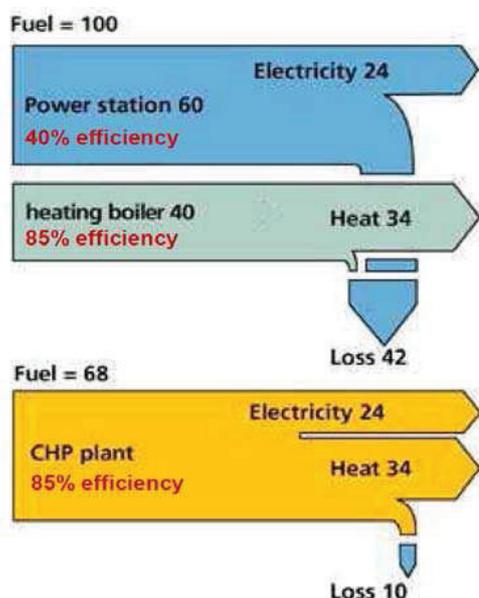
Background

Indian pulp and paper industry is the not the largest self-generator of electricity in the country but has installed capacity for power generation of over 1500 MW. The combination of significant and steady process steam demand, high on-site electricity demand, high annual operating hours, and on-site generated fuels (i.e., wood waste and black liquor) has made CHP an operationally and financially attractive option for many mills around the country.

Brief about Technology/Practice

Cogeneration or Combined Heat and Power (CHP) are defined as the sequential generation of two different forms of useful energy from a single primary energy source, typically mechanical energy and thermal energy. Mechanical energy may be used either to drive an alternator for producing electricity, or to rotate equipment such as compressor, pump or fan for delivering various services. Thermal energy can be used either for direct process applications or for indirectly producing steam, hot water, hot air for dryer or chilled water for process cooling.

Cogeneration provides a wide range of technologies for application in various domains of economic activities. The overall efficiency of energy use in cogeneration mode can be up to 85 per cent and above in some cases.



For example in the scheme shown in Figure 26, an industry requires 24 units of electrical energy and 34 units of heat energy. Through separate heat and power route the primary energy input in power plant will be 60 units ($24/0.40$). If a separate boiler is used for steam generation then the fuel input to boiler will be 40 units ($34/0.85$). If the plant had cogeneration then the fuel input will be only 68 units ($(24+34)/0.85$) to meet both electrical and thermal energy requirements. It can be observed that the losses, which were 42 units in the case of, separate heat and power has reduced to 10 units in cogeneration mode.

Figure 20: Cogeneration advantage

Despite the benefits of CHP systems and their widespread use in the Indian pulp and paper industry (large and some medium mills) much potential for CHP remains. The potential for improving cogeneration in the Indian pulp & paper mills lies in two compartments.

- I. Installation of CHP systems for the small and medium scale paper mills
- II. Increasing the pressure of steam generated (in the boilers) to 105 bar.

Many small and medium sized paper mills do not employ a cogeneration system because of the low power tariffs in their state coupled with high landed cost of fuel. This may make the installation of CHP uneconomical. With the onset of micro turbine technology (steam turbines with less than 1 MW capacity) small and medium paper plants and other process plants may find the CHP as a viable option.

Large size pulp and paper plants which already employ a Cogeneration plant has good potential to upgrade to a high pressure cogeneration system to increase the cogeneration cycle efficiency and thereby reduce the consumption of fossil fuels in the plants. Increasing the cogeneration pressure from 44 bar to 105 bar will increase power generation from the same quantity of fuel by about 20%.

Potential Fuel/Energy Savings

The potential savings in fuel consumption that are possible by installing a new power plant of 15 MW capacity in the cases of 44 bar and 105 bar of steam are given below (The efficiency of boiler in the new installation would be 84%).

Table 16: Comparison on potential fuel savings for installing a new power plant of 15 MW capacity

For a CPP without any extraction		
	44 bar and 400°C	105 ata and 510 °C
Enthalpy of steam at inlet to turbine (kCal/kg)	767.33	811.78
Enthalpy of steam at outlet from turbine (kCal/kg)	532.55	532.55
Difference in enthalpy (kCal/kg)	234.77	279.23
Power generation (kWh/ton of steam)	272.99	324.69
Steam required for 15 MW power generation (TPH)	54.9456	46.19
Feedwater enthalpy (kCal/kg)	100	100
Efficiency	0.8	0.84
Fuel consumption (MTOE / hr)	4.58	3.92
Fuel consumption (MTOE / year)	36300	31004

The savings in fuel consumption that can be achieved is about 14.5%.

Other Benefits

Along with the saving of fossil fuels, cogeneration also allows to reduce the emission of greenhouse gases (particularly CO₂ emission). The production of electricity being on-site, the burden on the utility network is reduced and the transmission line losses eliminated.

Cogeneration makes sense from both macro and micro perspectives. At the macro level, it allows a part of the financial burden of the national power utility to be shared by the private sector; in addition, indigenous energy sources are conserved. At the micro level, the overall energy bill of the users can be reduced, particularly when there is a simultaneous need for both power and heat at the site, and a rational energy tariff is practiced in the country.

The benefits of CHP are significant and well documented. Pulp and paper mills benefit from improved power quality and reliability; greater energy cost stability, and, possibly, increased revenues from the export of excess electrical power to the grid. CHP systems are significantly more efficient than standard power plants, because they take advantage of waste heat that is usually lost in central power generating systems and also reduce electricity transmission losses. Thus, society also benefits from CHP in the form of reduced grid demand, reduced air pollution, and reduced GHG emissions.

CHP systems in the pulp and paper industry are typically designed with a mill's thermal energy demand in mind, as well as the supply steam temperatures and pressures that are required by key mill processes. Thus, electrical power generation is a secondary benefit.

Many mills will import supplementary electricity from the grid as needed, but best practice mills may be able to meet all on-site electrical power demand through self generation. CHP systems can also be used to directly drive mechanical equipment such as pumps and air compressors.

Cost and extent of mitigation

Table 17: GHG Mitigation Potential & cost on GHG mitigation in Indian pulp & paper industry

GHG mitigation potential in the Indian pulp & paper industry implementing CHP / improved cogeneration systems	CO₂ Tons/yr	3.2 million
Cost of GHG mitigation	USD / Ton of CO₂	124

Cost Benefits Analysis

	Without PAT	With PAT benefits
Energy savings	Rs. 52.96 million	Rs. 52.9 million
MTOE equivalent	--	5296
PAT benefit	--	Rs. 53.7 million
Total benefit	Rs. 52.96 million	Rs. 106.7 million
Investment	Rs. 600 million	Rs. 600 million
Payback period	136 months	68 months
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	50058	

TECHNOLOGY - 9

INSTALLATION OF BACK PRESSURE TURBINE IN PLACE OF PRDS

Background

With the increased cost of coal & high Power Export potential available, Ballarpur Industries Limited, Bigwan (BILT) thought it fit to go in for circulating Fluidised Bed Combustion (CFBC) Boiler-first of its kind in pulp & paper mills in this sub-continent- with a matching 30 MW Extraction Condensing Steam Turbine (with steaming conditions of 175 TPH, 105 kscg, 510 °C) supplied and engineered by Alsthom.

Brief about Technology/Practice

Net Power generation for process use is derived from Power generated less Station Power consumption. Power in excess of demand is being exported at Rs. 4.25 /unit to State Electricity Board. BILT had given high importance to energy saving towards maximizing power for export.

Since the steam for Deaeration is at 3 bar pressure, BILT thought it fit to install a 500 kW back pressure turbine for dropping the exhaust steam pressure from 5.5 bar to 2.5 bar as required for deaerator.

Potential Fuel/Energy Savings

Additional power (though small) accrues. No moving parts of the unit. Investment of mini STG for a 250 TPD plant is about Rs. 6.8 million. About 0.2 MW of power can be additionally generated. Additional revenue due to annual power sale is about Rs.6.8 million.

Cost Benefits Analysis

Savings that can be achieved for a model plant of 200 TPD would be **348 MTOE**.

	Without PAT	With PAT benefits
Energy savings	Rs. 5.4 million	Rs. 5.4 million
MTOE equivalent	--	348
PAT benefit	--	Rs. 3.5 million
Total benefit	Rs. 5.4 million	Rs. 8.9 million
Investment	Rs. 5.4 million	Rs. 5.4 million
Payback period	12 months	7 months
Replication Potential		
Number of plants	60% of the plants	
MTOE savings	3289	

TECHNOLOGY - 10

OPTIMISING ENERGY CONSUMPTION IN PRESSURE SCREENS

Background

To remove impurities unbleached pulp is screened after washing in pulp mill. At SIL there were four centrifugal screens for the purpose to screen 80 TPD pulp. These screens were replaced by a single pressure screen to handle entire pulp for saving power as well as maintenance cost.

Brief about Technology/Practice

Out of the four centrifugal screens, one or the other screen was always under maintenance leaving only three screens available for operation. Also, as there were four screens requiring maintenance, the work load on the maintenance department was also heavy. It was decided to replace all the centrifugal screens by a single pressure screen of matching capacity. Centrifugal screens have 2 mm diameter hole for screening where as pressure screen has got 0.3 mm slot. Centrifugal screens consumed around 55 kW (100 Amps) and that in case of pressure screen was 39 kW (70 Amps).

Optimising energy consumption in a Pressure screen

Pressure screens are very important for cleaning purpose. Basically two types of pressure screens are available 1) Coarse and fine screen 2) Slotted and hole screen.

The important performance parameters affecting the pressure screens are 1) cleaning efficiency 2) accept ratio 3) power consumption. Many technological advances related to pressure screens had taken place in the recent past. It is difficult to define capacity due to the number of variables; as a result it is extremely difficult to normalize it so that different situations can be compared.

The important parameters affecting the capacity are fibre properties (species, cooking method, degree of fibrillation etc), consistency, rotor design and speed, screen cylinder design parameters, temperature and pH. Because of all these factors it is very difficult to compare the capacities.

The latest rotors developed by reputed manufacturers / gives excellent performance at reduced speed and power.

