An Overview of Best Energy Management Practices in Pulp and Papermaking Processes for Improving Energy Efficiency in the Pulp and Paper Sector

SECTORAL WORKSHOP ON

BEST PRACTICES IN ENERGY EFFICIENCY IN PULP & PAPER SECTOR:

A PATH FOR DECARBONISATION

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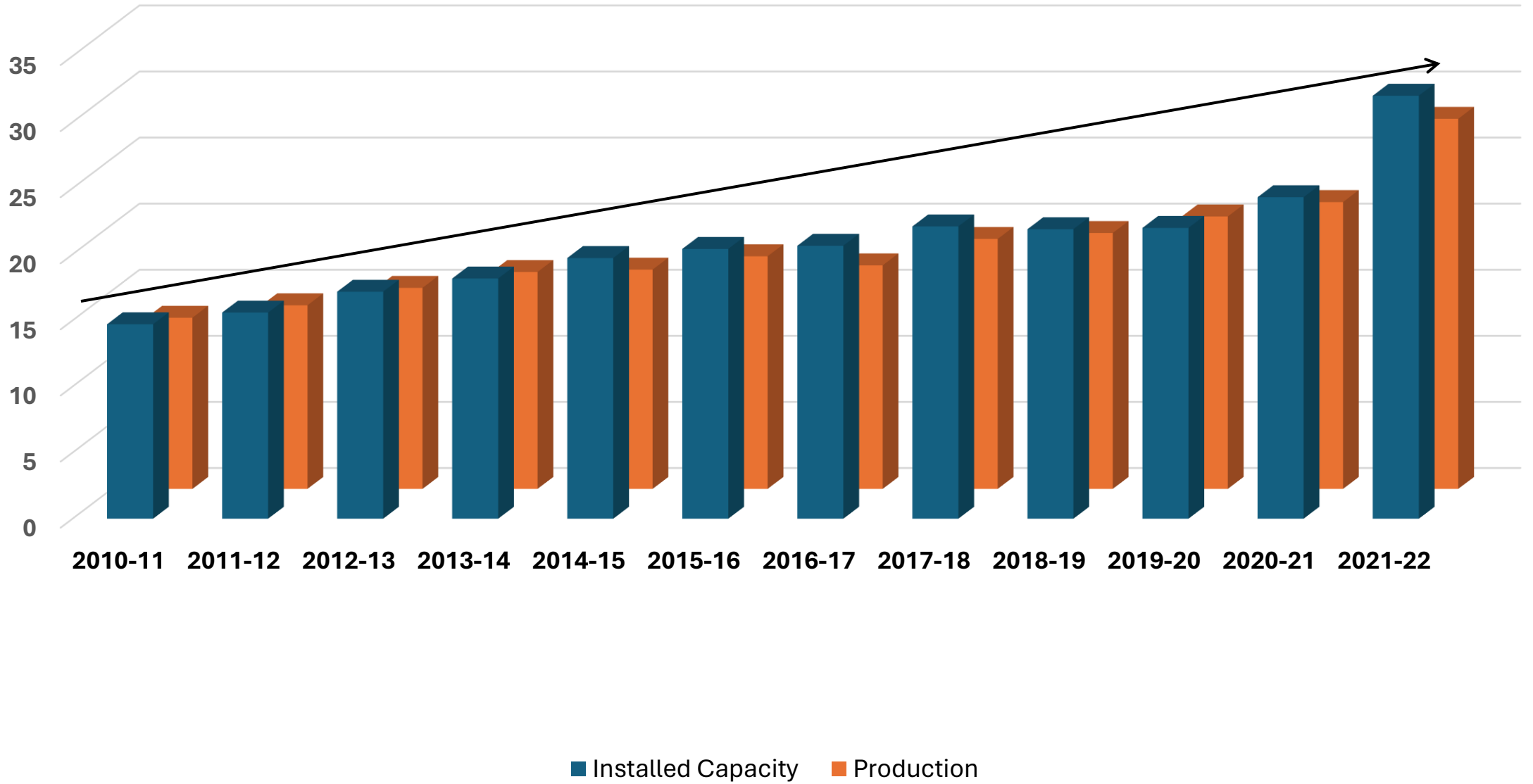
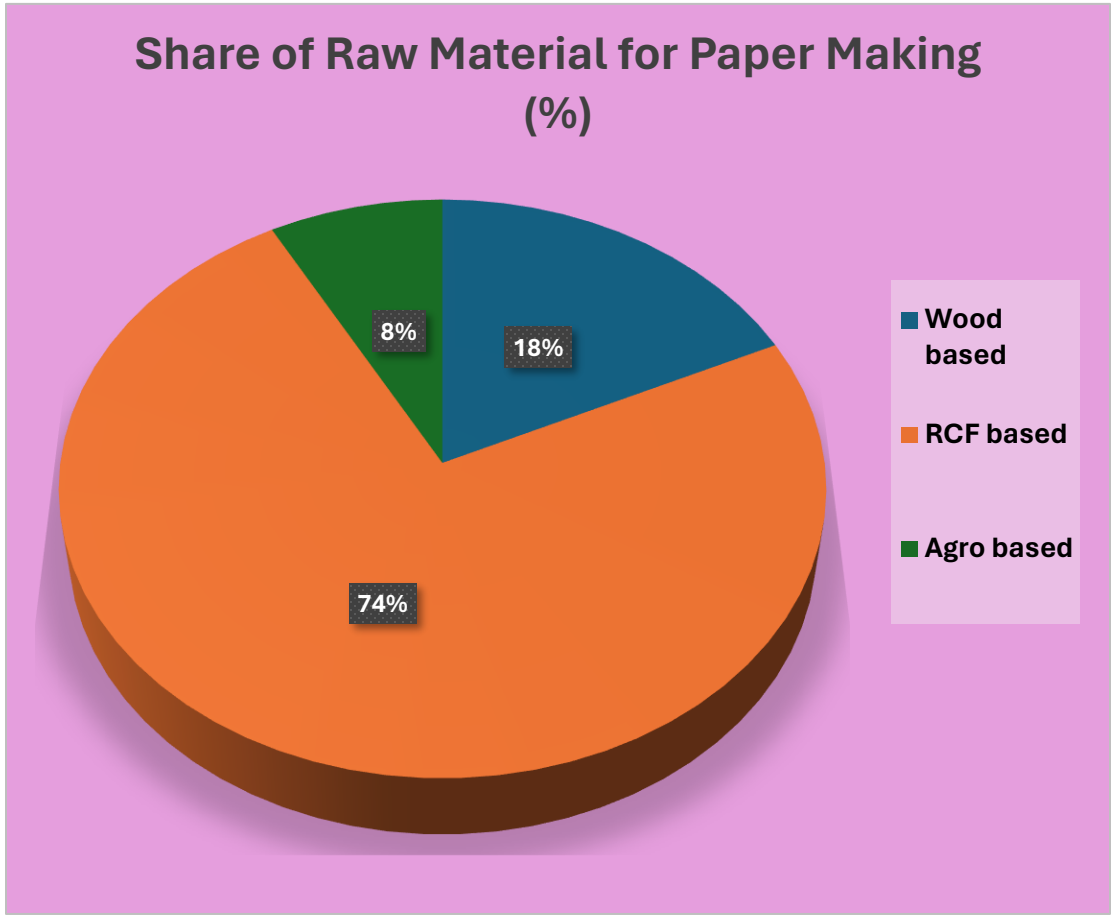
Growth of Pulp and Paper Industry in India During Past One Decade (Million Tons)



Capacity by Feedstock



Agro Based Mills -31 producing 2.24 Million tons

Recycled Fiber Based Mills - 450 producing 20.72 Million tons

Wood Based Mills -19 Producing 5.04 Million tons

Demand Drivers and Projections

- Indian GDP and Consumption of Paper and Paperboard
- Major End Use Industries
  - Cultural Papers
  - Packaging paper & paperboard
  - Hygiene and specialty
- Growth in Drugs and Pharmaceutical Industry
- Growth in Food Processing Industry
- e-Commerce Growth
- Alternative for SUPs

Demand Projection for Paper, Paperboard and newsprint

Year	Projected Demand (Million tons)
2023	28.92
2030	36.18
2035	40.40

Year	GDP (Rs. Crore)#
1950-51	495,274
1960-61	734,466
1970-71	1,082,340
1980-81	1,464,390
1990-91	2,486,353
2000-2001	4,281,910
2010-2011	8,211,816
2020-2021	13,368,279
2021-2022	14,500,812
2022-2023	15,461,721

#GDP at Constant Prices (Rs. Crore)

Energy and Environment in Global Context

- Water & Energy Utilization, and GHG emissions- important concerns worldwide.
- In 2021 - Globally, the paper and pulp were responsible for approximately 190 million tons of CO_2 emissions, (accounting for appr. 2% of all industrial emissions).
- India - highest rate of carbon emission growth. (3.8% growth annually to be the 4^{th} largest emitter worldwide).
- India's per capita carbon emissions are still one-eighth of the United States and one-third of the global average.
- India's total emissions in 2021 are estimated to be 2.7 billion tons, marginally less than the EU's total of 2.8 billion tons.