Performance comparison between some rotors (as an example):

Parallel Operation, Identical Equipment Except for Rotors

Table 18: Performance comparison between some rotors

	Rotor 1	Rotor 2	Latest rotor
Accept Flow (m ³ /h)	570	570	685
Differential Pressure (kPa)	-1.4	0.0	-35.0
Motor Load (%)	75	53	50
Specific Energy Consumption (kW - h/ADt)	7.4	5.2	4.1

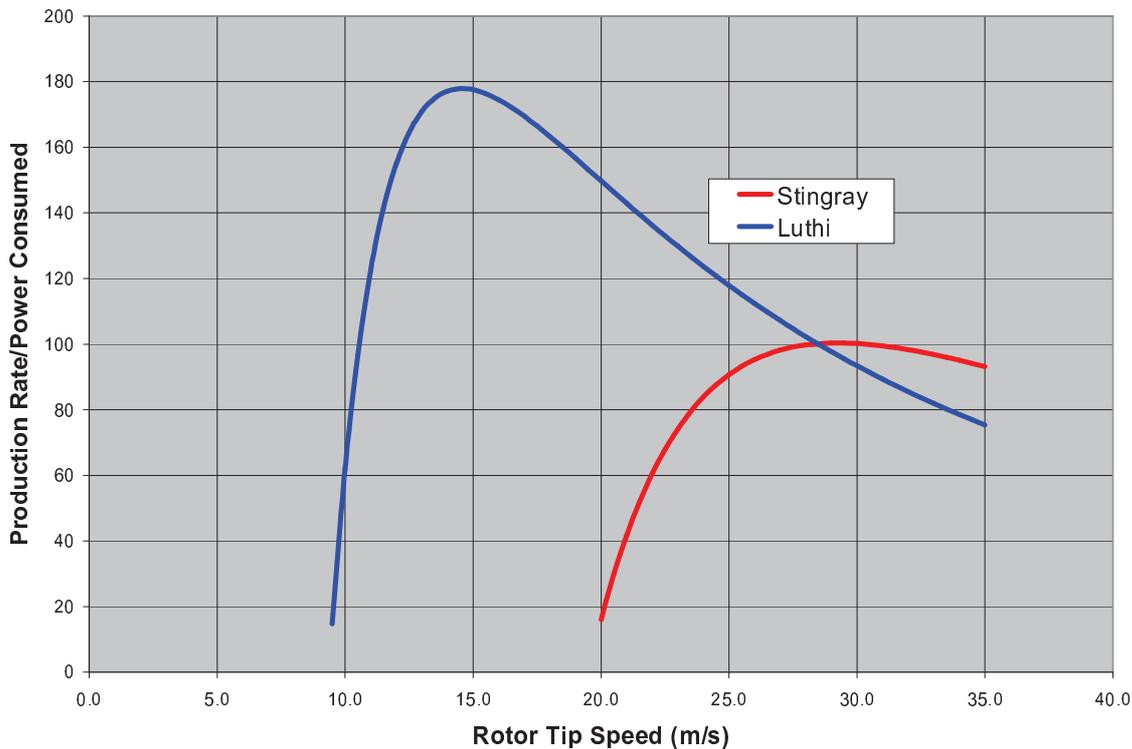


Figure 21: Capacity/Power consumed Vs. Rotor speed (m/s)

CII recommends to monitor the specific power consumption of the screens and reduce the energy consumption to around 5 kWhr/ton of accept pulp (BD basis) by replacing the rotor with a modern rotor from any reputed supplier. The choice of the new rotor should be based on the net specific energy consumption projected / guaranteed by the supplier.

While conduction PAT baseline study at a mill, the following screen was found to offer good potential for energy saving.

- Screen Type : Slot Screen (Screen – 1 aka CO-8)
- Motor rating : 250 kW
- Actual power ~ 132 kW (215 Amps)
- Throughput : 18.8 kWhr/BDMt
- Can be reduced to 5 kWh/BDMt
 - Replace the screen with energy efficient screen
 - Potential to save around 95 kW

Potential Fuel/Energy Savings (if Implemented):

- Power consumption had reduced by about 16 kW (30 Amps) by replacing centrifugal screens with pressure screens. Energy saving is equivalent to 35 MTOE.
- Power consumption reduction in a pressure screen by changing the rotor with an energy efficient rotor can be about 95 kW for a 150 TPD paper machine. Energy saving is equivalent to 210 MTOE.

Other Benefits

As the screening is done with 0.3 mm slot in the pressure screen, quality of screened pulp will also improve as compared to that from centrifugal screen.

Cost Benefits Analysis

Savings that can be achieved for a model plant of 200 TPD would be **280 MTOE**.

	Without PAT	With PAT benefit
Energy savings	Rs. 3.0 million	Rs. 3.0 million
MTOE equivalent	--	280
PAT benefit	--	Rs. 2.8 million
Total benefit	Rs. 3.0 million	Rs. 5.8 million
Investment	Rs. 5 million	Rs. 5 million
Payback period	20 months	10 months
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	2646	

TECHNOLOGY - 11

ULTRA-LOW INTENSITY REFINING

Background

The refining of pulp prior to making paper is one of the most important steps in the papermaking process. Refining involves imparting mechanical action to pulp fibers in order to alter their cell wall structure. With optimized refining, high quality products can be produced using less expensive fiber while reducing both chemical and energy usage. The importance of proper refining is now greater than ever due to the increased use of recycled fibers, faster paper machine speeds, increased demands from customers, and a focus at all mills to reduce their manufacturing costs.

It was found during the baseline energy audit in Star Paper Mills that the power consumption stock preparation plant is significant and the major consumer is the refiner section. It was found that two refiners were operating of 750 kW and the specific edge loading (SEL) was found to be around 0.55 Ws/m.

Brief about Technology/Practice

For refining of hard wood fibre, it is advisable to have the SEL between 0.2 – 0.88 Ws/m. Though the plant Star Paper Mills Limited has been operating in this range, moving closer to 0.2 Ws/m is desirable with significant benefits. These benefits include better strength and porosity development, improved refining efficiency, and greater shive reduction. To achieve low intensity refining in an efficient manner requires refiner plates with narrow bar-groove patterns.

All short fibered pulps benefit from very low intensity refining, for both improved quality and energy efficiency.

The ability to achieve these benefits with fine bar-groove patterns can be explained by the following mechanism. With a greater number of bar edge crossing points, there is a greater chance of capturing short fiber material on the bar edges and treating it in the refining zone. This results in a thicker fiber mat between the plates (more fiber-to-fiber interaction) and a greater number of fibers being treated. Each impact on the fibers is gentler as the applied power is distributed over a high number of bar edges. The gentle refining action increases the specific surface area of the fibers by fibrillating their outer surface, leading to greater strength development. In the case of hardwood chemical pulps, this also leads to a faster change in drainage (freeness, °SR) for a given amount of applied energy. Fiber length is preserved, and fiber collapse is minimized so as to lessen the amount of bulk loss with refining.

Low intensity refining also contributes to longer plate life as each bar is subjected to lower refining forces, thereby reducing its wear rate. There is also a better fiber mat formation in the refining zone, a wider gap between the rotor and stator refiner plates, and less plate-to-plate contact.

Potential Fuel/Energy Savings

A 220 TPD fibre based integrated pulp & paper mill would typically have the following benefits;

Present SEC	=	60 kWhr/ton
SEL ¹⁷	=	1.2 Ws/m
Freeness rise	=	16 → 27° SR ¹⁸
Total pulp production	>	220 TPD
Power saving	=	10% x 60 kWhr/ton x 220 TPD x 330
day/yr x Rs. 5.50 /kWhr	=	Rs. 2.39 million
Investment (for fine bar tackles)	=	Rs. 1.5 million
Saving that can be achieved by implementation	=	118 MTOE

Other Benefits

Some of the most significant benefits achieved through low intensity refining have been:

- Improved tensile strength and porosity at a given bulk or drainage
- Increase bulk at smoothness or drainage
- Improved pick resistance of hardwood vessel segments
- Reduced energy requirements to achieve target specifications for hardwood pulps
- Greater shive reduction at a given drainage for mechanical pulps

Subsequent manufacturing cost reductions can result from improved filler retention, increased filler usage, increased machine speed and reduced basis weight, as well as reduced off-spec product and fewer customer complaints.

Cost Benefits Analysis

Savings that can be achieved for a model plant of 200 TPD would be **107 MTOE**.

	Without PAT	With PAT benefits
Energy savings	Rs 2.2 million	Rs. 2.2 million
PAT benefit	--	Rs. 1.0 million
Total benefit	Rs. 2.2 million	Rs. 3.2 million
Investment	Rs. 1.4 million	Rs. 1.4 million
Payback period	8 months	5 months
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	1011	

¹⁷ Specific edge load

¹⁸ Schopper Reigler

TECHNOLOGY - 12

INSTALLATION OF HEAT PUMP/ CHILLER HEAT PUMP

Background

In a 200 TPD integrated paper mill about 42 TPH of DM water at 60°C is sent to the deaerator where in the temperature of around 130°C and a pressure of 2.5 bar is maintained. For the heating of DM water from 45°C to 95°C in the deaerator LP Steam quantity of 4.8 TPH is used.

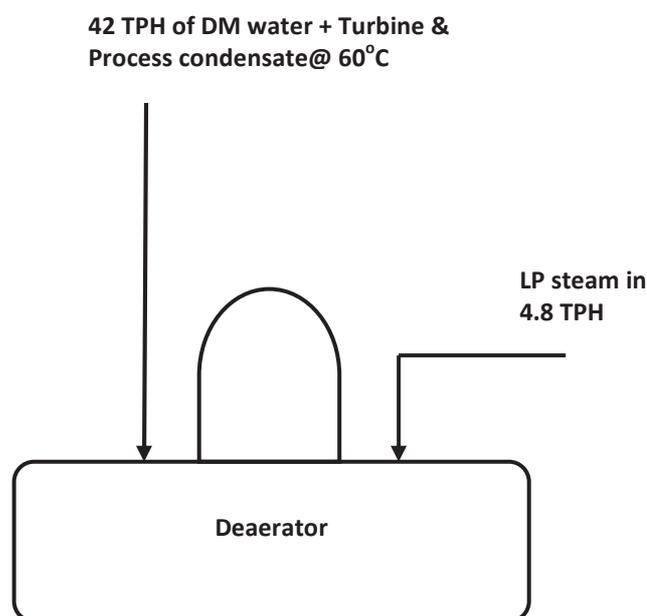


Figure 22: Deaerator flow diagram

Brief about Technology/Practice

Heat pumps drive heat from a lower temperature to medium temperature, using high grade energy (electricity, fuel, or high-temperature waste heat). Thus heat pumps can transfer heat from natural heat sources in the surroundings, such as the air, ground or water, or from man-made heat sources such as industrial or domestic waste, to a building or an industrial application.

Heat pumps can also be used for cooling. Heat is then transferred in the opposite direction, from the application that is cooled, to surroundings at a higher temperature. Sometimes the excess heat from cooling is used to meet a simultaneous heat demand.