Energy use in paper industry

Thermal (~ 70%)

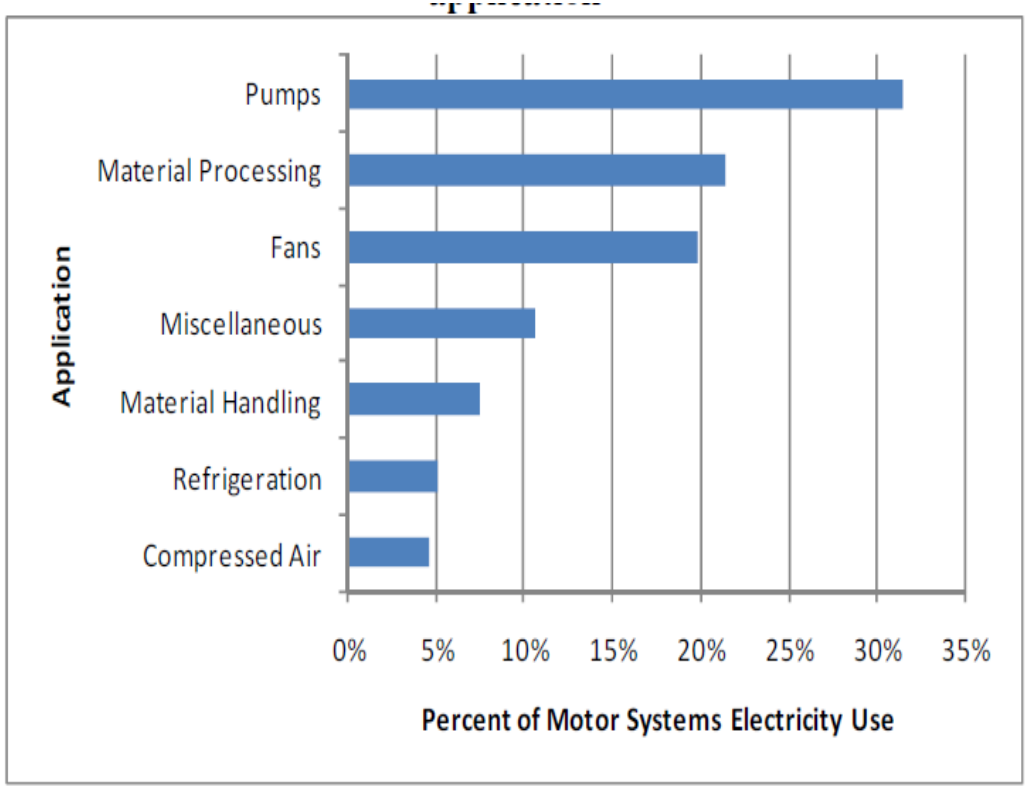
Electrical (~30%)

Breakdown of power and steam consumption

S. No.	Section	Power Consumption, kWh/ton of paper	Steam Consumption, ton/ton of paper
1	Pulp Mill (including Raw material cleaning, Digester, screening & washing and bleach plant)	300-325	1.2-2.5
2	Recovery Section	250-300	3.0-3.5
3	Stock Preparation & Paper Machine	350-450	2.5-4.0
4	Effluent Treatment Plant	75-100	-
5	Power Generation Plant (12 MW)	150-200	6.0-6.5
6	Others (including ClO_2, O_2 plant, office, street light)	100-125	-
	Total	**1,225-1500**	**12.7- 16.5**