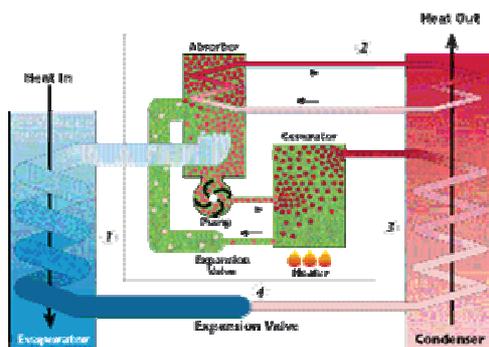
In order to transport heat from a heat source to a heat sink, external energy is needed to drive the heat pump. Theoretically, the total heat delivered by the heat pump is equal to the heat extracted from the heat source, plus the amount of drive energy supplied.

Absorption heat pumps are thermally driven, which means that heat rather than mechanical energy is supplied to drive the cycle. Absorption heat pumps for space conditioning are often gas-fired, while industrial installations are usually driven by high-pressure steam or waste heat.

Absorption systems utilise the ability of liquids or salts to absorb the vapour of the working fluid. The most common working pairs for absorption systems are:

- Water (working fluid) and lithium bromide (absorbent); and
- Ammonia (working fluid) and water (absorbent).

In absorption systems, compression of the working fluid is achieved thermally in a solution circuit which consists of an absorber, a solution pump, a generator and an expansion valve as shown in the figure below. Low-pressure vapour from the evaporator is absorbed in the absorber. This process generates heat. The solution is pumped to high pressure and then enters the generator, where the working fluid is boiled off with an external heat supply at a high temperature. The working fluid (vapour) is condensed in the condenser while the absorbent is returned to the absorber via the expansion valve.



Heat is extracted from the heat source in the evaporator. Useful heat is given off at medium temperature in the condenser and in the absorber. In the generator high-temperature heat is supplied to the process. A small amount of electricity may be needed to operate the solution pump.

Figure 23: Adsorption system

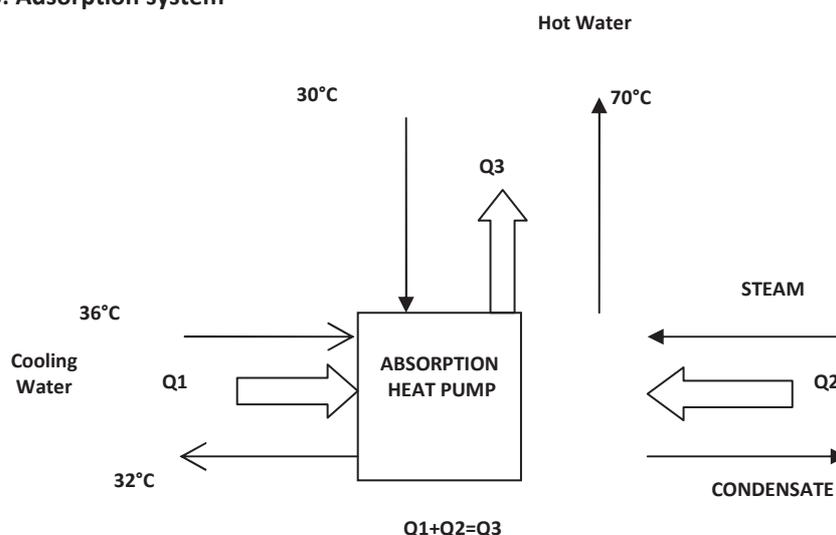


Figure 24: Adsorption heat pump flow diagram

For example, in the above diagram, heat from cooling water (Q1) and steam (Q2) is taken by the absorption heat pump to supply hot water (Q3=Q1+Q2) to the required equipment.

Potential Fuel/Energy Savings (if Implemented)

For the heating portion in the deaerator, there is a potential to save energy by installing a chiller heat pump and reducing steam consumption by taking in heat from a low grade heat source (as explained above in case of a vapor absorption heat pump). This low grade heat source can be return chilled water releasing heat from a temperature of 14°C to attain 10°C.

By installing a chiller heat pump for this application can reduce the steam consumption in by 0.8 TPH.

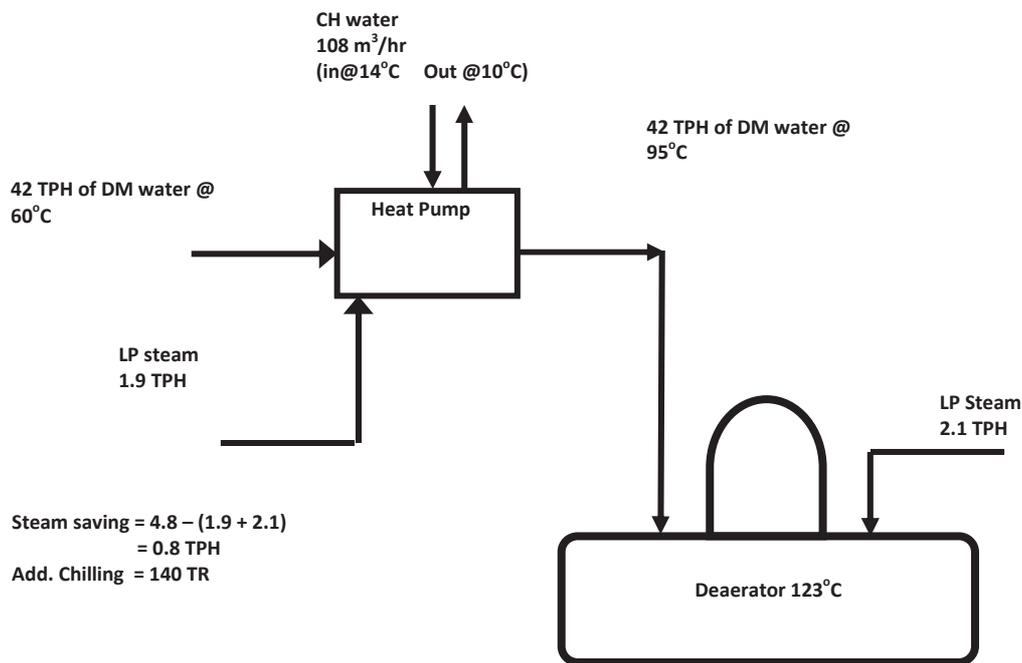


Figure 25: Deaerator flow diagram

It was observed that similar potential exists for other two deaerators. The estimated LP steam saving for boiler CF6 is around 2 TPH and for boiler CF 1-5 is around 1.5 TPH.

Annual savings (only steam saving)	=	(0.8 TPH x Rs. 800 /ton) x 8000 hr/yr
	=	Rs. 5.1 million
Investment	=	Rs. 15.0 million

Other benefits

The overall annual saving is around 5.1 million and the investment is around 7.0 million with a payback period of 17 months.

Additionally benefits like generation of chilling effect equivalent to 140 TR are possible.

Saving that can be achieved by installing chiller heat pump = 265 MTOE (Considering saving of HP steam consumption as 50% of saving of LP steam consumption in a cogeneration system and

steam enthalpy as 767.32 kCal/kg and boiler efficiency as 80%). The investment required to install a chiller heat pump would be Rs. 7.0 million.

Cost Benefits Analysis

For a model plant of 200 TPD, the savings would be **265 MTOE**.

	Without PAT	With PAT benefits
Energy savings	Rs. 5.1 million	Rs. 5.1 million
MTOE equivalent		265
PAT benefit	--	Rs. 2.7 million
Total benefit	Rs. 5.1 million	Rs. 7.8 million
Investment	Rs. 15 million	Rs. 15 million
Payback period	36 months	23 months
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	3005	

TECHNOLOGY - 13

OPTIMISING BLOW-THROUGH STEAM CONSUMPTION

Background

In a paper mill of 450 TPD capacity, the paper machine dryer the incoming steam turns partly to condensate. The differential pressure over the dryer is the main figure in the system design. This must be maintained to evacuate the condensate in a proper manner and amount. The condensate rate must be in balance with the amount of the “blow-through” steam flow. The “blow through” steam is normally used in the cylinders of lower temperature.

Brief about Technology/Practice

Excess flow of blow through steam will lead to heat loss through the heat exchanger. Some of the paper machines have cascade system installed for the steam and condensate. During operation of the cascade system it has to be ensured that all the flash steam generated in the condensate flash vessel has to be routed to another dryer group.

Field observations revealed that some of the valves leading the flash vapours to the heat exchanger were partially open (as shown in the figure). This creates loss of steam in the system and there by increases the steam consumption in the paper machine.

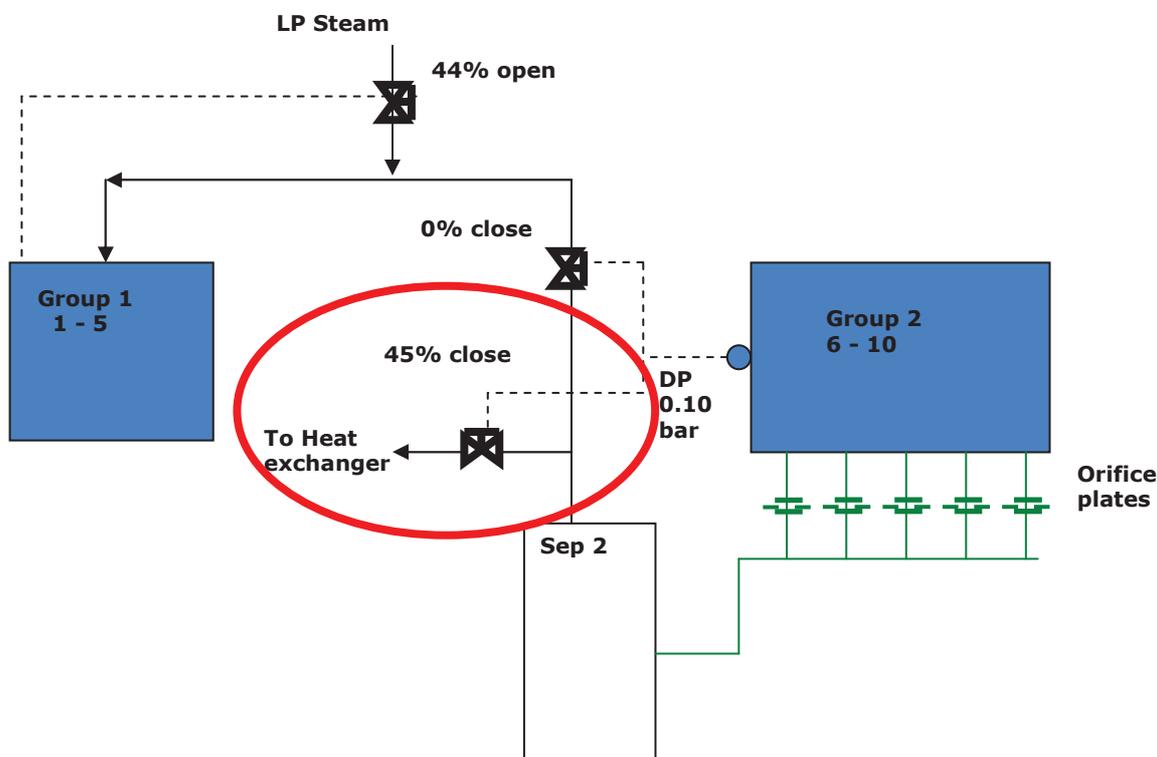


Figure 26: Valves leading the flash vapours

True picture of Paper machine dryer performance can be assessed by calculating the value of steam consumption per ton of paper produced (machine production). The following table summarizes the dryer performances of the six paper machines installed at a 450 TPD wood based integrated paper mill.

Table 19: Dryer performances of the six paper machines installed at a 450 TPD wood based integrated paper mill

PM	after press dryness	pope reel moisture	Water Evaporation/ton of paper	Steam /ton of paper	Steam / water evap
1	31.50%	4.50%	2.13	2.76	1.30
2	36.50%	4.50%	1.69	2.30	1.36
3	45.50%	4.50%	1.15	2.60	2.26
4	23.50%	4.50%	3.21		
5	41.50%	4.50%	1.36	1.77	1.30
6	42.50%	4.50%	1.31	2.38	1.82

The norm for steam consumption is 1.3 Tons/ton of water evaporated. From the above table, we can infer that at the plant there is a good potential to reduce the steam consumption in the paper machines by ensuring that the flash vapours are not led to the heat exchanger.

To optimise the steam consumption in a cascade system the following can be done

- Installation of spoiler bars, stationery siphons and providing adequate insulation for the hot exposed surfaces including the sides of the dryer cylinders
- Convert from open hood / semi-open hood dryer systems to closed hoods with proper pocket ventilation system. This helps the paper machine operating team to balance between productivity and energy efficiency.
- Installation of cascade / thermo compressor based systems for the steam and condensate system in the dryer section to lower the steam consumption in the paper machine.
- Balance the drying load on different cylinders of the dryer system.
- Correctly size the orifices installed on the condensate lines between the dryer cylinder and the flash vessel. (In other words one may alter the resistance offered by the condensate to flow down from the dryer cylinder to the condensate collection / flash tank. The aim is to enable optimum condensate flow at lower Dp (differential pressure) set points and minimize blow-through steam consumption.
- Detailed dryer performance study will throw light on how to lower the steam consumption below the norm of 1.3 Tons steam / Ton_{water evaporated}.

- Install dryer management software to dynamically adjust the dryer parameters for optimum performance.

Potential Fuel/Energy Savings (if Implemented):

For a model 200 TPD paper machine with present steam consumption of 1.5 T/T_{w_{ev}}, a reduction of 0.2 T/T_{w_{ev}} will result in savings of about 23760 Tons/Annum of steam.

(Assuming 1.8 Ton_{w_{ev}}/Ton of paper and considering saving of HP steam consumption as 50% of saving of LP steam consumption in a cogeneration system and steam enthalpy as 767.32 kCal/kg and boiler efficiency as 80%).

Cost Benefits Analysis

The savings for a 200 TPD model plant savings would be **991 MTOE**.

	Without PAT	With PAT benefits
Energy savings	Rs. 7.1 million	Rs. 7.1 million
MTOE equivalent	--	991
PAT benefit	--	Rs. 10.0 million
Total benefit	Rs. 7.1 million	Rs. 17.1 million
Investment	Rs. 21 million	Rs. 21 million
Replication Potential		
Number of plants	50% of the plants	
MTOE savings	11240	

TECHNOLOGY - 14

REPLACE VACUUM PUMPS WITH VACCUM BLOWERS

Background

Vacuum pumps are used to maintain vacuum at various sections of Paper Machine to remove water by the flow of air. Vacuum pumps consume significant amount of power for their operation in a paper machine. Latest trend is to replace vacuum pumps with vacuum blowers. The efficiency of vacuum pumps is around 40% where as that of vacuum blowers is around 60%. The replacement with vacuum blowers will reduce the energy consumption by about 40%.

Brief about Technology/Practice

In the paper machine section, Ball had installed a large 1500 kW Turbo-air (vacuum) blower, instead of opting for conventional Vacuum Pump. The Turbo-Air Blower unit had been procured from Mantel-Voith, Germany.

Potential Fuel/Energy Savings

Savings in valuable Electrical Power.

Other Benefits

- Single unit instead of Battery of units.
- Minimal Maintenance Problems & Reduced downtime & hence High availability.

Ballarpur Industries Limited, Bigwan procured the blower together with the paper machine in its entirety and thus the investment required only for the vacuum blower was not available. Estimated investment for a new installation is Rs. 12.6 million.

Cost Benefits Analysis

For a Paper Machine of 70 TPD, the power consumption of vacuum pumps (7 numbers) is around 627 kW. Approximate cost of installing vacuum blowers would be Rs. 12.6 million

Considering, vacuum pumps power consumption for a model plant of 200 TPD capacity as 1.4 MW, power cost as Rs. 3.5 per kWh and the approximate savings that can be achieved by replacing vacuum pumps with vacuum blowers as about 40%, the savings for a 200 TPD model plant would be **1218 MTOE**.

	Without PAT	With PAT benefits
Energy savings	Rs. 15.7 million	Rs. 15.7 million
MTOE equivalent	--	1218
PAT benefit	--	Rs. 12.4 million
Total benefit	Rs. 15.7 million	Rs. 28.1 million
Investment	Rs. 12.6 million	Rs. 12.6 million
Replication Potential		
Number of plants	60% of the plants	
MTOE savings	13815	

TECHNOLOGY - 15

BIO-METHANATION FROM WASTE WATER DISCHARGE OF AGRO BASED PULP MILL

Background

Bagasse and wheat straw are the main sources of fibre based on agro feed stock. Bagasse contains some residual sugar which increases the BOD (Biological Oxygen demand) of the wash water. These residual sugars and other biodegradable material can be used as a nutrient source for a particular type of microbes which release methane gas as part of their metabolic activity. Wheat straw wash water is easily bio degradable. It produces methane gas when treated an-aerobically.

Methane gas, having high calorific value, can be used as fuel in the boiler to produce steam and thus power from steam. Thus, saving fuel used for making steam as well as power.

Brief about Technology/Practice

Prior to pulping, wheat straw is washed to remove chlorides and other impurities which hinder the working of Fluidized Bed reactor for chemical recovery based on Copeland process. The wash water contains high COD and hence, it was treated in anaerobic lagoon before being mixed with the combined mill's effluent for treatment in ETP working on activated sludge process. The methane gas generated during anaerobic treatment was wasted as there was no recovery from lagoon. Thus, not only energy was wasted through lagoon but methane gas released in to atmosphere creates GHG effect. Hence, it was decided to treat this effluent into UASB reactor and recover methane to burn in to Rice husk fired boiler for generating steam and power. Methane gas substitutes Rice husk partially in the boiler.

UASB system

Wash water is treated on filter to remove floating material. The suspended solids in filtrate are allowed to settle in clarifier before being taken to buffer tank. In buffer tank lime is added to maintain pH and buffer stock is kept to feed reactor even in the case of disrupted effluent supply. From buffer tank effluent is fed to UASB reactor, where the effluent comes into contact with sludge bed maintained in the Reactor. The anaerobically treated effluent is mixed with mill's combined effluent for further treatment.

Potential Fuel/Energy Savings

Table 20: Biogas Potential

Biogas Potential / Ton of Washed Bagasse at TNPL	
COD potential/T of Bagasse	25 kg
Gas generation potential per kg CODr (@ 85% COD redn.)	10.6 m ³
Furnace oil equivalent	6.4 L
Revenue equivalent to F. oil	Rs. 12.7 million

Plant design data (TNPL)

COD Load	:	57.6 T/Day
Hydraulic Retention Time	:	20 hrs
Reactor Volume	:	2 X 5,000 m ³
Volumetric Loading Rate	:	6.0 kg COD/m ³ /Day
COD Reduction	:	85%
Gas Production Factor	:	0.47 M ³ /kg CODr
Gas Production	:	23,000 m ³ /Day
Flow	:	12,000 m ³ /Day
Retention time	:	20 hrs

Considering 800 TPD waste bagasse is required for a 200 TPD plant, the amount of furnace oil saving for a 700 TPD plant is about 5499.65 TPA which is equivalent to savings of 5527 MTOE.

Other Benefits

The system helps in three fold

- It helps in maintaining clean environment by reducing pollution load viz. C.O.D and by restricting release of methane gas in to atmosphere, thereby reducing Green House Gas effect.
- It helps in co-generation of power and steam for use in the paper mill and substituting Rice husk partially thereby adding to the economy.
- It helps in the economics of the company by carbon trading under CDM projects.

Environmental Benefits from Aug. 03 to Dec. 06

COD Reduced: 34,580 Tons

GHG Reduced: 1.20 million Tons of CO₂ equivalent

Economical Benefits from Aug. 03 to Dec. 06

Biogas generated: 15.65 million m³

Furnace oil saving: 9320 tons

SIL

The total cost of procurement and installation of UASB reactor system at SIL was Rs. 23.5 million. The net annual energy saved based on the methane generation is about Rs. 4.0 million

TNPL

The total cost of equipment and installation of UASB reactor system at TNPL was Rs. 44.0 million. The net annual energy saved based on the methane generation offsetting the furnace oil consumption is about Rs. 53.0 million.

Cost Benefits Analysis

For a model plant of 200 TPD, the savings that can be achieved would be **1579 MTOE**.