Breakdown of motor-system electricity use

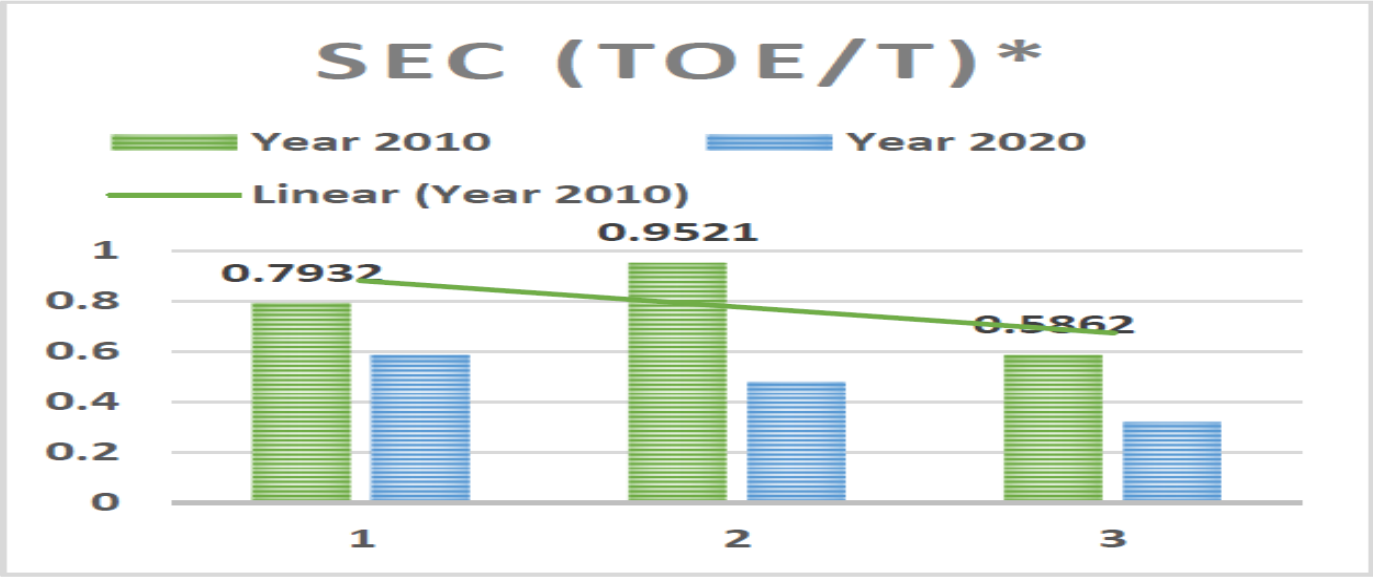
Pumps, fans, and materials processing equipment account for over 70%) electricity use



Source: U.S. DOE (2002a)

Impact of PAT on GHG emissions (2010 to 2020)

- PAT Scheme has shown pathway for energy efficiency and GHG reduction.
- It has resulted in total savings of about 4.5 million TOE and equivalent reduction of about 2.56 million tonne CO2.



*Specific Energy Reduction in Tone of Oil Equivalent/Tonne, [1: Wood Based, 2: Agro Based, 3: RCF Based].

Legal Framework for Energy Efficiency and Carbon Credit

- Carbon Credit Trading Scheme, 2023 ('Carbon Credit Scheme') notified on June 28, 2023.
- The pulp and paper sector selected as one of the sectors for Carbon Credit Market to implement the scheme.
- The existing Gate to Gate concept of PAT will be followed to convert the energy inputs into CO_2 emissions.

Approach for improving energy efficiency and reducing GHG emissions

Many opportunities already exist and other will become available in the future. These opportunities can be divided as follows:

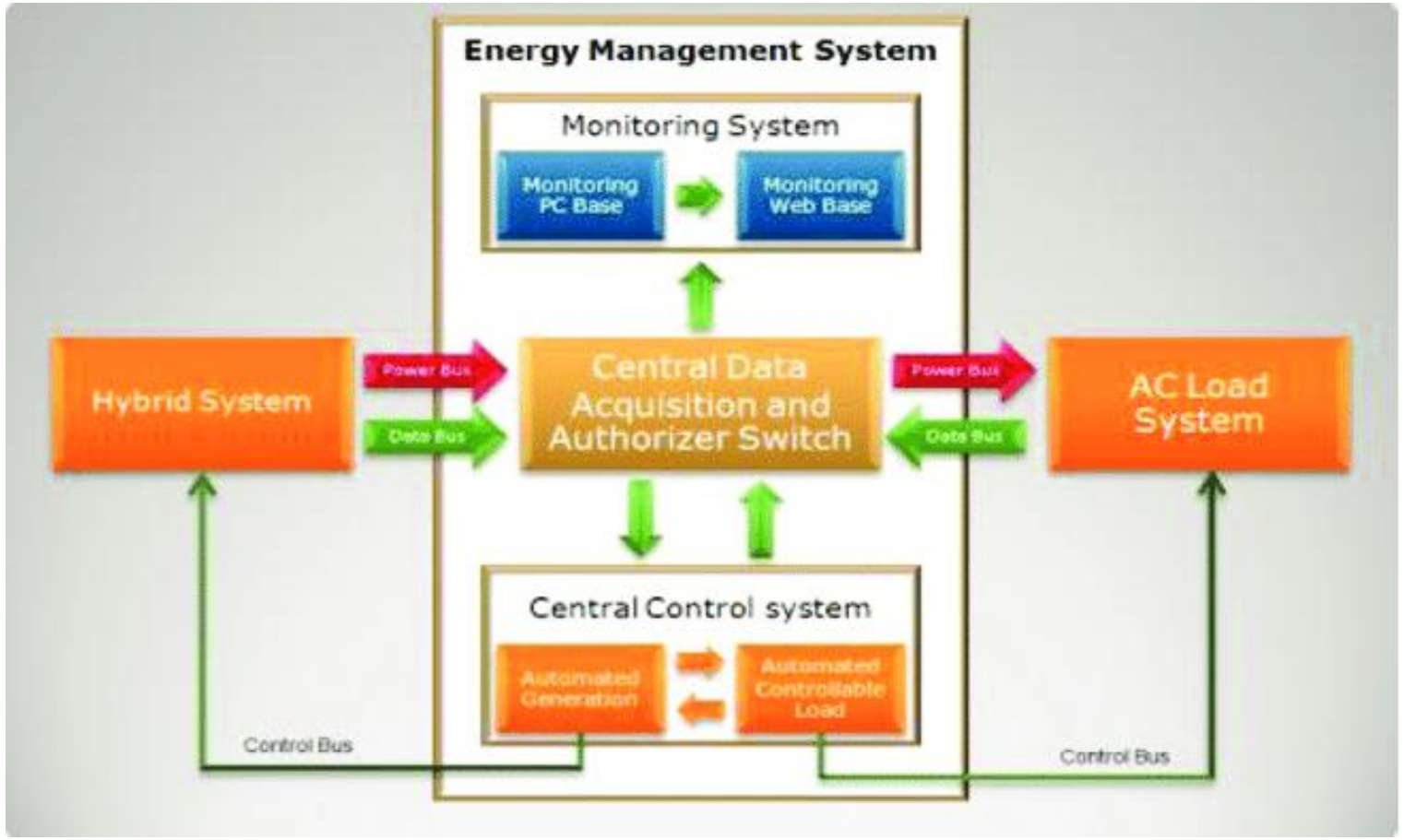
- **general measures, such as energy management systems, process integration, new equipment and efficient modes of operation;**
- increasing on-site use and production of energy from biomass residues (fuel switch) and expanding the adoption of combined heat and power (CHP) technology;
- **retrofitting the existing mills with energy-efficient technologies (e.g. BATs).**
- increased use of recovered paper and paper recycling; a reduction of about 37 % in CO2 emissions is estimated by substituting virgin wood with recycled fibres (Roth et al.,2016);
- **development and adoption of emerging and breakthrough technologies;**
- Maximise the use of renewable energy (solar, wind etc)
- **In-house innovations in process and product development**.

General Energy Efficiency Measures

- **Adopt Energy Management Programs and Systems (EnMs)**
  - Regular Energy management programs and Energy teams
  - Install Energy monitoring and control systems (EnMs)
- **Implement Energy Conservation and optimization Projects for**
  - Steam generation and distribution systems
  - Motor, pump, fan and compressed air systems
  - Process specific ECMs
  - Water conservation measures
- **Adopt Process integration systems (Thermal and Water Pinch)**
- **Replace oversized/inefficient motors and pumps with high-efficiency motors and pumps**

Energy Optimization by using Energy Management System (EnMS):

The EnMS consists of Servers, Data Concentrators and Energy Meters. The Server and Data Concentrator communicate via ERP Networks in the mills. It allows real time data collection; compilation, analysis to identify potential energy saving in equipment.



Energy Optimization by using Energy Management System (EnMS):

- In Paper Making Section, motor voltage ranges from 230V to 11KV, with power rating upto 1.2 MW.
- Analysis of energy consumption Reports (Hourly, Shift, Day, Month and Year Wise) reveals the variation in major equipment and possibilities of energy savings.
    - Vacuum pumps, (14-35%)
    - Refiners, (3-9%)
    - Sectional drives, (20-37%)
    - Pumps and auxiliaries, (35-40%)

It is evident that power consumption by 'Process pumps and auxiliaries' emerges as one of the major factors in power and cost saving.