	Without PAT	With PAT benefits
Energy savings	Rs. 47.1 million	Rs. 47.1 million
MTOE equivalent	--	1579
PAT benefit	--	Rs. 16.0 million
Total benefit	Rs. 47.1 million	Rs. 63.1 million
Investment	Rs. 12.6 million	Rs. 12.6 million
Payback period	3.2 sonths	2.4 months
Replication Potential		
Number of plants	60% of the plants	
MTOE savings	14924	

5.0 FUTURE ENERGY SAVING OPPORTUNITIES

TECHNOLOGY - 1

BLACK LIQUOR GASIFICATION

Background

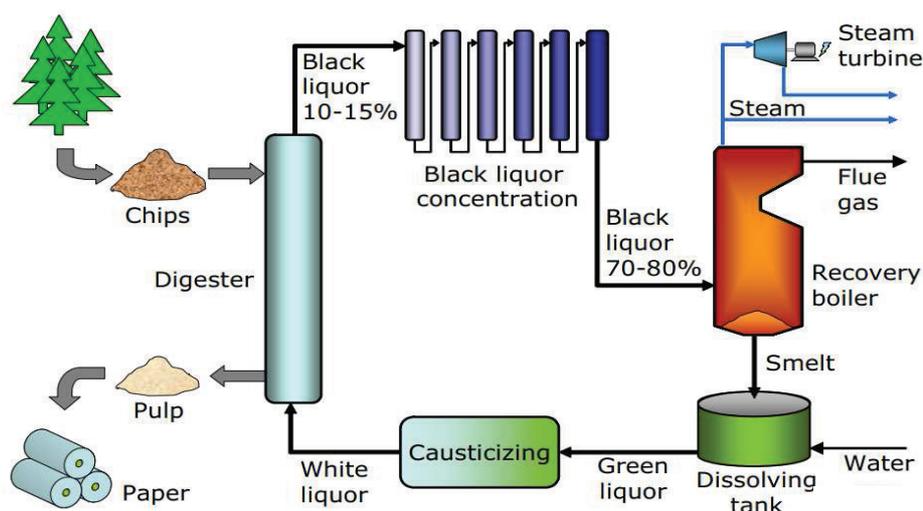
Black liquor, also called spent pulping liquor, is the dark, lignin-rich solution remaining from Lignocellulosic biomass, after the cellulose fibers for making paper have been extracted through chemical means.

Black liquor is associated with the following process liquors.

- Kraft (sulfate pulping) black liquor
- Sulfite pulping spent liquor
- Semi-chemical soda pulping spent liquor

Process description

At most chemical pulp mills today, the black liquor is concentrated to a solution of about 80% solids, and then burned in Tomlinson recovery boilers. Steam from the Tomlinson boiler, together with steam from the hog fuel boilers, provides steam needed to run the pulp mill. The steam may be expanded through a steam turbine before being used at the mill, resulting in some electricity generation. In addition to energy generation, a critical task of the Tomlinson boiler is to begin the process of recovering the pulping chemicals for re-use in pulp production. The in-organic fraction of the black liquor leaves a Tomlinson reactor a molten smelt that can represent an explosion hazard on contact with water.



5

Figure 27: Process Description

Black Liquor gasification is an emerging commercial technology with a long R&D history. This technology removes the biomass materials from black liquor by gasifying them in a high temperature chamber. The gasification process converts the complex hydrocarbon mixture into simpler gaseous molecules, primarily hydrogen, carbon monoxide, carbon dioxide, and methane. The inorganic pulping chemicals in the black liquor are recovered for re-use in pulping, however, gasification modifies the composition if sulfur is present.

The gasification products cannot be readily stored, so the gasification process must be integrated with other conversion processes to utilize the output. Upon generation, the product gases are cleaned of impurities for use as chemical feedstocks, to fuel the gasification process after start up, or in applications such as fuel cells and gas combustion turbines. Turbines are able to generate electricity as well as provide heat used in boilers to generate steam.

Black liquor gasification may either augment or replace the Tomlinson recovery system. Commercialization has been reached for process designs that operate at low temperature (~600°C) and high temperature (950-1000°C).

A low-temperature, near-atmospheric-pressure black liquor gasification process has been commercialized by ThermoChem Recovery International (TRI), an American company. The design utilizes indirect -heating of the black liquor via pulse - combustor heat exchange tubes immersed in a fluidized bed. Steam is used to fluidize the bed in which the black liquor is gasified. The raw gas produced with this steam reformer design is rich in hydrogen gas. With the moderate temperature maintained in the reactor (~600°C), the condensed-phase material leaves as a dry solid rather than as a smelt, eliminating the smelt - water explosion hazard ^[1].

A high-temperature gasification process is under development and commercialization by Chemrec AB, a Swedish company. Similar to an entrained -flow coal gasifier, the Chemrec design operates under elevated pressure at a high operating temperature (950-1000°C). Since the original Chemrec gasification invention was patented in 1987, Chemrec has pioneered several high temperature gasification system designs, experimenting with atmospheric air, pressurized air, and pressurized oxygen used to partially oxidize the black liquor. The inorganic material in the black liquor leaves the reactor as a liquid smelt, however, the gasification process and quench system eliminate the smelt-water explosion hazard.

Chemrec is pursuing black liquor gasification commercialization along two lines:

- The Chemrec Booster System for increasing black liquor recovery capacity and flexibility in chemical recovery. This system is now commercially offered. The technology involves air-blown gasification of the black liquor near atmospheric pressure, operating in parallel with existing Tomlinson recovery boilers.
- The Chemrec Black Liquor Gasification Combined Cycle System (BLGCC) for full replacement of old recovery boilers, doubling of bio based electricity production, and 5% increase in pulping capacity. This system has been in the development plant phase since 1994, advancing from pressured air to pressurized oxygen designs.

Energy Required

Black liquor gasification combined with gas turbine electric generation can produce enough electricity to make the pulping industry a net exporter of electric power. A detailed study [1] showed that a reference mill using a Tomlinson system would need to import 36 MWe to meet its on site electricity needs to process 1,580 dry short tons of unbleached pulp per day – about 1/3 of the total process electricity demand. In contrast, the mill-scale black liquor gasification systems would have available for export 15 to 22 MWe.

In the Indian scenario, a 200 TPD kraft pulp mill using a Tomlinson system would need to import 5.0 MWe to meet its onsite electricity needs to process 200 Tonnes of unbleached pulp per day. While, the mill-scale black liquor gasification systems would have available for export 2 to 3 MWe.

Major Equipment

Major equipment for the ThermoChem system includes the gasification vessel, a venturi scrubber for gas cleanup and cooling, a mix tank for solids recovery, sulfur recovery system, a gas turbine for power generation, and a heat recovery steam generator.

Major equipment for the Chemrec Booster includes the gasification and quench chamber, a venturi scrubber and spray cooler for particulate removal and gas cooling, and sulfur recovery system. The Chemrec BLGCC system includes an air separation unit, the gasification chamber and quench, a condenser for gas cooling, gas clean up and sulfur removal units, a gas turbine for power generation, and a heat recovery steam generator.

Commercialization Status

Commercially available, research is on going. ThermoChem has two commercial scale plants installed:

- 1) Norampac project, Trenton, Ontario, Canada; this 115 tons per day black liquor solids project began commissioning in July of 2003 and ran at essentially 100 percent availability during the fourth quarter 2003;



Figure 28: Normapac Steam reformer

- 2) Georgia- Pacific, Big Island VA; this 200 tons per day non-sulfur black liquor solids project achieved mechanical completion in December 2003 and is currently in commissioning and start-up.

Chemrec operated 2 pilot plants for the Booster System from 1987 through 1996. Chemrec installed the first generation commercial Booster plant to augment the chemical recovery capacity provided by the existing Tomlinson boiler, 300 ton solids per day, at Weyerhaeuser, New Bern, NC. The gasifier operated from 1996 to 2000 before being shut down to repair stress cracking in the pressure vessel. The plant was re-engineered and rebuilt to the second generation commercial Booster plant, and restarted operation in June 2003.

Chemrec operated a pilot plant for the BLGCC System from 1994 through 2000 at Stora Enso, Skoghall, Sweden. Chemrec has a 20 ton solids per day pilot BLGCC plant under construction in 2004 at Kappa Kraftliner, Piteå, Sweden.



Figure 29: Chermac DP 1 Pilot Plant

Chermac DP 1 Pilot Plant

Capital and Operating Cost

Conventional Tomlinson recovery boilers and gasification alternatives are major capital investments. A detailed engineering case study evaluated the economics of kraft black liquor gasification and power generation relative to a new Tomlinson recovery system base case. The study analyzed projected mature ThermoChem and Chemrec gasification technology to process kraft black liquor and generate power through combining with a gas turbine producing electricity for a hypothetical mill producing 200 tons of unbleached pulp per day. The Tomlinson base case had a total installed cost of about Rs. 900 million, versus Rs. 1670 million for the ThermoChem system, and Rs. 1380 million and Rs. 1720 million for Chemrec options. The ThermoChem and Chemrec options provided annual internal rates of up to 20% per year without subsidy for renewable electric energy production. The total installed cost for the ThermoChem Norampac project (Trenton, Ontario mill) processing 115 ton per day of black liquor solids is Rs. 1222 million.

TECHNOLOGY - 2

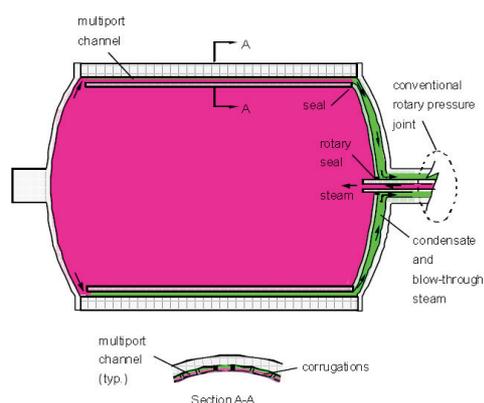
INSTALLATION OF MULTI-PORT DRYERS TO REDUCE STEAM CONSUMPTION IN PAPER MACHINES

Brief about the of best practice / technology

A great impediment to heat transfer in a drum (cylinder) dryer is the layer of liquid water that forms on the inside surface of the cylinder as moisture is removed from the paper that is passing over the outside surface of the drum. Siphons have long been used to remove this condensate from the inside of the dryers, and recent designs reduce the thickness of the condensate layer. Spoiler bars, too, are aimed at reducing the thermal resistance of the condensate layer, and they have shown some success in this regard. The Multiport dryer concept has the potential to significantly improve the existing situation with siphons and spoiler bars. Increased thermal efficiency can reduce the number of dryer units in a plant, or it can allow increased paper output. In either case, the result can be substantial cost savings for the papermaking process.

The Multiport cylinder dryer concept, illustrated in Figure 24, offers a radically new approach to increasing paper drying rates. This design minimizes the insulating rim of condensate by channeling the dryer steam through small longitudinal ports aligned at the cylinder's surface. The steam velocity is increased in the small ports compared to the full inside cross-sectional flow area in a conventional dryer.

In addition, the condensate layer is predicted to be of the order of one tenth that of conventional dryers. These two effects of increased convection heat transfer, with increased steam velocity and reduced condensate layer thickness, contribute to the reduced thermal resistance found in Multiport dryers.