General process-specific energy efficiency measures

- **Chemical Pulping**
- *Pulping*
  - Use of pulping aids to increase yield
  - Digester improvement
  - Optimize the dilution factor control
  - Digester blow/flash heat recovery
  - Continuous digester control system
- *Bleaching*
  - Heat recovery from bleach plant effluents
  - Chlorine dioxide (ClO2) heat exchange
  - Improved brown stock washing
- *Chemical Recovery*
  - Quaternary air injection
  - Black liquor solids concentration
  - Improved composite tubes for recovery boiler
  - Recovery boiler deposition monitoring
  - Lime kiln modification
  - Lime kiln electrostatic precipitation

- **Papermaking**
  - Advanced dryer controls
  - Waste heat recovery
  - Control of dew point
  - Paper machine vacuum system optimization
  - Optimization of water removal in forming and pressing
  - Shoe (extended nip) press
  - Reduction of blow through losses
  - Gap forming
  - Reduction of air requirements
  - Optimizing pocket ventilation temperature

Best Available Technologies (BATs) for Pulp & Paper Sector

TRL is based on a scale from 1 to 9 with 9 being the most mature technology.

BATs for Kraft & RCF Pulping Processes

Type of Technology	Estimated Emission Reduction	Estimated Energy saving	TRL
Steam cycle washing	10%	30-40%	7-8
Ligno Boost	10%		
Black liquor gasification	!0%	2 GJ/ton pulp	8-9
Recycled paper fractionation	5%	11–13% EL 40% Heat	8-9
Efficient screening		15%	9
High consistency pulping		8%	9
Sludge dryer	5%		8-9

BATs for Forming, Pressing, and Drying in Paper Making

Type of Technology	Estimated Emission Reduction	Estimated Energy saving	TRL
Steam box	5%	5%	
High consistency forming	3%	8% EL	7
Dry sheet forming	42%	50%	7
Closed hood	13%	45% EL	9
Transport membrane Condenser			
Laser Ultrasonic Stiffness Sensor		3%	
Hot pressing	8%	0.61GJ/ton paper	7-8
Displacement Pressing		30%	
Impulse drying of paper	20%	0.44GJ/ton paper	7
Condebelt dryers		1.6 GJ steam & 20 kWh/ ton paper	7-8

BATs for Energy Production Process

Type of Technology	Estimated Emission Reduction	Estimated Energy saving	TRL
Biomass gasification			8-9
Biomass CHP			9
Biogas production from sludge	2%		9
Waste heat recovery	9%	3.5 GJ/ton pulp or 1.07 GJ/ton paper	9
Energy management	15%		9
Focus on maintenance	10%		9

Innovative Technologies (IT) for Pulp & Paper Sector

TRL is based on a scale from 1 to 9 with 9 being the most mature technology

Innovative Technologies (IT) for Pre-treatment & Pulp Production

Type of Technology	Estimated Emission Reduction	Estimated Energy saving	TRL
Microwave pre-treatment			
Hemicellulose extraction before chemical pulping			
Deep eutectic solvents (DES)	20%	40%	3
Utilization of green liquor		25%	7-8
Membrane concentration of black liquor		36%	6-7

Innovative Technologies (IT) for Forming and Paper Making

Type of Technology	Est. Emission Redn	Est Energy saving	TRL
Functional surface			8-9
New fibrous fillers		25%	5-6
Flash Condensing	50%	20%	3-5
Dry pulp for cure-formed paper	55%	25%	3

Innovative Technologies (IT) for Pressing & Drying

Type of Technology	Emission Redn	Energy saving	TRL
Displacement pressing		30%	5-6
Supercritical CO_2	45%	20%	3
Superheated steam drying	50%	25%	3-5
Gas-fired dryers		10-20%	6-7
Boost dryer		12%	6-7
Microwave Drying		12%	3-4

Innovative Technologies (IT) for Steam Production

Type of Technology	Est. Emission Redn	Est. Energy saving	TRL
Use of Hydrogen as a fuel			7-8
Direct electric heating			7-8
Heat pump recovering waste heat			6-7
Carbon capture and storage			6

Other New and Emerging Process Technologies

Currently emerging technologies include convergence of various technologies, like information technology, nanotechnology, biotechnology, cognitive science, robotics, and artificial intelligence etc.