The results of the ANL experiments showed that the heat transfer coefficient for the proposed Multiport dryer is approximately 15 times higher than that of a conventional dryer without spoiler bars and over six times higher than that of a conventional drum dryer with spoiler bars. (See figure 30.) Translating those results into thermal efficiencies, the Multiport dryer is 90% more efficient than conventional drum dryers without spoiler bars and 20% more efficient than conventional drum dryers with spoiler bars.

Figure 30: Schematic diagram of Multiport dryer

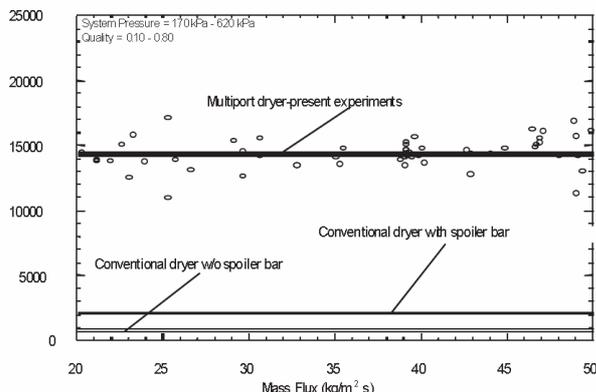


Figure 31: Multiport dryer present experiments

In contrast to conventional dryers, the steam in the multiport cylindrical dryer flows through longitudinally oriented passages, or “ports,” near the dryer’s inner surface. Forcing the steam closer to the cylinder surface minimizes the condensate layer (by up to 90%), which improves heat transfer, increases the dryer shell’s surface temperature, and provides a more uniform surface temperature. Also, since the steam flow velocity is very high in the small ports, the dominant heat transfer mode in the new

multiport dryer design is convection, which is markedly more effective than conduction, the dominant heat transfer mode in conventional dryers. All of this makes each dryer more effective in evaporating water.

Potential fuel / energy savings for the model plant (also in terms of MTOE)

The multiport dryers can increase paper production rates by 50% relative to conventional dryers and by 20% relative to dryers fitted with “spoiler bars.” This means that the multiport dryer technology offers paper manufacturers a range of advantages:

- Reduce the number of dryers,
- Increase the production rate, or
- Reduce energy costs through reduced steam pressure.

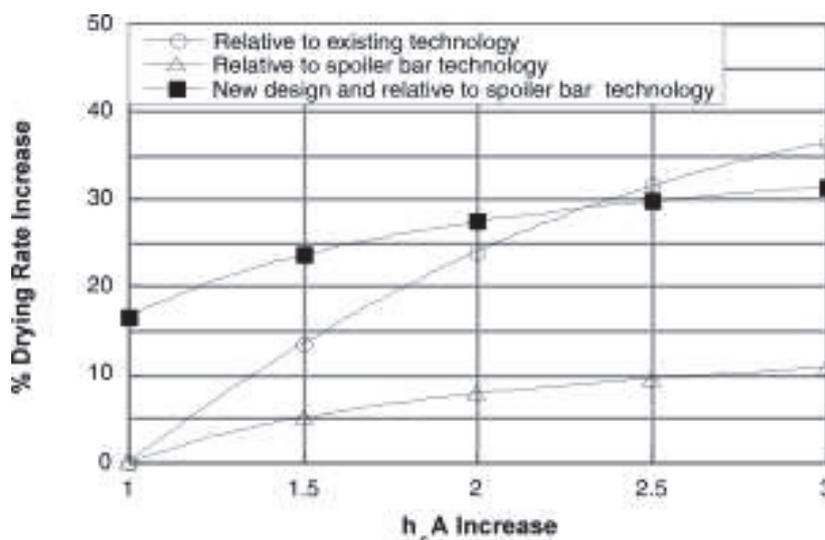


Figure 32: Increased drying rates with multiport technology

Other benefits (including environmental)

The multiport dryer technology offers significant advantages in installation cost. It is being engineered as a retrofit device, which means that it can be installed in existing paper dryers. The installation of a multiport dryer retrofit is projected to cost only 20% as much as the installation of a new dryer cylinder, thus producing an 80% capital saving.

TECHNOLOGY – 3

INSTALLATION OF ENERGY MONITORING SYSTEM

Background

Being an integrated paper mill with multiple fibre sources, Hindustan Newspaper Limited (HNL) has numerous equipment adding up to the total energy requirement. As the energy cost is about 30% of the production cost, the plant team felt that there was a need for improved monitoring system for energy consumed in different areas of the plant.

Brief about Technology/Practice

116 energy meters spread across the plant were linked to one central computer. Real time monitoring of the energy usage of any equipment could be done from one location. Moreover, the system can generate reports in various forms of energy consumption pattern on hourly, daily, monthly, yearly basis or for any given period of time. Additionally, the implemented system also integrates the data of water consumption, amounts of different chemicals and other raw materials used. Trend patterns from the data stored in the computer system can be generated to evaluate the effects of any particular modification done in the plant.

Potential Fuel/Energy Savings

This monitoring system enabled the plant team to monitor the energy consumption patterns of various equipment easily and thereby providing the opportunity to reduce energy usage and the total specific energy consumption per tonne of output.

Other Benefits

Reduction in use of water and chemicals is also possible, by proper monitoring and control, which is beneficial for environment.

The cost of implementation of the monitoring system at Hindustan Newspaper Limited was about Rs. 2.5 million.

TECHNOLOGY - 4

USE OF INORGANIC FIBROUS FILLERS IN PAPER MAKING TO INCREASE FILLER LOADING OVER 20%

Brief about the of best practice / technology

Some companies have developed new fibrous filler that may overcome these problems and achieve additional replacement of high-cost wood fiber. Increasing filler loading will also reduce the specific energy consumption of the mill.

One method of improving filler retention is by Wet end addition of strength and retention aids. Another approach tried to improve the filler retention was preparing and using pre flocculated filler. Pre flocculation is treating the filler particles with a chemical modifier which causes them to flocculate, prior to the paper stock. There are some commercially pre flocculated systems available namely 'Hylode' developed by English Clays Lowering Pochin and Co Ltd. and 'Snowfloc' developed by Blue circle PLC. The latter system enables chalk (Calcium carbonate) to be used in Rosin -alum system.

Out of the conventional elements used as fillers Ground Calcium carbonate (GCC) had relatively better retention than china clay but lower than talc.

New inorganic fibrous fillers have been developed that could raise the filler loading limit to up to 50%, while maintaining paper strength and quality in many products. Reportedly, the use of fillers could reduce energy consumption by 25% and costs by Rs 500 to Rs 2500 per ton of paper produced. Energy savings are attributable to avoided wood pulp production and reduced drying energy due to an increase in the percentage of press solids in the sheet. Mill scale production trials of this technology are underway. The technology consists of two parts.

Part I “Fibrous Filler” Technology

This refers to a series of calcium silicate products. The two products are

- 1) Silicate nano-fibres (SNF) or ultra-high opaque pigments
- 2) Silicate macro-particle (SMP) or ultra-high bulk pigments

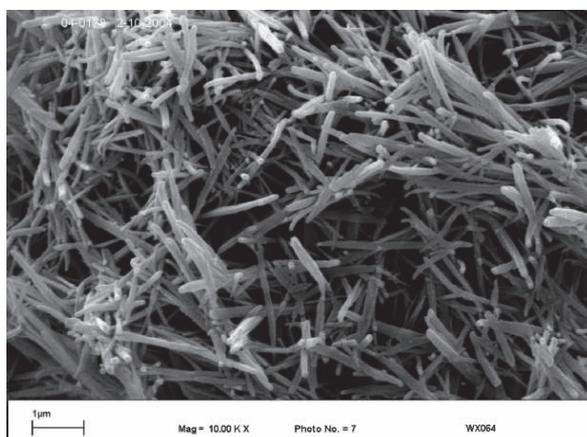


Figure 33: Silicate Nano-Fibers

3) “Super” precipitated calcium carbonates, or “S”-PCC (Figure 3a, 3b, and 3c)

4) Chemical pretreatment of fillers

The focus of this paper is the technology, collectively referred to as “fibrous filler”.

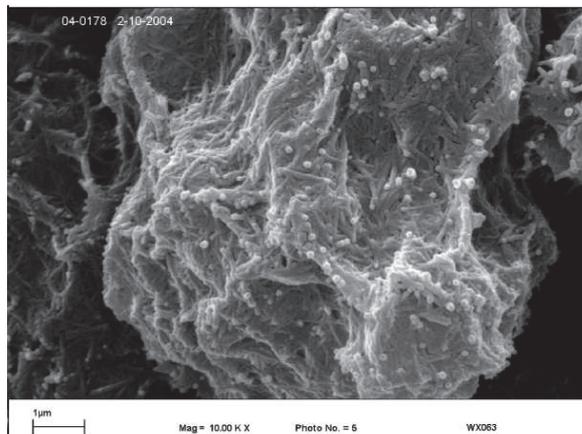


Figure 34: Silicate Nano-Fibers

Potential fuel / energy savings for the model plant

Potential Economic Benefits of “Fibrous Fillers” – Value Proposition

The previous data has clearly demonstrated several potential economic benefits of using “fibrous filler.” The key areas can be summarized as follows:

1. TiO₂ reduction
2. Basis weight reduction
3. Increase in filler level and equilibrium moisture in paper
4. Energy savings

Energy Savings

Based on the data it has been demonstrated that it would be technically feasible to replace 40% pulp with 40% “fibrous fillers,” thus a mill can produce 200 tons/day paper by operating a 120 tons/day pulp mill and a 80 tons/day “fibrous filler” mill. This is compared with the case of 15% filler addition being practiced at present. The following are estimated savings in energy usage with the above-described scenario.

Table 21: Comparison of fibrous filler addition on paper production

	15% filler addition	40% filler addition
Paper production	200 TPD	200 TPD
Pulp required	170 TPD	120 TPD
Pulp required (Tons/yr)	56100	39600
Difference in pulp quantity (TPY)		16500
Energy consumed for pulp making in a year (MTOE)	20196	14256
Difference (MTOE)		5940

Assumptions: (1) Pulp making consumes 60% of energy used for papermaking (2) Paper making consumes 0.6 MTOE/ton of paper

Cost Benefits Analysis:

	Without PAT	With PAT
Annual savings (@Rs. 15000/ton of pulp)	Rs. 247.5 million	Rs. 247.5 million
Filler cost increase	Rs. 82.5 million	Rs. 82.5 million
PAT benefit	--	Rs. 57 million
Total benefit	Rs. 165 million	Rs. 222 million
Investment	Futuristic Technology	

6.0 Cost Abatement Curve

Table 22: Cost Abatement Curve

Graph reference	Description of proposal	Investment in Million Rs./MTOE	savings, MTOE
A	Advanced process control systems	14812.5	1947.0
B	Installing shoe press	17076.6	1423.0
C	Blow through steam consumption	17275.5	991.0
D	High pressure co generation system	20147.3	5296.0
E	Rotor replacement	20714.3	280.0
F	Black liquor firing	21765.7	11141.4
G	Vaccum blowers	23070.6	1218.0
H	Oxyfuel combustion technology	25429.5	291.0
I	Back-Pressure turbines	25574.7	348.0
J	Heat pump installation	29433.9	265.0
K	Ultra-low intensity refining	29906.5	107.0
L	Bio-methanation	39962.0	1579.0
M	Delignification system	54563.5	2520.0
N	Centrifugal compressors	14812.5	162.0

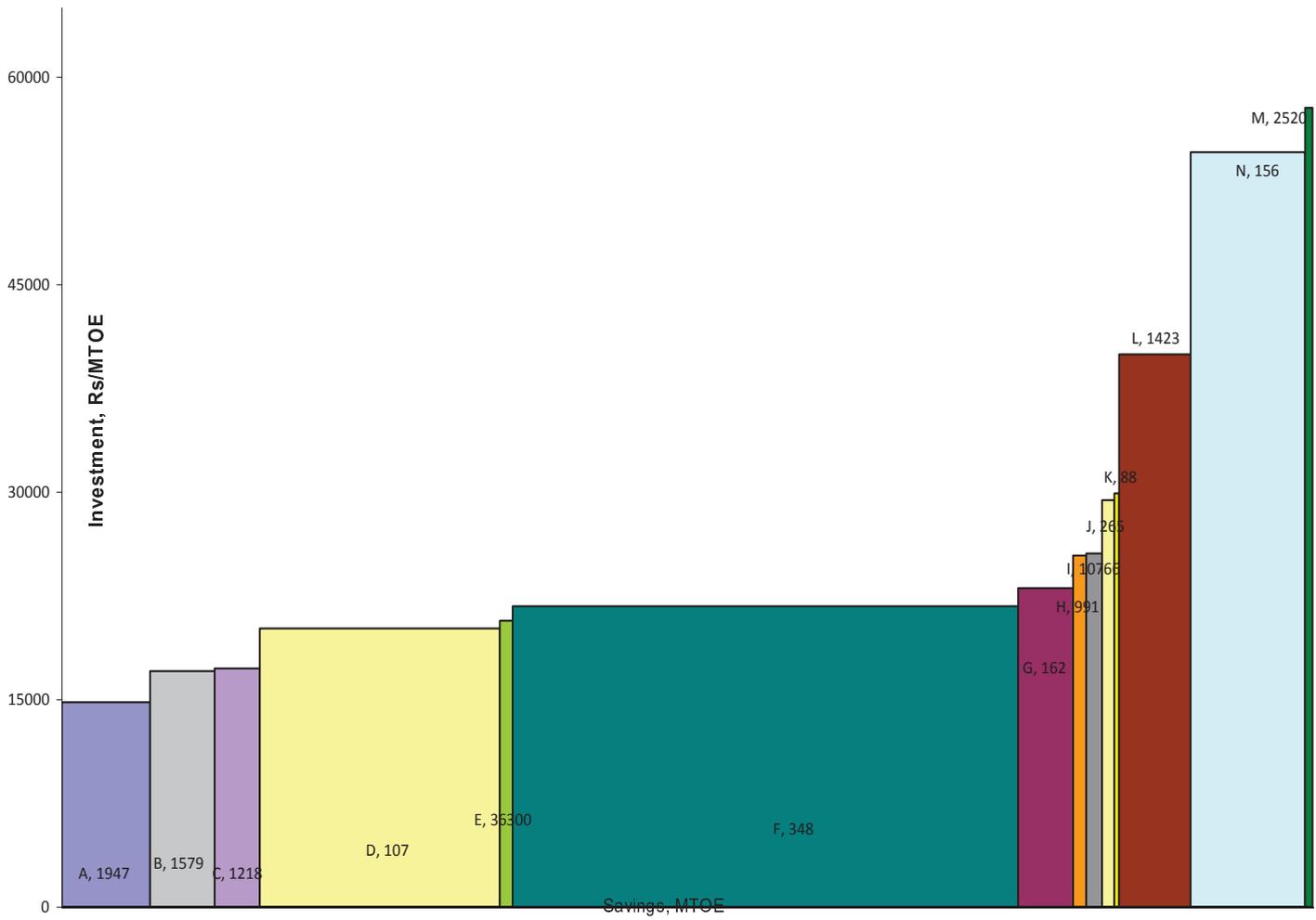


Figure 35: Cost abatement curve

7.0 Conclusion

Paper & pulp sector is witnessing good growth rate in the recent years of around 6-7% and is expected to reach 20 million tons by 2020. Paper production likely to grow at 8.4% while the consumption of paper will also grow at 9%. To meet the growing demand new capacity addition is required.

PAT is an opportunity to prioritize the energy reduction project that offers shorter pay-back period. PAT also helps in the reducing the input cost of the product thereby designated consumers can increase their competitiveness in the global market.

Paper & pulp sector has to achieve 117704.4 MTOE of energy saving as a PAT target at the end of first phase of the PAT cycle (2012-15). This contributes around 1.76% of the overall PAT target.

With this background, developing a technology compendium on Paper Sector is a small effort to assist designated consumers in formulating resilient actions to achieve their PAT targets. The exhaustive list of 19 energy saving projects would gives directions to designated consumers to focus on energy conservation projects.

Apart from that, few other options like installation of high-efficient motors, installation of High efficient fans, optimization of the design of a pumping system, optimization of compressed air systems and lighting system efficiency improvement would result in enormous energy savings.

This technology compendium is an effort towards this direction discussing not only on the efficient use of energy but also the utilization of waste energy. We believe that this compendium would help designated consumers to choose appropriate technology and achieve PAT targets.

Annexure I : GHG INVENTORISATION & TREND ANALYSIS

Greenhouse gas emissions from the pulp and paper source category are predominantly CO₂ with smaller amounts of CH₄ and N₂O. The GHG emissions associated with the pulp and paper mill operations can be attributed to:

1. The combustion of on-site fuels; and
2. non-energy-related emission sources, such as by-product CO₂ emissions from the lime kiln chemical reactions and CH₄ emissions from wastewater treatment.

These emissions are emitted directly from the pulp and paper plant site. In addition, indirect emissions of GHG are associated with the off-site generation of steam and electricity that are purchased by or transferred to the mill. Table 2.1 shows the relative magnitude of nationwide GHG emissions (in million metric tonnes of CO₂ equivalents per year [mtCO₂e/yr] and million short tons of CO₂ equivalents per year [ton CO₂e/yr] from stationary sources in the pulp and paper manufacturing sector.

Table 23: Relative magnitude of nationwide GHG emissions; Source MoEF (2007)

GHG component	Quantity CO ₂ eq (1000 Tons)	Percentage
Carbon di oxide (CO ₂)	5222.50	99.50%
Methane (CH ₄)	1.05	0.02%
Nitrous oxide (N ₂ O)	24.80	0.48%
Total	5248.35	100.00%

The above estimate of GHG emissions in Indian Pulp & paper sector by MoEF accounts for does not account for the GHG emitted for captive power generation.

IEA estimate of GHG emissions of year 2007 and onwards

IEA's calculation of the GHG emission of the Indian pulp & paper sector follows the pattern of that of MoEF. In other words, GHG emissions on account of captive power generation is accounted under the head "Electricity" and thus not accounted to the pulp & paper sector under the "Industry" head.

The IEA developed two different scenarios to analyse the industrial sector:

- ❖ The **Baseline Scenario** reflects developments that are expected on the basis of the energy policies that have been implemented or that have been approved and are to be implemented.
- ❖ The **BLUE Scenario** is target driven and aims to achieve total emissions from the industry that are 24% lower in 2050 than the 2007 level.

The following estimates were published by IEA in its information paper named "ENERGY TRANSITION FOR INDUSTRY: INDIA AND THE GLOBAL CONTEXT"

Table 24: IEA Estimate

Mil. T CO ₂ /yr Year	Low Demand		High Demand		Strong Growth	
	Baseline	Blue	Baseline	Blue	Baseline	Blue
2007	8	8	8	8	8	8
2015	13	9	15	11	14	10
2030	21	11	33	17	40	23
2050	26	17	62	31	87	50

Decline in GHG intensity for Indian integrated Pulp & Paper mills

Energy intensity data compiled from different sources show an interesting reduction trend in the energy / GHG emission intensity for producing paper in an Indian integrated pulp & paper mill. The values given in Table 40 summarizes the decreasing trend in energy intensity which was achieved inspite of incurring additional energy consumption for commissioning and operation of pollution prevention/ reduction equipment in the later years.

Table 25: Decline in emission intensity

Year	Energy intensity	GHG intensity
1987	74.2 GJ/T	7.2 T CO ₂ /T
2002	60.0 GJ/T	5.8 T CO ₂ /T
2009	52.5 GJ/T	5.1 T CO ₂ /T

The reduction in energy and GHG emission intensity can be credited to the adoption of energy efficiency measures in the Indian pulp & paper industry and also for migrating to advanced technologies in the process areas.