- **Desilication of silica rich black liquor**
- **Thermal treatment for reduced viscosity of black liquors**
- **Bio refinery concept for pulp and paper mills**
- **Black liquor gasification**
- **Higher dryness of paper entering at dryers**
- **Replacement of water as a carrier material**
- **Magnetically-coupled adjustable-speed drives**
- **Stickies and efficient contaminant removal**
- **Bio-drying technology for the drying of pulp and paper mixed sludges**

Case Studies on Innovative measures / developments in the mills

Case study -1

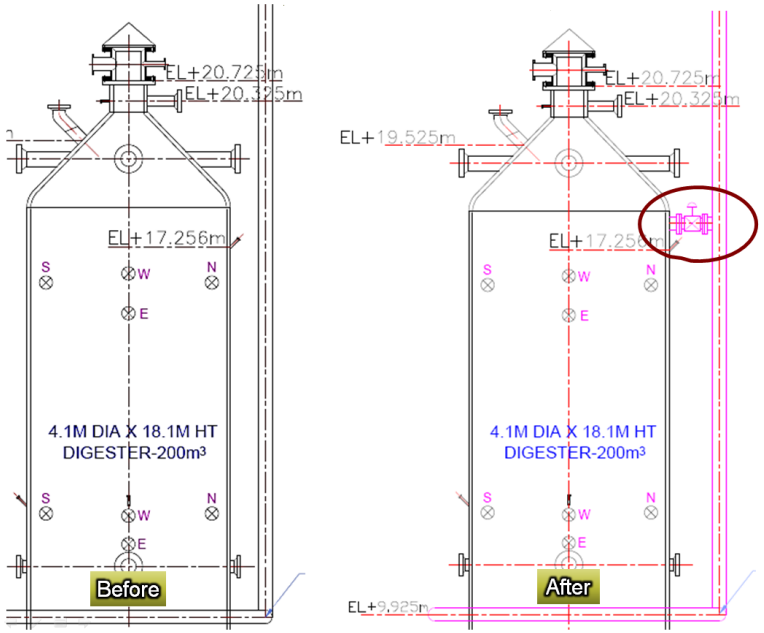
Digester Modification to increase the Pulp Production from 380 to 430 tpd.

Mill Details:

- Four digesters (200 m^3 cap.) for 380 tpd pulp, Retrofitted in 2006–07, earlier venting under a pressure discharge system.
- In 2016, the digesters converted to RDH system, with conical construction of discharge.

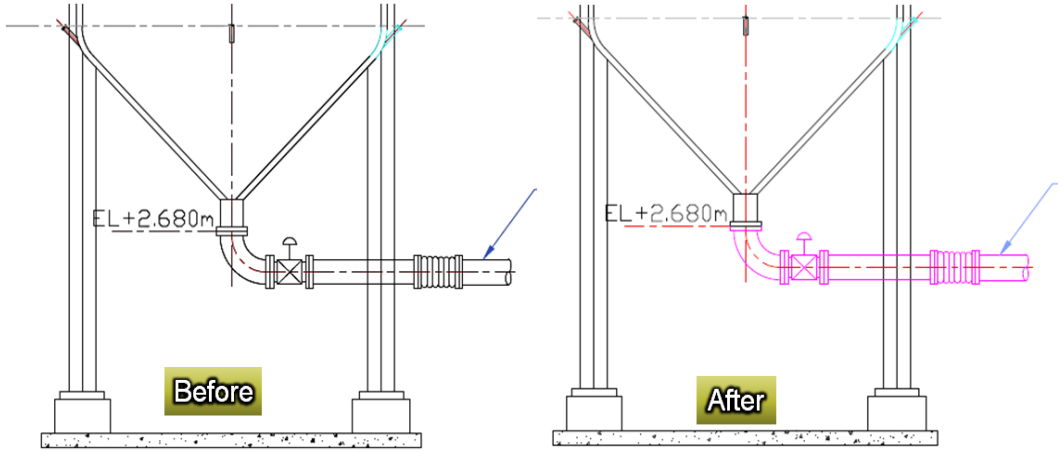
Action Taken:

- The top air evacuation system along with the existing middle air evacuation system was installed to have better chip packing.
- The middle header's control valve was enlarged from 12 to 16 inches in diameter.
- The conical nozzle outlet size of 300 mm dia, was enlarged to 500 mm. A suction ring header for the RC pump of the digester was added from the middle strainer sizing to increase the circulation rate during the TTT operation.
- With these modifications, the electrical load of RC pumps increased by 15 amps, indicating a better circulation effect. H-factor and uniform temperature during the TTT cycle were achieved in a cycle time reduction of 20 minutes.



Modification – 2

- The middle header's control valve enlarged from 12 to 16 inches in diameter.
- Investment cost - Rs. 34.07 lacs.