GHG mitigation potential for the projects specified in the report is as follows;

Table 26: Technology wise emission saving potential

Description of proposal	savings, MTOE	Sector savings, MTOE	Thermal / Electrical savings	Emission savings (Tons of CO ₂) ¹⁹
Advanced process control systems	1947.0	18403.2	Thermal	77293.2
Installing shoe press	1423.0	32280.7	Thermal	135578.8
Blow through steam consumption	991.0	11240.4	Thermal	47209.6
High pressure co-	5296.0	50058.1	Thermal	210243.9

generation system				
Rotor replacement	280.0	2646.6	Electrical	28053.7
Black liquor firing	11141.4	84247.3	Thermal	353838.7
Vaccum blowers	1218.0	13815.1	Electrical	146440.3
Oxyfuel combustion technology	291.0	3300.7	Thermal	13862.8
Back-Pressure turbines	348.0	3289.3	Electrical	13815.1
Heat pump installation	265.0	3005.8	Thermal	12624.2
Ultra-low intensity refining	107.0	1011.4	Electrical	10720.5
Bio-methanation	1579.0	14924.8	Thermal	37312.0
Delignification system	2520.0	28583.0	Thermal	120048.7
Centrifugal compressors	162.0	1837.5	Electrical	19477.3

**** GHG savings indicated is calculated only for the reference plant of 200 TPD. Projects explained in this compendium should be seen individually for its applicability in a particular plant.***

**** The reader is advised not to sum up individual GHG emission savings and extrapolate for the sector as it might be misleading***

Annexure 2: BASIS OF SAVINGS ESTIMATIONS / SAMPLE CALCULATION

Basis for calculation:

Operating hours of the plant	=	8000 hrs
Plant size	=	200 TPD
Cost of electrical energy	=	Rs. 3.50 / kWh
1 MTOE value	=	Rs. 10,154

Sample Calculation:

Savings without PAT

Energy saved	=	500 kWh
Annual savings	=	500 kWh X Rs. 3.50 / kWh X 8000 hrs
	=	Rs. 14.00 million / annum
Investment	=	Rs. 20.00 million
Payback	=	<u>Rs. 20.00 million</u> X 12 months Rs. 14.00 million
	=	18 months

Savings with PAT

Energy saved	=	500 kWh
Annual savings	=	500 kWh X Rs. 3.50 / kWh X 8000 hrs
	=	Rs. 14.00 million / annum
MTOE saved	=	344
MTOE savings	=	344 X Rs. 10,154 / MTOE
	=	Rs. 3.40 million
Total savings	=	Rs. 14.00 million + Rs. 3.40 million
	=	Rs. 17.40 million
Investment	=	Rs. 20.00 million

$$\begin{aligned} \text{Payback} &= \frac{\text{Rs. 20.00 million}}{\text{Rs. 17.40 million}} \times 12 \text{ months} \\ &= 14 \text{ months} \end{aligned}$$

Miscellaneous:

$$1 \text{ kWh} = 860 \text{ kCal}$$

$$1 \text{ MTOE} = 10^7 \text{ kCal}$$

Cost of heat (sample calculation):

$$1 \text{ Mtoe} = 1 * 10^7 \text{ kcal}$$

$$1 \text{ Mtoe} = \text{Rs. } 10154^{20}$$

$$\text{Annual coal savings} = 5000 \text{ kg}$$

$$\text{Calorific value} = 6000 \text{ kcal / kg}$$

$$\text{Kcal savings} = 5000 \text{ kg} * 6000 \text{ kcal / kg}$$

$$= 30000000 \text{ kcal}$$

$$\text{MTOE savings} = \frac{30000000 \text{ kcal}}{1 * 10^7 \text{ kcal}}$$

$$= 3 \text{ Mtoe}$$

$$\text{Annual cost savings} = \text{Rs. } 10154 / \text{Mtoe} * 3 \text{ Mtoe}$$

$$= \text{Rs. } 30462$$

Calculation of GHG emissions:

GHG emission depends on the type of fuel being used i.e., coal, diesel or electricity. Emission reduction for a particular project has been arrived on the basis of CO₂ emitted per MTOE.

If a process runs only with electricity, then CO₂ emitted per MTOE is calculated as follows:

$$\text{Electricity (1 kwh)} = 860 \text{ kcal}$$

Electricity emission factor	=	0.91 kg of CO ₂ /kwh ²¹
1 MTOE	=	10 ⁷ kcal
kwh / MTOE	=	10 ⁷ kcal / 860 kcal
	=	11627.9 kwh / MTOE
Tons of CO ₂ / MTOE	=	0.91 kg of CO ₂ /kwh * 11627.9 kwh / MTOE
	=	10.6 MT of CO ₂ / MTOE

Similarly, if a process uses coal as a energy source, then tons of CO₂ / MTOE would be 4.2 considering, calorific value of coal to be 4500 kcal / kg and emission factor of coal to be 2.2 tons of CO₂/ ton of coal is burnt

Emission per MTOE is listed below for other fuel types:

Diesel	=	2.3 MT of CO ₂ / MTOE
Natural gas	=	2.2 MT of CO ₂ / MTOE

In order to calculate the GHG emission savings, the projects have been classified based on the type of savings it achieves. For example, if a project gives coal savings, the MTOE savings has been multiplied with the corresponding coal CO₂ emission / MTOE and the value is arrived.

Example 1

Type of project	=	Thermal
Fuel saved	=	Coal
MTOE saved	=	100 MTOE
Tons of CO ₂ / MTOE	=	4.2
GHG savings	=	100 MTOE * 4.2 tons of CO ₂ / MTOE
	=	420 tons of CO ₂

Example 2,

Type of project	=	Electrical
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Fuel saved	=	electricity
MTOE saved	=	100 MTOE
Tons of CO ₂ / MTOE	=	10.6
GHG savings	=	100 MTOE * 10.6 tons of CO ₂ / MTOE
	=	1060 tons of CO ₂

Annexure 3: LIST OF EQUIPMENT / TECHNOLOGY SUPPLIERS

1) ThermoChem Recovery International	www.tri-inc.net/
2) Chemrec AB;	www.chemrec.se/
3) Metso Paper India Pvt. Ltd	
4) Andritz Oy	
5) Voith Paper Technology (India) Private Limited	www.voithpaper.com
6) GR International	www.griinc.org
7) Kadant Johnson India	www.kadant.com
8) Arjun Technologies Ltd	www.arjuntech.com
9) Andritz Technologies Pvt. Ltd	www.andritz.com
10) GL & V India Pvt. Ltd	www.glv.com
11) Chemical and Pulping Ltd	www.chempulp.com
12) Abhishek Sales Corporation	www.abhisheklive.com
13) Atlascapco	www.atlascapco.in
14) Aditi Engineering Corporation	
15) Kirloskar Pnematic	www.kpclapps.com
16) Ingersoll-Rand (India) Ltd	www.ingersollrand.co.in
17) Chicago Pneumatic	www.cp.com
18) ABB	www.abb.co.in
19) Siemens	www.siemens.co.in
20) Rockwell Automation	in.rockwellautomation.com
21) BHEL	www.bhel.com
22) Cethar Vessels	www.cethar.com
23) Honeywell	www.honeywell.com
24) Conserve	www.conserveindia.org
25) Enercon	www.enerconindia.net
26) Turbotech	www.turbotechindia.com
27) GL&V India Pvt. Ltd	www.glv.com
28) Parason	www.parasonglobal.com
29) Thermax Ltd – Adsorption Cooling	www.thermaxindia.com
30) Kadant Johnson India	www.kadant.com

- | | |
|--------------------------------------|--|
| 31) Forbes Marshall | www.forbesmarshall.com |
| 32) Suzler Pumps India Ltd | www.suzler.com |
| 33) MAN Turbo India Pvt. Ltd | www.manturboindia.com |
| 34) Ion Exchange India Limited | www.ionexchange.co.in |
| 35) Viswa Equipments Private Limited | www.viswaequipments.com |

ABBREVIATIONS

ANL	- Argonne National Laboratory
APC	- Advance process control
BEE	- Bureau of Energy Efficiency
BL	- Black liquor
BLGCC	- Black liquor gasification combined cycle
BOD	- Biological Oxygen Demand
CAGR	- Compound Annual Growth Rate
CDM	- Clean Development Mechanism
CFB	- Circulating Fluidized Bed
CHP	- Combined Heat & Power
cm²	- Square Centimetre
CO₂	- Carbon dioxide
COD	- Chemical Oxygen Demand
CPPRI	- Central pulp & paper research institute
CREP	- Corporate Responsibility for Environment Protection
DC	- Designated Consumer
DIPP	- Department of Industry Policy and Promotion
DM	- Demineralised water
ECA	- Energy Conservation Act
ESP	- Electro static precipitator
ETP	- Effluent Treatment Plant
FMCG	- Fast moving consumer goods
FY	- Financial Yea
g	- Grams
GDP	- Gross Domestic Product
GHG	- Greenhouse Gas
GJ	- Giga Joule
Ha	- Hectare
HP	- High Pressure
HVLC	- High volume low concentration
INR	- Indian Rupee
J	- Joules
KJ	- Kilo Joules
KL	- Kilo Litre
kN	- kilo Newton
KW/T	- Kolowatt / Ton
KWH	- Kilowatt Hour
LP	- Low pressure
M	- Month
m²	- Square Metre
m³/hr	- Cubic Metre per Hour
Min	- Minutes
MI	- Million litre
mm²	- Square milli metre

mMTOE	– million Metric Tonne of Oil Equivalent
MoEF	– Ministry of Environment & Forest
MPM	– Metres per minute
MTOE	– Metric Tonne of Oil Equivalent
MWe	– Mega Watt Electrical
NCG	– Non condensable gases
Nm³	- Normal Cubic metre
°C	– Degree Centigrade
P & W	– Printing and writing paper
PJ	– Pico Joules
RCF	– Recycled cellulose fiber
SEL	– Specific Edge Loading
STG	– Steam turbine generator
T	- Tone
T/MW	– Tone per Mega Watt
T/T	– Ton per Ton
Tappi industries	- leading association for the worldwide pulp, paper, packaging, and converting industries
TERI	– The Energy Research Institute
TiO₂	– Titanium dioxide
TNPL	– Tamil Nadu Newsprint and Paper Limited
Tone	– 1000 Kilograms
TPA	– Tones per Annum
TPH	– Tones per hour
UAFB	– Up-flow anaerobic sludge blanket
USD	– US Dollar
Vs.	- Versus
WA	- Washington
Wev	– Water evaporated
Yr	– Year

BIBLIOGRAPHY

1. Indian Pulp & Paper Technical Association
2. National and International Best Practices Manual- Paper and Pulp Industry Vol-1
3. IPMA – Indian Paper Manufacturer’s Association
4. CPPRI 2006 – Central Pulp & Paper Research Institute
5. Department of Industrial Policy & Promotion
6. Poyry; CARE Research: August 2011
7. Research India 2008
8. Central Pulp & Paper Research Institute data, as on December, 2010
9. Department of Industrial Policy & Promotion - Annual report 2010 -11
10. National Productivity Council / Central Pollution Control Board, March 2006
11. National Productivity Council / Central Pollution Control Board, March 2006
12. Centre for Monitoring Indian Economy Pvt. Ltd - CME
13. CARE Research: August 2011
14. India Paper Outlook
15. Poyry
16. Princeton Environmental Institute
17. Chemrec AB, Technology
18. Biorenewable Resources Engineering New Products from Agriculture, Iowa State Press, Ames IA
19. ThermoChem Recovery International Inc
20. Improving Process Heating System Performance: A Sourcebook for Industry. DOE and the Industrial Heating Equipment Association (IHEA)
21. Pulp Paper Canada
22. US DOE Energy Efficiency & Renewable Energy
23. Thermax – Papertech presentations
24. Parason & AFT – Papertech presentations