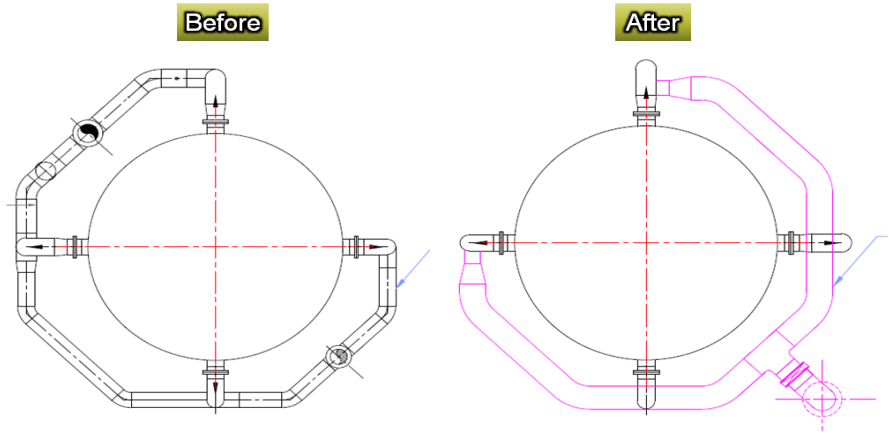


Modification – 3

The discharge line nozzle's diameter increased from 300 to 500 mm.

Investment cost – Rs. 101.52 lacs.

- **Modification – 1**
- Modification of top air evacuation in digester with the existing system
- Investment cost - Rs. 24.51 Lacs



Schematic diagrams of before and after modifications of the Digester

Benefits Achieved

Modification-1

- Chip fill quantity in digester increased by 1.5 tons/digester
- Chip fill time reduction achieved is by 7 minutes minimum (from 32 minutes to 25 minutes)

Modification – 2

- Circulation volume increased from 130 LPS to 180 LPS.
- TTT time cycle reduced by 15 mins / cycle and Uniform Temperature profile achieved.

Modification – 3

- Clean pump out in one stroke
- Cycle time reduction from 310 minutes to 290 minutes / pump-out
- Displacement liquor entry under low velocity.

Description	Values
Increase in Pulp Production, tpd	380 to 430
Investment, Rs Lacs	148
Savings, Rs. Crores	8.15

Case study -2

Solar Sludge Dryer for handling of MLSS

Mixed liquor suspended solids (MLSS) is the concentrated suspended solids from an aeration tank of ASP (Activated sludge process) generated during the treatment of wastewater. It consists mostly of microorganisms and non-biodegradable suspended matter, which has a high calorific value ranging from 3260 to 3460 kJ/kg fuel.

Dewatered MLSS contains a significant amount of water (upto 70%). and is handled as a solid material.

The MLSS was earlier used as fertilizer and after solar drying (from 15% to 70%) is used in power boiler as biomass.

Description	Value
Coal savings, tpa	30
Annualized cost savings, Rs in Lacs	4.10

Cost of investment – Rs. 17. 5 Lacs , 6 tons of MLSS are being dried per batch in a cycle of six days.

Case study -3

Firing of Bio-gas from Anaerobic Digestion of waste waters in limekiln

Benefits:

- Reduction of furnace oil in the rotary lime kiln to a level of 3 - 3.5 kl/day
- Mitigation of biogas to the atmosphere.
- Elimination of odor nuisance
- Reduced organic load to ETP and improved performance of the treated waste water.
- Reduced energy and nutrient consumption in the aeration system.

Case study -4

Modification of boiler for Firing of Bio fuels

Following modifications were carried out in the existing system –

- Primary & Secondary Screen
- Drag Chain Coal Feeders

Description	Value
Coal savings, tpa	27650
Annualized cost savings, Rs. Lacs	1123

- Without affecting the mill operation, modifications were made to the existing boiler.
- Mill is running the system successfully and avoided additional Boiler investment.
- About 47% of the plants coal requirement is met with these modifications.

Conclusions

- Significant savings can be achieved by adopting very simple measures. It is therefore necessary that mills should look into their energy consumption pattern and plan a regular energy monitoring and control system.
- Help from external agencies can be useful for the identification and implementation of the recommendations for achieving energy efficiency and cost reduction drive.
- The mills should also prepare a plan to implement the energy-efficient technologies in a phase wise manner to achieve the energy efficiency targets and subsequent GHG reduction.

Thank You